DESIGN OF A PROPELLER FOR DOWNWIND FASTER THAN THE WIND VEHICLE

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By

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DESIGN OF A PROPELLER FOR DOWNWIND FASTER THAN THE WIND VEHICLE

of

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APPROVED FOR THE DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

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ABSTRACT

DESIGN OF A PROPELLER FOR DOWNWIND FASTER THAN THE WIND VEHICLE

This is in part of the wind powered vehicle to achieve going downwind faster than the wind. With the increase in the demand of a clean energy and green environment contribution, design the propeller for this vehicle is the task. The design is a ground vehicle that exceeds the speed of the wind when it is powered by steady-state wind. While other wind-powered vehicles exceed wind speed while tacking, this vehicle will exceed wind speed while going dead downwind. The optimum propeller design that produces thrust at very low Reynolds number (<100,000) will break through the concept of exceeding wind speed. The task is achieved in designing the vehicle and the propeller. The propeller is designed using propeller tools such as JavaProp and JavaFoil. The analysis is carried out for different airfoils at different rpm and diameter where the design point is achieved. Comparison of a 16", 18" and 20 "of a diameter and having decided to choose with the 16" the efficiency achieved is 70 percent. The constraint of the vehicle dimensions and materials allows only 73 percent of efficiency. The results produced from exceeding wind speed will help in the future work of hybrid vehicles. The propeller will be constructed out of, windsurfing masts, high-density foam, and fiberglass.

By Shethal Thomas Kodiyattu

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank the persons who has been of the utmost support in encouraging, guiding me from the initial to final completion of this project. Firstly I thank almighty God for having given the peace and knowledge beyond all understanding in helping me thorough all situations. One of the verses that kept me uplifted through all times "Do not be anxious about anything, but in everything, by prayer and petition, with thanksgiving, present your requests to God. And the peace of God, which transcends all understanding, will guard your hearts and your minds in Christ Jesus." Philippians 4:6-7.

Secondly, I thank Dr. Nikos Mourtos for having the same faith and continually of support throughout the completion of the project and having offered the opportunity of carrying out this project. I would to also thank the department of Mechanical and Aerospace engineering and San Jose State library facility.

Lastly, I thank my parents and sister for the encouragement and moral support through it all.

INTRODUCTION

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1.0 Introduction

1.1 Motivation behind the project

The energy crisis and environmental concerns have increased interest in green engineering Using wind-power to produce energy or to propel a vehicle is one application of green engineering [1] . The design is of a ground vehicle that exceeds the speed of the wind when it is powered by steady-state wind. While other wind-powered vehicles exceed wind speed while tacking, this vehicle will exceed wind speed while going dead downwind. The vehicle will be the first of its kind designed to achieve twice the wind speed or greater. The vehicle is designed to use off the shelf parts and easily accessible materials. The propeller will be constructed out of, windsurfing masts, high-density foam, and fiberglass [13]. The vehicle will be tested at the Alameda Naval Station runway in April 2010

The theory behind going down wind faster than the wind works parallel to a sail boat concept [3]. Here the task is putting a ground wind powered vehicle to test to see if it can go faster than the wind. A major part that will contribute to this test is the propeller, the key to understanding going downwind faster than the wind is that the wheels are turning the propeller and that the propeller needs to only produce enough lift in still air to overcome the forces required to turn it. It is self-starting downwind and once it starts moving, accelerates rapidly. The next challenge is when the constraints such as the wind speed and gear ratio is included the most efficient propeller becomes a challenge.

To bring in a little bit of the history of this concept, in the year 1960's Dr. Andrew Bauer shown in figure1, an aerodynamicist who worked for Douglas aircraft was intrigued by a proposal from a student. This paper proposed a wind powered device that could travel directly downwind faster than the wind. They worked on building this vehicle and with no existing test run information claims to have sustained approximately 1.2 times windspeed. Now the present teams challenge is to work to build the similar vehicle with more advanced analysis on the physics carried out to determine if Dr. Bauer accomplished the task.

This report contains the design of the propeller based on the constraints by the vehicle developers. The various design carried out determines the design of a propeller to prove the concept of going downwind faster than the wind. Here the analysis is carried out theoretically to evaluate if the propeller will be able to produce enough lift to go twice the wind speed.

Figure1. Dr.Andrew Bauer's cart

1.2 Downwind faster than the wind concept

The vehicle is designed to start from rest and accelerate in steady state downwind. It will only be accelerated by the wind, meaning that there is no use of hydraulics or batteries to initiate acceleration. The proposed vehicle makes use of a propeller that is geared to the wheels to create an aerodynamic torque as the vehicle is propelled forward by the wind. However, the propeller cannot function until the relative velocity is large enough for the propeller to produce static thrust, meaning that the relative velocity is close or equal to the wind velocity, as displayed by the given equation 1 taken from the momentum theory:

$$T = \frac{\pi}{4} D^2 (V_R + \Delta v) \rho \Delta v \qquad (1)$$

For the purpose of analysis, the equations of motion for the vehicle will be broken down into three parts: where the vehicle velocity is less than the wind ($V_V < W$); where the vehicle velocity equals the wind ($V_V = W$); and where the vehicle velocity is higher than the wind ($V_V > W$).

The first case in consideration:

As the vehicle picks up speed, the wheels rotate due to the friction between the ground and the tires. This rotational velocity is then transferred via a transmission to power the propeller. However, because the relative velocity the propeller experiences is negative, meaning that the air being pushed through the propeller by the wind is higher than the oncoming air being pushed

through due to the vehicle's velocity, the propeller acts only as a windmill, producing zero thrust. The propeller is spinning at an angular velocity, gradually increasing as the vehicle's velocity increases. The stream tube is displayed in Figure 2, where the vehicle is moving from left to right.

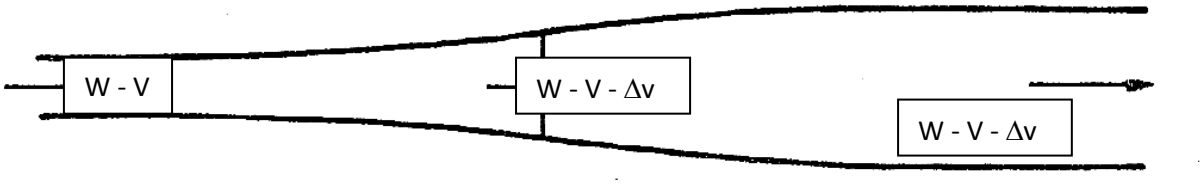

Figure2. Stream tube for a propeller at initial stage

Using the momentum theory and the conservation of mass, the mass flow through the propeller is denoted by equation 2:

$$\dot{m} = \rho(W + V_V + \Delta v)A_P \tag{2}$$

or

$$\dot{m} = \rho(V_R + \Delta v)A_P \tag{3}$$

Here, the velocities are taken in the reference frame of the propeller, where velocities travelling to the right, in Figure 2, are considered positive. Therefore, the relative velocity is considered negative until it reaches the wind speed. Following the sign convention, the mass flow will be positive while the propeller produces thrust and negative during initial stage

Knowing that the propeller is at 0N of thrust production and not adding thrust the equations of motion can be derived by the following equations. Since the vehicle is experiencing a tailwind,

the drag created by the wind flowing over the vehicle will act as the initial accelerator of the system, in the form of skin friction drag and form drag. Inspecting Figure 2 reveals the following equation for the net force on the vehicle

$$F_{net} = D - T_W - \mu_f(mg) \quad (4)$$

This equation is only valid where the relative velocity is less than the wind velocity, for the drag is a function of the relative velocity and will act against the direction of the cart once the vehicle reaches speeds above the wind velocity.

$V_V > W$

Once the vehicle has surpassed the wind velocity, the propeller thrust kicks in and produces an additional forward force. Here the vehicle will continue to accelerate until the system reaches an equilibrium point where the thrust produced by the propeller is equivalent to the losses due to friction and aerodynamic drag. Assuming that there is no slip (i.e. Crr =1), the power that is transferred from the wind pushing the vehicle and the ground friction can be displayed by equation 5:

$$P_W = T_W * V_V \quad (5)$$

The ideal power produced by the propeller can be found using equation 6

$$P_{Ideal} = T_P(V_R + \Delta v) \quad (6)$$

And the ideal efficiency is denoted by equation 7:

$$\mu_{Ideal} = \frac{V_R + \Delta v}{V_R} \quad (7)$$

Combining the equations gives way to the actual power produced by the propeller

$$P_P = T_P(V_R + \Delta v)/\eta_P \tag{8}$$

However, since the propeller is being powered by the rear axle via a transmission can be related by equation :

$$\frac{T_P(V-W)}{\eta_P} = F_W * V * \eta_g \tag{9}$$

Solving for the thrust of the propeller yields the following:

$$T_P = F_W * \frac{V}{(V-W)} * \eta_P * \eta_g \tag{10}$$

Knowing the relation between the thrust produced by a propeller and the force that the wheel experiences as it turns, the net thrust of the vehicle can be determined by the following equation

$$T_{net} = F_W * \left(\frac{V}{(V-W)} * \eta_P * \eta_g - 1\right) \tag{11}$$

By inspection of Equation 2.5 it becomes obvious that this vehicle will only operate if

$$\frac{V}{(V-W)} * \eta_P * \eta_g > 1 \tag{12}$$

which is only possible if this vehicle is optimized toward efficiency.

CHAPTER 2. Preview to propeller theory

The propeller theory which began with Rankine and Froude gives an overall description of the fluid motion where the propeller is treated as an actuator disk that imparts a certain momentum to the fluid passing through it. The simple momentum theory gives a good indication of the efficiency of a propeller but fails to furnish the required design data for the propeller blades. It was realized that the induced velocities along the blades had to be determined in order to solve the basic propeller problem. A certain optimum loading exists for each propeller configuration in analogy with the case of elliptical loading on a wing. Bertz formulated the theorem of rigid vortex sheet, tactically referring to light loading; and Prandtl devised the method of calculating the loading function on the basis on an infinite number of blades and then applying a tip correction that was obtained by a simple two dimensional treatment. Betz proved that the most efficient loading along the propeller balse corresponds to the requirements of rigid vortex behind the propeller. The velocity of the flow is such that all the vortex lines move rearwardly as if attached to a perfectly rigid sheet. This solid spiral moves with a velocity that is referred to as a displacement velocity. The vortex surface is infact unstable and will not maintain its ideal shape for any length of time. With the wake specified thrust torque and efficiency can be calculated [2].

CHAPTER 3. Propeller design

3.1 Constraints and requirements to the design

The vehicle produces a thrust of 200 N and having 2 blades will not add to the weight of the vehicle to prove the concept of going twice faster than the wind. The propeller design was proposed with the following diameter of 16', 18' and 20'. The wind speed or the relative wind speed on a normal day estimated to be 8 m/s. Inorder to get the most efficient propeller the rpm was varied from 60-200[1/min] to find the design point for each of the diameter and corresponding airfoil that was selected.

3.2 Theoretical background of Javaprop

JavaProp is a relatively simple program, which is based on the blade element theory. The blade is divided into small sections, which are handled independently from each other. Each segment has a chord and a blade angle and associated airfoil characteristics. The theory makes no provision for three dimensional effects, like sweep angle or cross flow. But it is able to find the additional axial and circumferential velocity added to the incoming flow by each blade segment. This additional velocity results in an acceleration of the flow and thus thrust. Usually this simplified model works very well, when the power and thrust loading of the propeller (power per disk area) is relatively small, as it is the case for most aircraft propellers.

3.3 JavaProp design process

Java prop helps design propeller blades by inputting the constraints and varying the variables among the rpm, diameter, airfoils and blade angle.

The computer program is based on the formulas in comparison to Adkins vs. Larrabee. Based on the theory of the optimum propeller (as developed by Betz, Prandtl, Glauert), only a small number of design parameters must be specified. These are

- the number of blades *B*,
- the axial velocity *v* of the flow (flight speed or boat speed),
- the diameter *D* of the propeller,
- the selected distribution of airfoil lift and drag coefficients C_L and C_D along the radius,
- the desired thrust *T* or the available shaft power *P*,
- the density *rho* of the medium (air: ~1.22 kg/m³, water: ~1000 kg/m³).

The design procedure creates the blade geometry in terms of the chord distribution along the radius as well as the distribution of the blade angle. The local chord length *c* depends mainly on the prescribed lift coefficient C_L to have wider blades, having to chose a smaller design lift coefficient (resp. angle of attack) and vice versa. It should be noted, that the design procedure does not work accurately for high thrust loadings as they occur under static conditions. If the power coefficient *Pc* is less that 1.5, otherwise the theory is not fully applicable and may lead to errors. Figure 3 shows the flowchart of the design process.

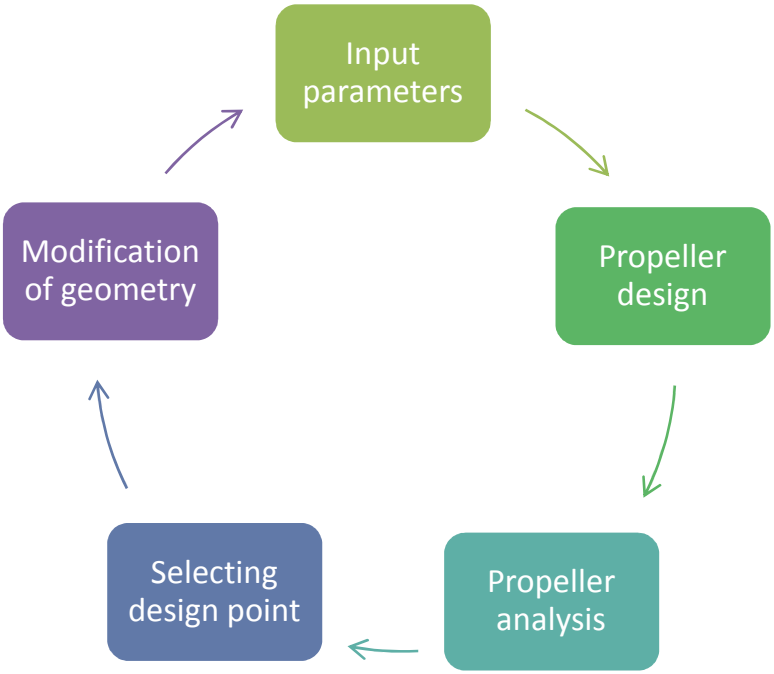

Figure 3: Flow chart of design process

A propeller shows a strong variation of the twist distribution along the radius. The local inflow, seen by a segment of the propeller consists of two parts:

- the *axial* velocity component *v* due to the movement of the aircraft and
- the circumferential component caused by the *rotation* of the propeller.

The *rotational* component depends on the rotation speed and the radial position, where the blade section is located; at the axis this component is zero, whereas at the wing tip ($r = D/2$) it reaches its maximum value.

The total velocity is the sum of the axial and the rotational component:

.

The following equations are basic equations while carrying out the analysis of the geometry to check if it meets the design criteria. From these equations the design point can be selected.

Table 1: Equations for design point

Thrust	c_T	$c_T = \frac{T}{\rho \cdot n^2 \cdot D^4}$
Power	c_P	$c_P = \frac{P}{\rho \cdot n^3 \cdot D^5}$
Advance Ratio	v/nD	$v/nD = \frac{v}{n \cdot D}$
Efficiency	η	$\eta = \frac{v}{n \cdot D} \cdot \frac{c_T}{c_P}$

CHAPTER 4 Selection of airfoils

4.1 Airfoil Comparison

Due to the high Mach number, compressibility effects (recompression shocks, causing additional drag) reduce the efficiency of the propeller. A practical way to keep the drag of an airfoil at acceptable levels is the use of thinner and less cambered airfoils. To avoid excessive drag, a

certain critical camber and thickness should not be exceeded. The Mach number, at which the flow reaches supersonic speed at some point on the airfoil, is called the critical Mach number. Sometimes it might be acceptable to have a small supersonic region at the propeller tip, because a reduction of the diameter (to avoid supersonic tips) also decreases the performance. But in general, a propeller should be designed to avoid supersonic flow by choosing the right airfoil thickness and the right diameter. The analysis of compressibility effects on propeller performance is a very complex matter, and cannot be handled here, but, concluding from experimental data, it is possible to develop a rule of thumb. The different airfoils were being selected based on their maximum allowable thickness and camber for a given Mach number and vice versa.

The airfoils selected were the CLARK–Y, NACA6412, MH 114 and NACA9412 because the characteristics that met the design constraints [5].

The first step while carrying out a propeller design to choosing an airfoil is looking into the airfoil characteristics such as the L/D ratio, the maximum C_L, stall angle depending on the desired thickness as well.

Table 2: Airfoil characteristics comparison

	CLARK Y	NACA 6412	NACA 9412	MH 114
Thickness	0.117c	0.12 c	0.12c	0.13c
Camber	0.034c	0.06c	0.09c	0.6c
Trailing edge angle	15.3deg	14.2deg	13.7deg	11.8deg
Lower flatness	.718c	.812c	.381c	.808c
Leading edge radius	.12c	.17c	.17c	.27c
Max CL	1.295	1.785	2.148	1.981
Max CL angle	8.5	12.0	12.0	12.0
Max L/D	51.61	60.34	58.12	46.291
Max L/D angle	7.0	4.0	0.5	6.5
Max L/D CL	1.18	1.268	1.229	1.676
Stall angle	8.5deg	4.0deg	12.0deg	12.0deg
Zero- lift angle	-3.5deg	-6.0deg	-9.5deg	-8.0deg

The geometry of the blades is determined by the task to transform as much energy as possible from the incoming air flow into mechanical energy. The characteristics hence on the blade are determined by the airfoil that is being selected. Some of the airfoil characteristics that play an important role are the drag polar curve, lift curve, stall angle, zero lift angle and L/D ratio.

The drag coefficient can be written as functions of many different variables as shown in figure 3, 7 and 10. The strongest dependence of drag is on the lift coefficient because of the induced drag effect. In general the drag coefficient is a function of Reynolds number and Mach number. Mostly for the normal flight regime, the dependence on these numbers is the similar to the dependence as observed on the airfoil.

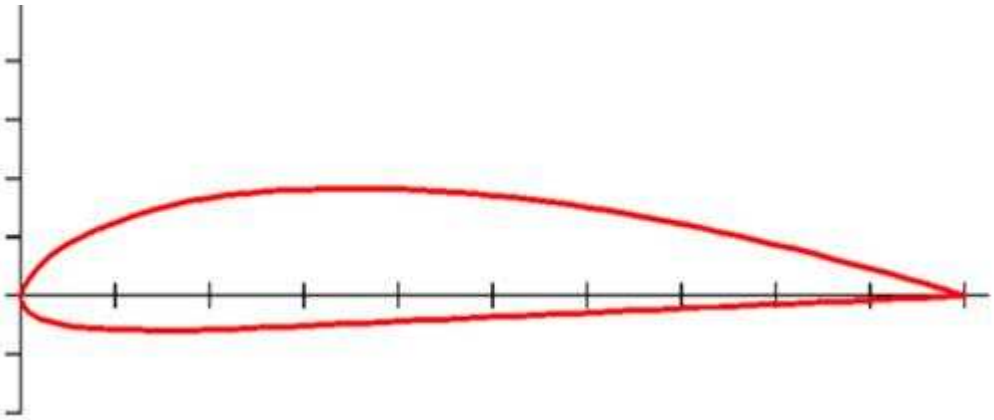

Figure 4.Clark Y Geometry

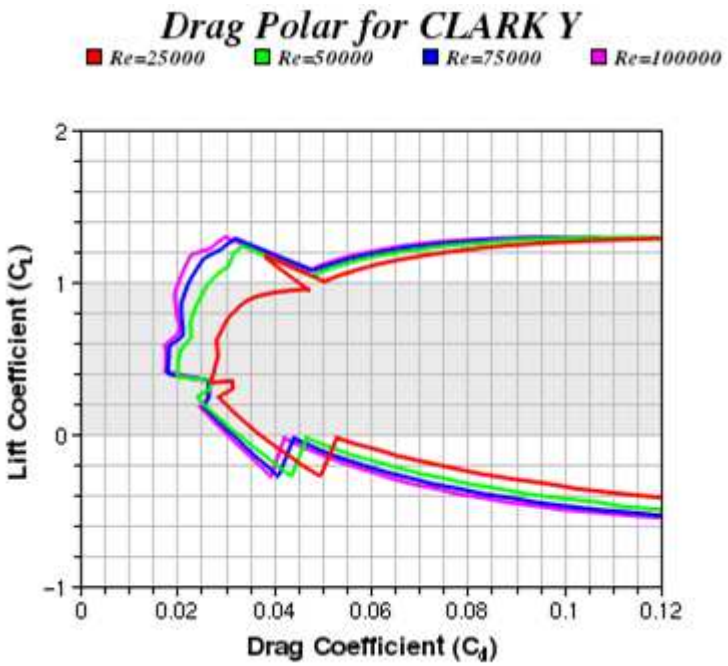

Figure5. Drag polar for Clark Y

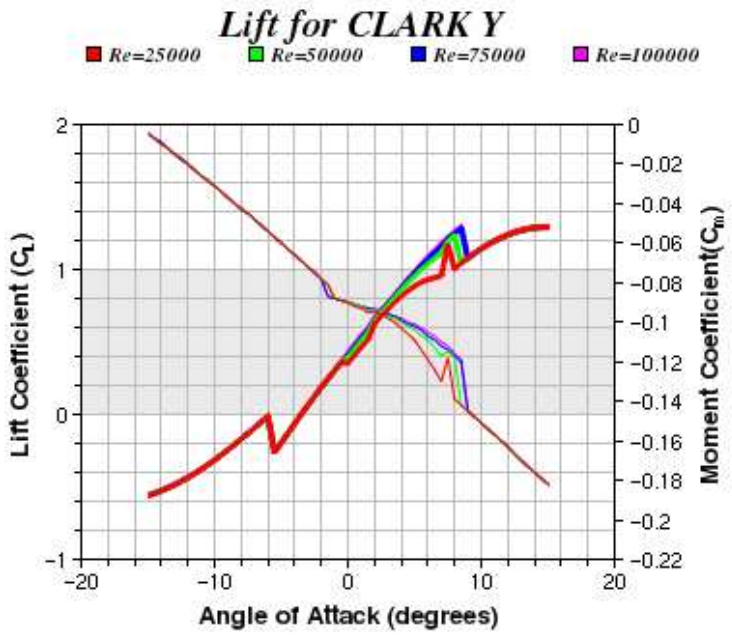

Figure 6. Lift for Clark Y

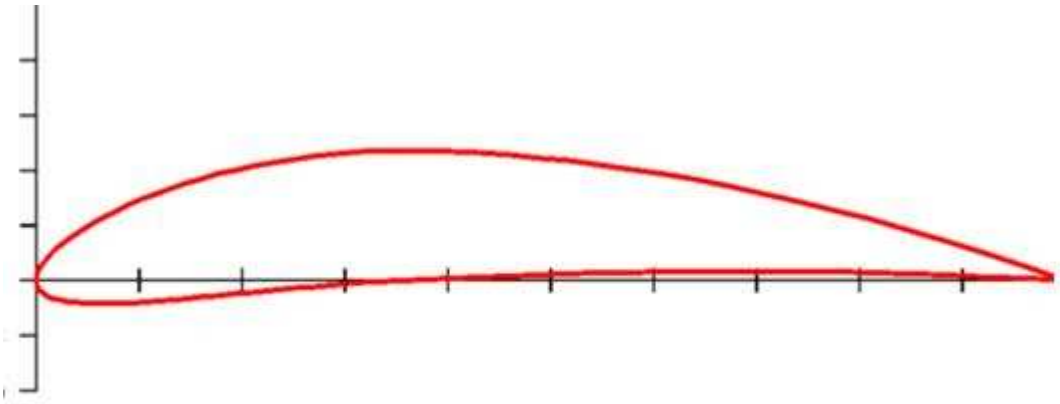

Figure 7. NACA 6412 Plot Geometry

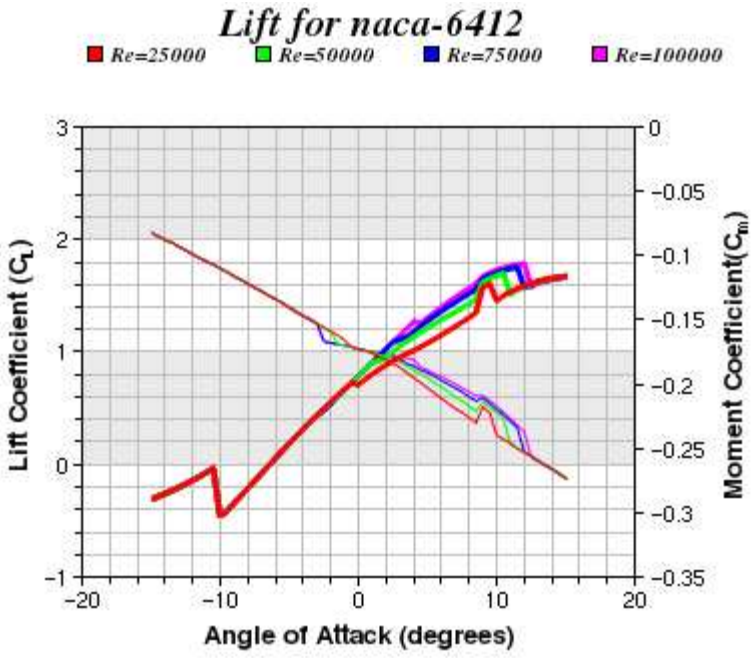

Figure 8 . Lift for NACA 6412

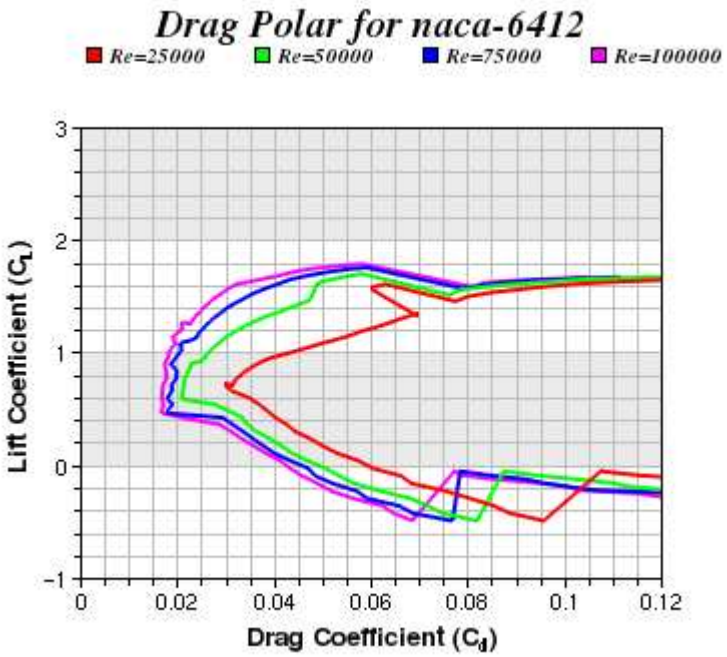

Figure 9 . Drag Polar for NACA 6412

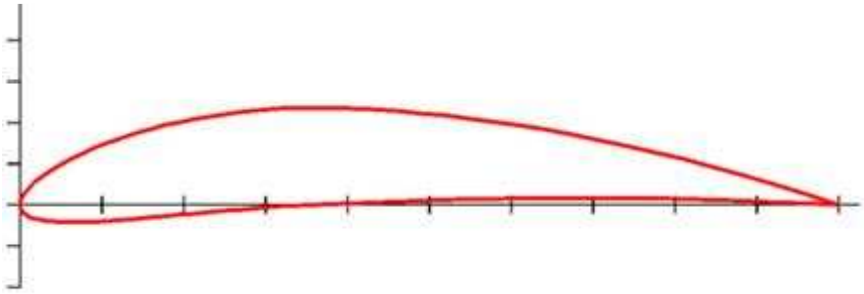

Figure 10.NACA 9412 Geometry

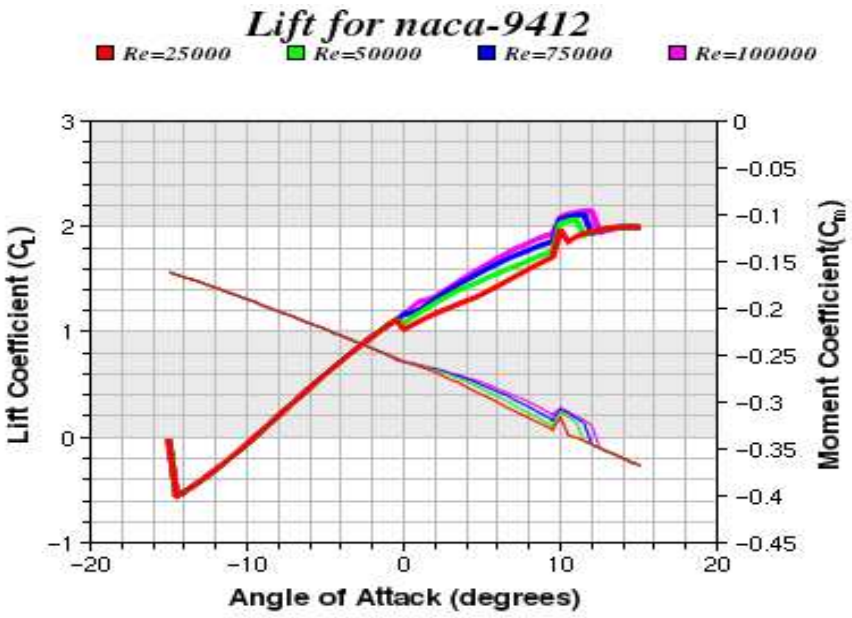

Figure 11. Lift for NACA 9412

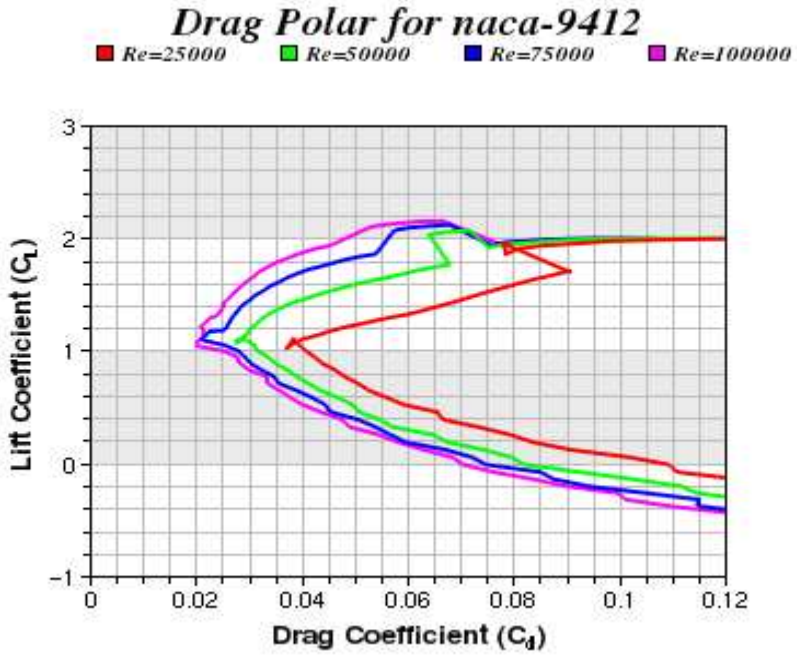

Figure 12. Drag Polar for NACA 9412

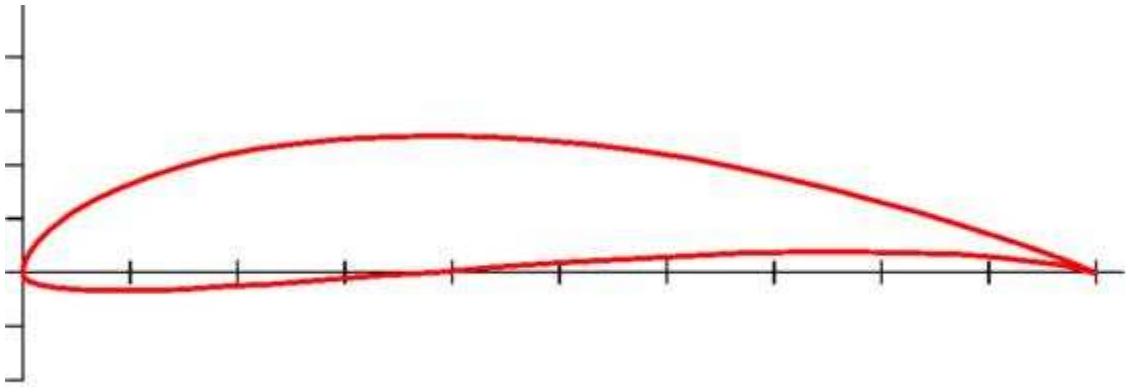

Figure13. MH 114 airfoil geometry

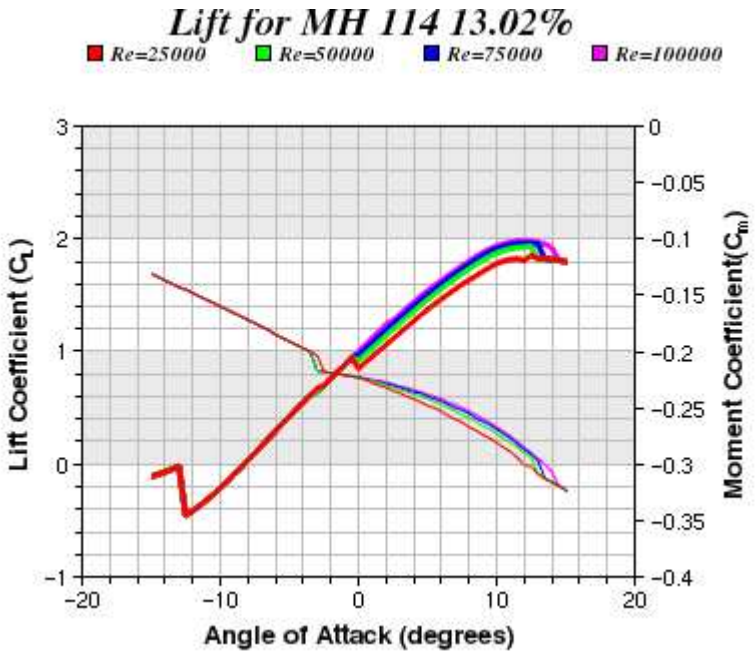

Figure 14. Lift curve of MH 114

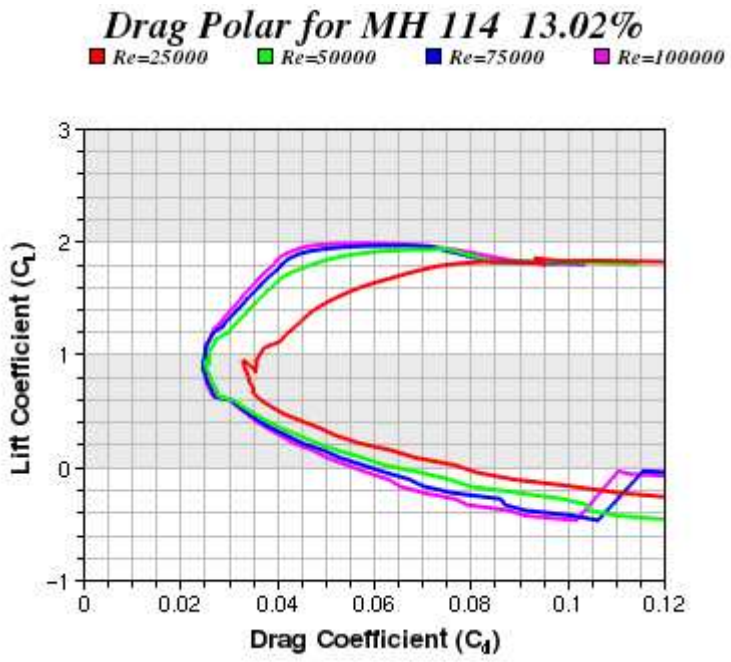

Figure 15. Drag polar of MH114

4.2 Airfoil selection

Based on the comparison between Clark Y, NACA 6412 and NACA 9412 the NACA 6412 was considered appropriate for the design of the propeller. The suitable reasons being that NACA 6412 had a better L/D ratio of about 60.34 compared to Clark-Y of about 50.61 and that it had less camber than NACA 9412. The facts being that the thickness of NACA 6412 is about 6% and the camber thickness of NACA 9412 being about 9%. For construction convenience the NACA 6412 was easy with the technique which was being used to construct the whole propeller.

4.3 Input variables and constants

In order to find the design point the input variables were

Diameter: The propeller diameter was varied between 16', 18' and 20'and varying individually the rpm for each of the diameter from 40[1/min] to 200[1/min].

Spinner Diameter: The spinner diameter was kept constant for all the diameters.

Speed of rotation: The speed of rotation was being varied from 40[1/min] to about 200[1/min] for each of the diameters.

Velocity: The propeller is optimized for a wind velocity of about 8m/sec being expected to be about 18mph on a normal day at the testing station as mentioned as one of the design constraints

Number of blades: The propeller was designed to have just 2 blades.

Propeller used: The different airfoil used was the Clark- Y, NACA 6412 and MH114 airfoil.

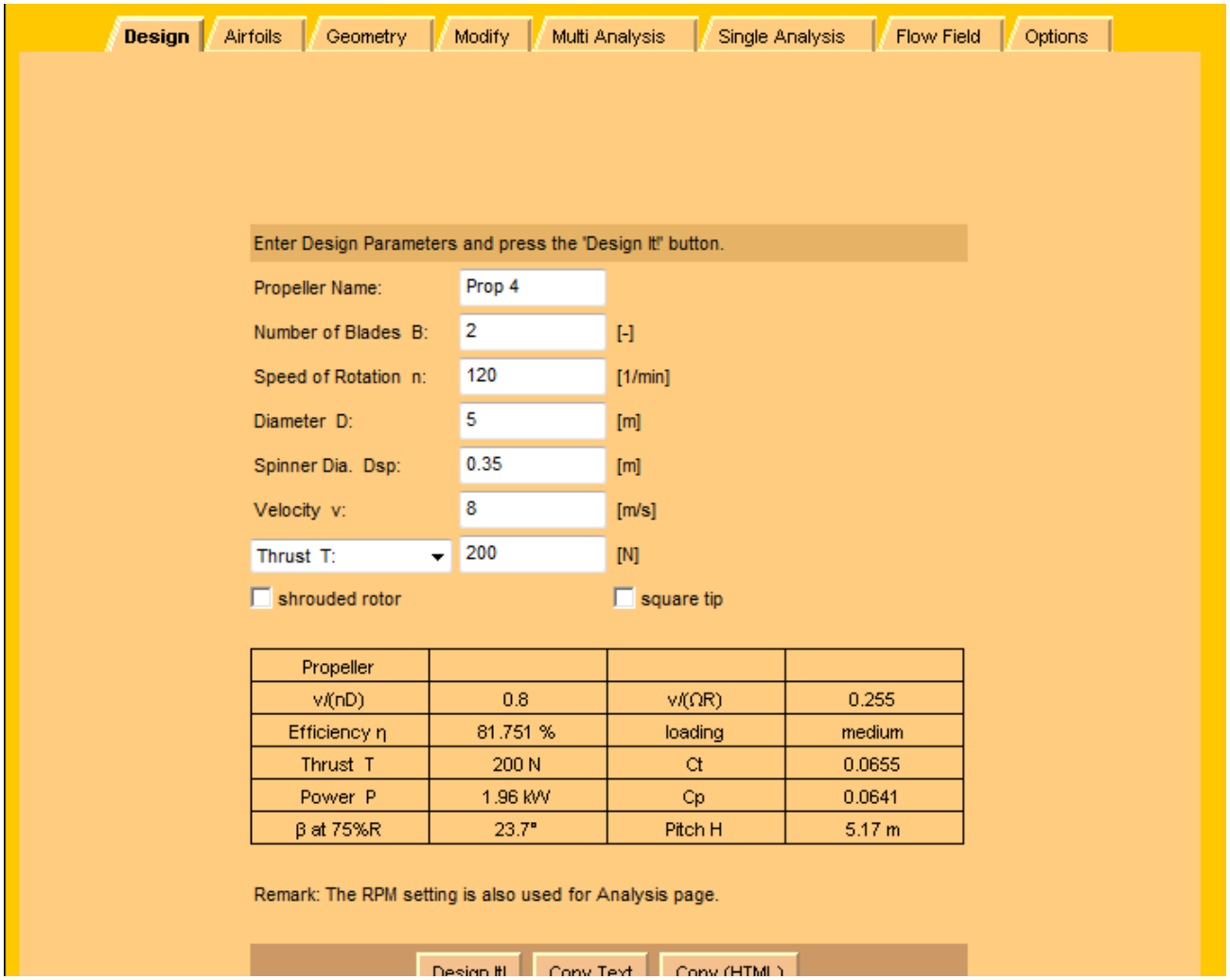

Figure 16: Input parameters in Javaprop

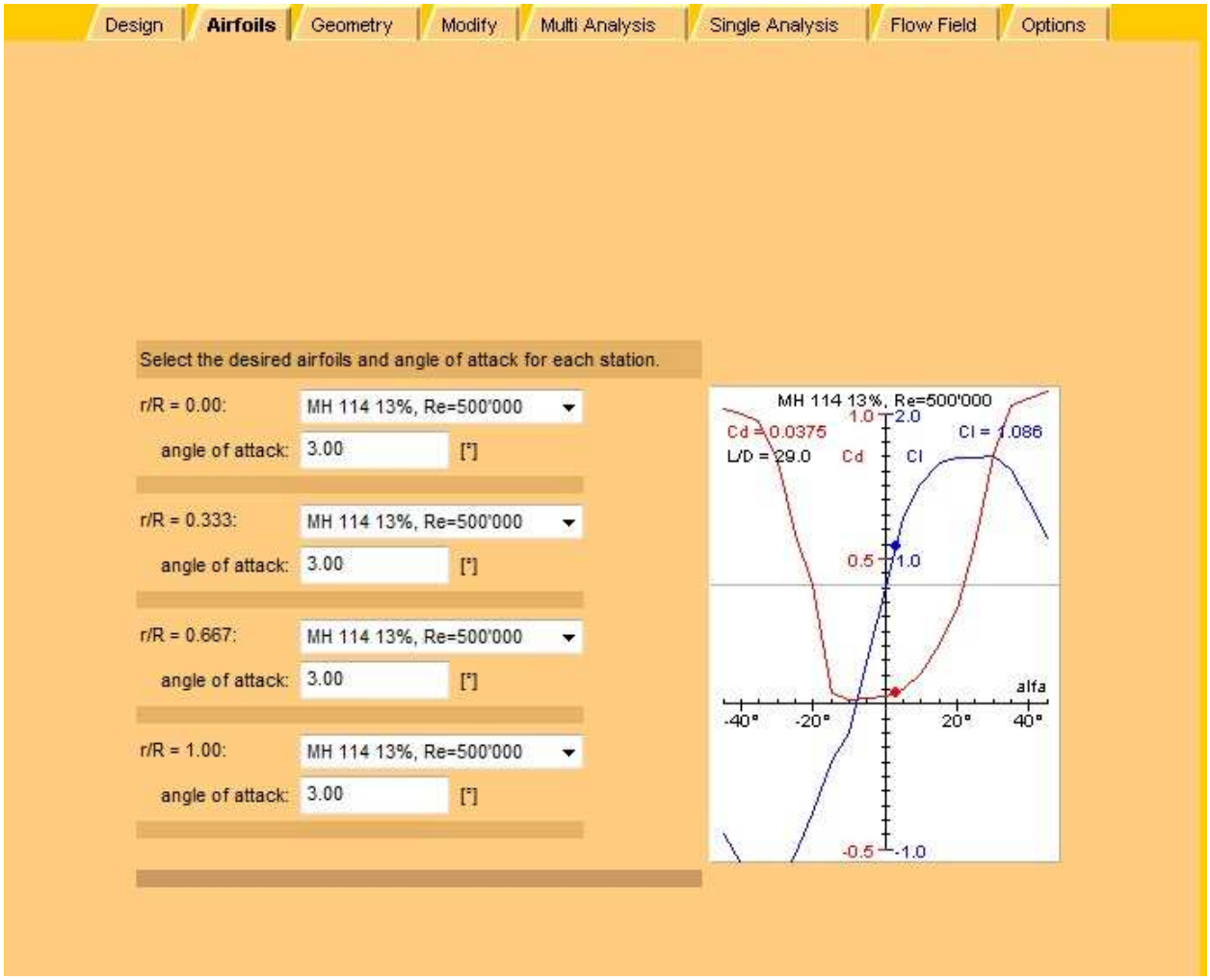

Figure 17: Input of the airfoil in Javaprop

4.4 Javaprop output

The analysis is a so called "Blade Element Method" and uses the same airfoil polars as the design procedure. The influence of blade number and tip loss are taken into account by the "Prandtl Tip-Loss Factor". Given below describes the analysis of the output which is an important factor depending on the variables given.

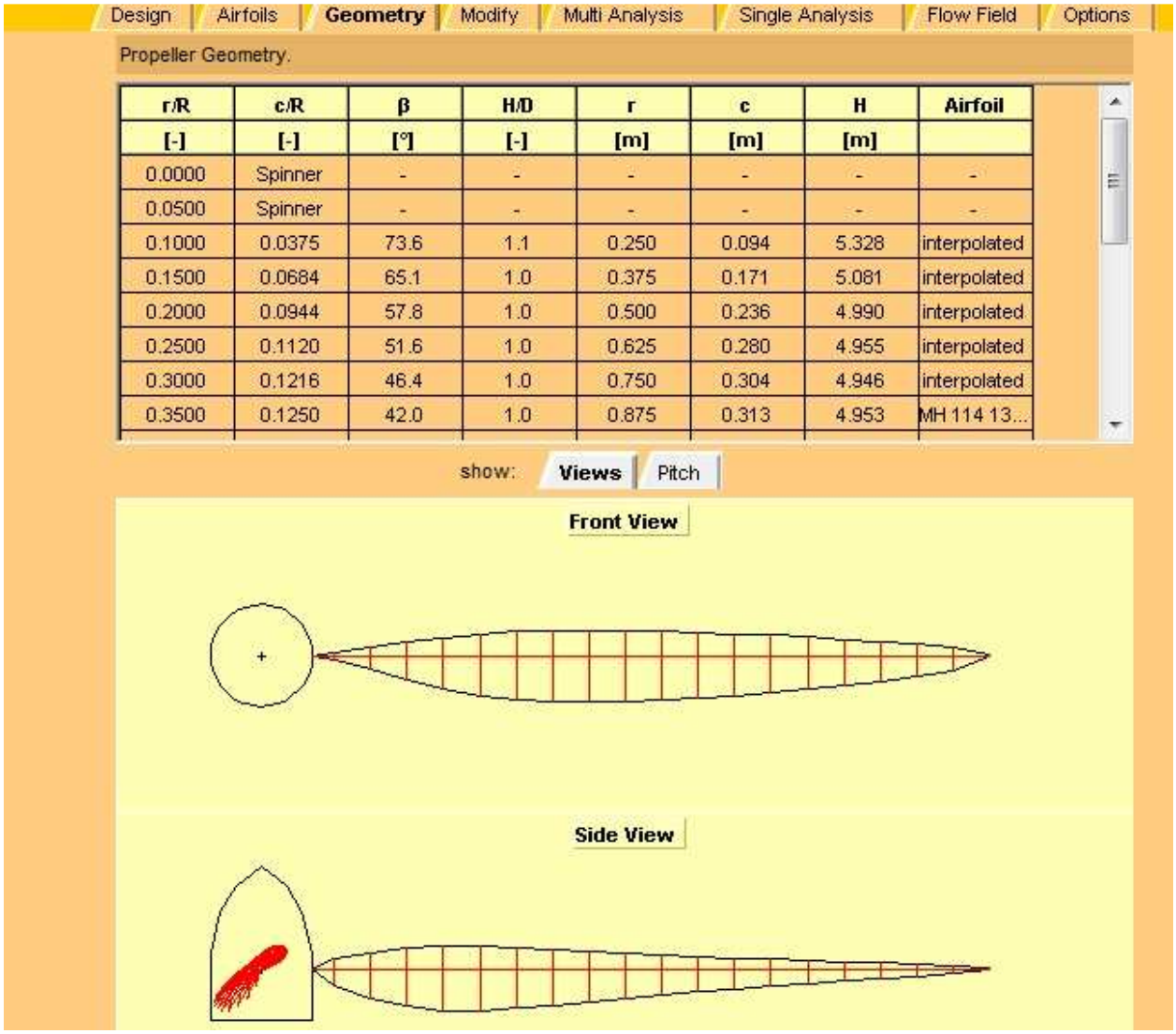

Figure 18. Geometry of the propeller

4.4.1 Analysis of the output

First, it is possible to analyze the propeller for its full operating range, from static to the beginning of the windmilling stage. The results of this "Multi Analysis" are presented a table and a graph showing the thrust and power coefficient depending on the advance ratio *v/(nD)*. The only detail about the flow conditions on the blade is the number of blade sections where the airfoil has stalled, which is given as a "percentage stalled" number. When 100% of the blades are stalled, all airfoils operate beyond their maximum lift, which is usually the case at low speed. Due to the definition of the efficiency the efficiency at larger advance ratios may be higher than at the design point; this does not mean the efficiency in the design point is not maximized. The results also show the maximum possible efficiency for each advance ratio, labeled η^*. This efficiency could only be reached with a propeller without any frictional losses.

Second way to analyze the data this is "Single Analysis" which gives more details for the aerodynamic conditions along the radius. The tables attached in the appendix A, B and plot shows the distribution of lift and drag coefficient and a table lists all data of interest. These include the additional local flow velocity induced by the propeller wake in terms of the so called "interference factors". These factors are labeled *a* and *a'*, where *a* is the ratio of the additional axial velocity to the onset flow velocity. A value of 0.05 for *a* means that an aircraft propeller adds 5% of the flight velocity *v* to its jet. The total axial flow velocity in the propeller plane will be *(1+a)*v*. In a similar way, the factor *a'* defines the ratio of the additional swirl component at the propeller in relation to the local circumferential velocity Ω **r*. The total circumferential velocity seen by the airfoil section is *(1-a')*Ω*r*. Also, it is possible to calculate the local flow direction immediately behind the propeller in terms of a swirl angle Ω. As the previously given total velocities, this angle is again valid in the propeller plane only or immediately behind the

propeller. The slipstream extends downstream from this point, which makes a point far behind the propeller feel twice the induced velocity components (here the slipstream extends downstream as well as upstream). So the additional axial velocity far behind the propeller is *2*a*v* and the additional rotational velocity in the slipstream is *2*a'* Ω *r* and the resulting swirl angle δ_ff (far field)

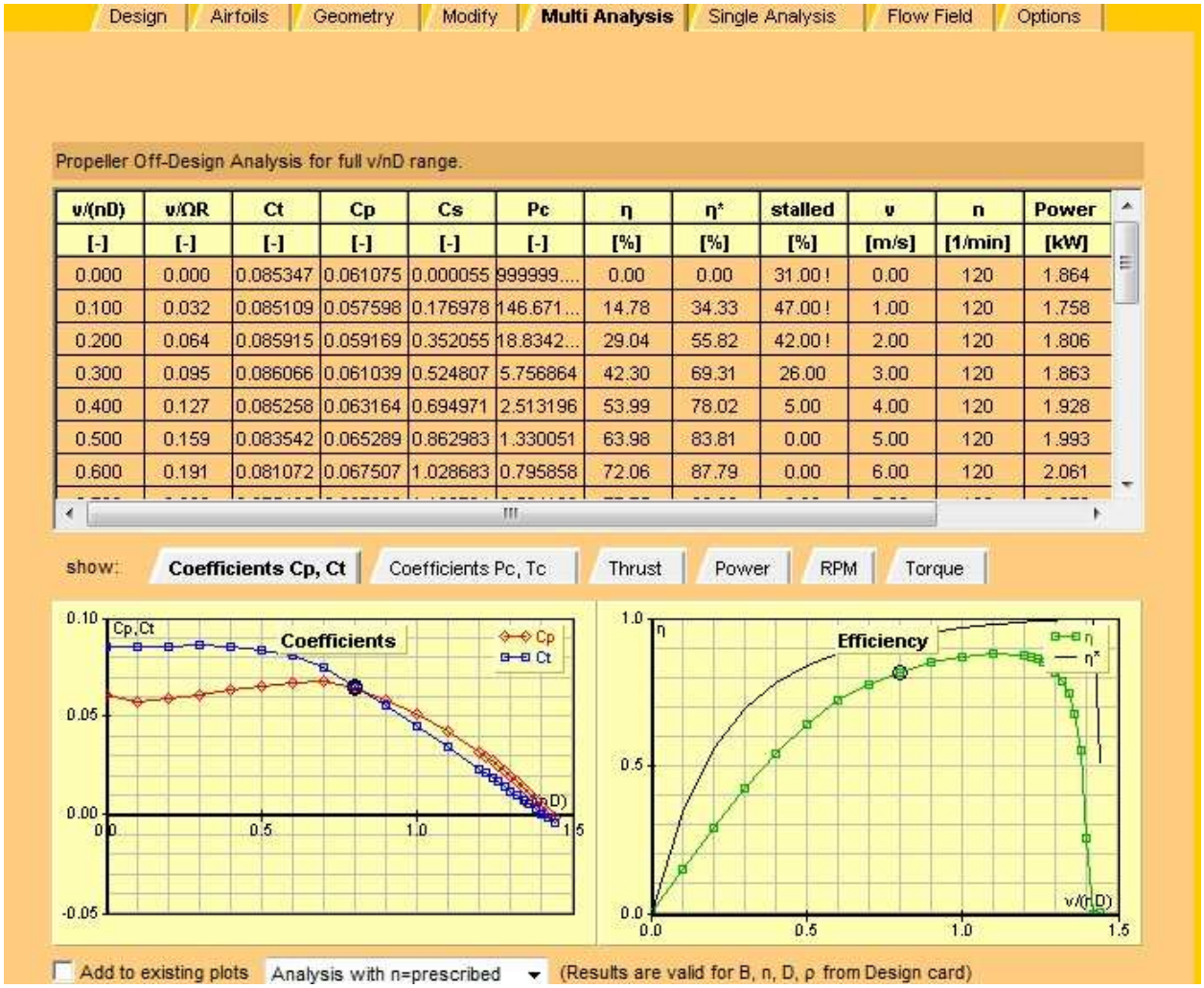

Figure 19: Multi analysis of the propeller

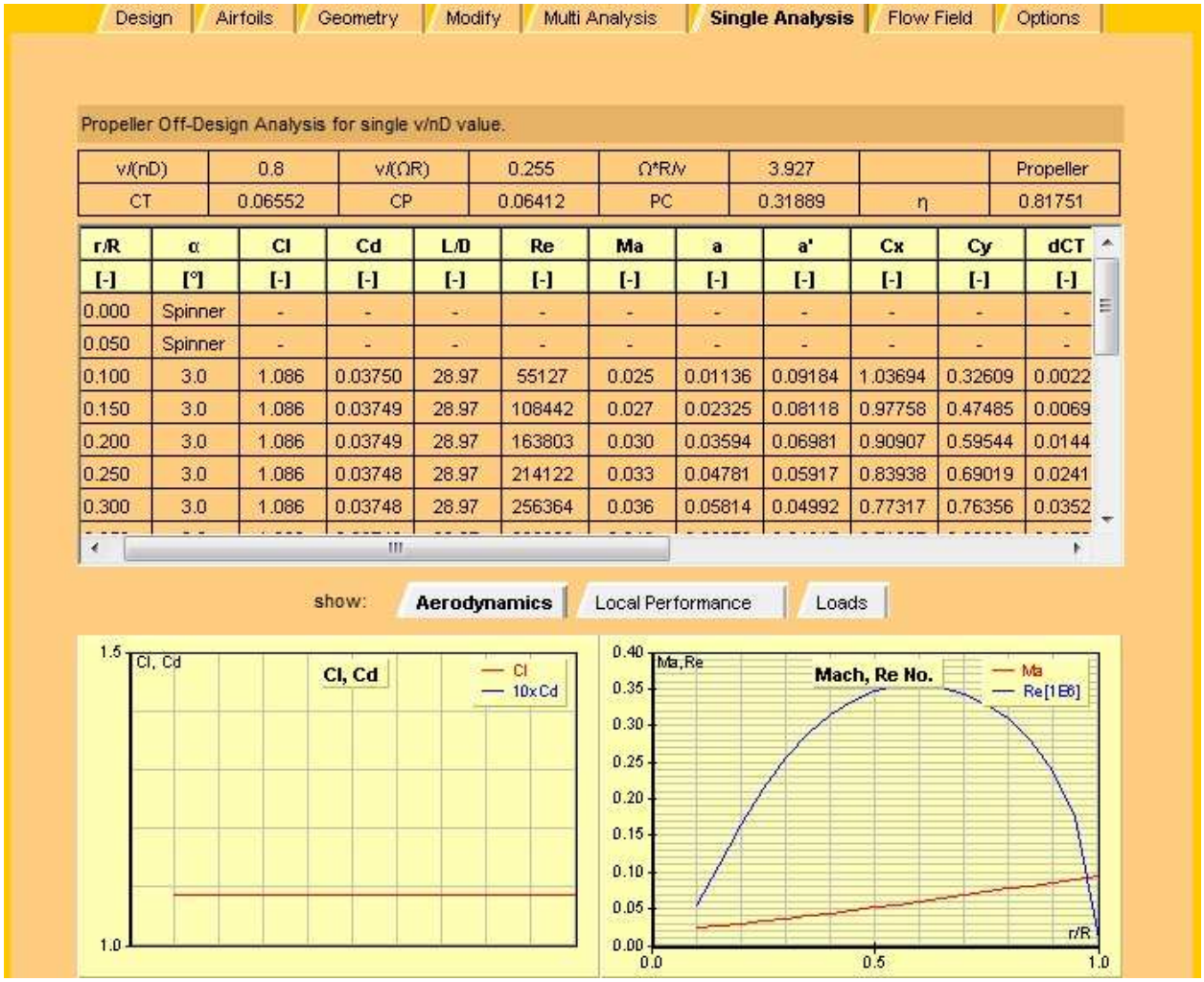

Figure20: Single analysis of the propeller

4.5 Results based on Java Prop

The steps that were carried out find the design point for the Clark- Y airfoil were to tabulate all the efficiency, advance ratio for each of the diameter and varying rpm. The following figure gives the description of the each of the diameters the critical point of choosing the rpm for the set diameter. The graphs plotted below are plotted based on the results obtained from the tables in the appendix A, B and C. For example for a 16 feet propeller at an rpm of 120[1/min] the single analysis is shown in table 16 and multi analysis is shown in table 18. The advance ratio of the

blades at the corresponding β is analyzed based on blade element theory. The coefficient of thrust, coefficient of power, coefficient of toque as well

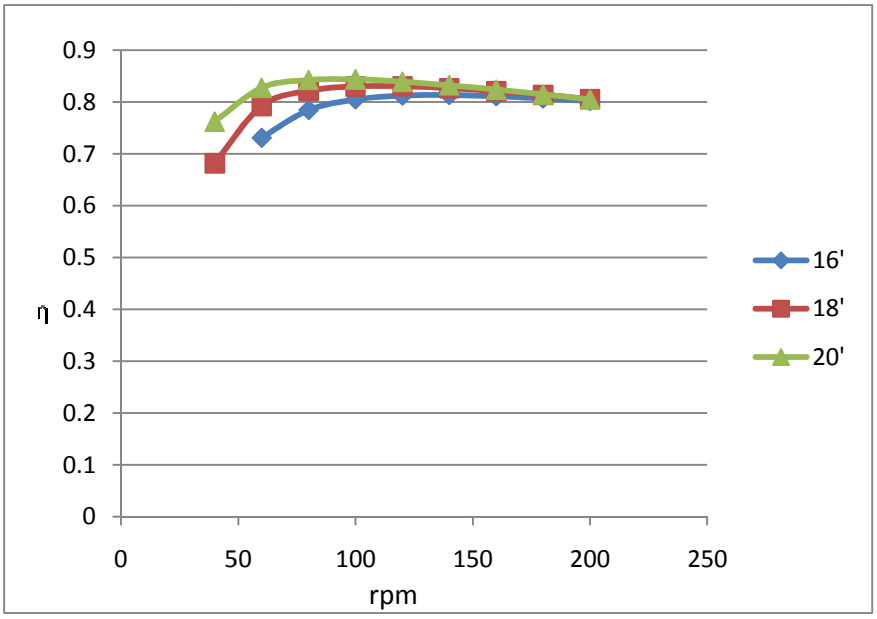

Figure 21. Comparison of different diameter (efficiency Vs rpm) for Clark- Y airfoil

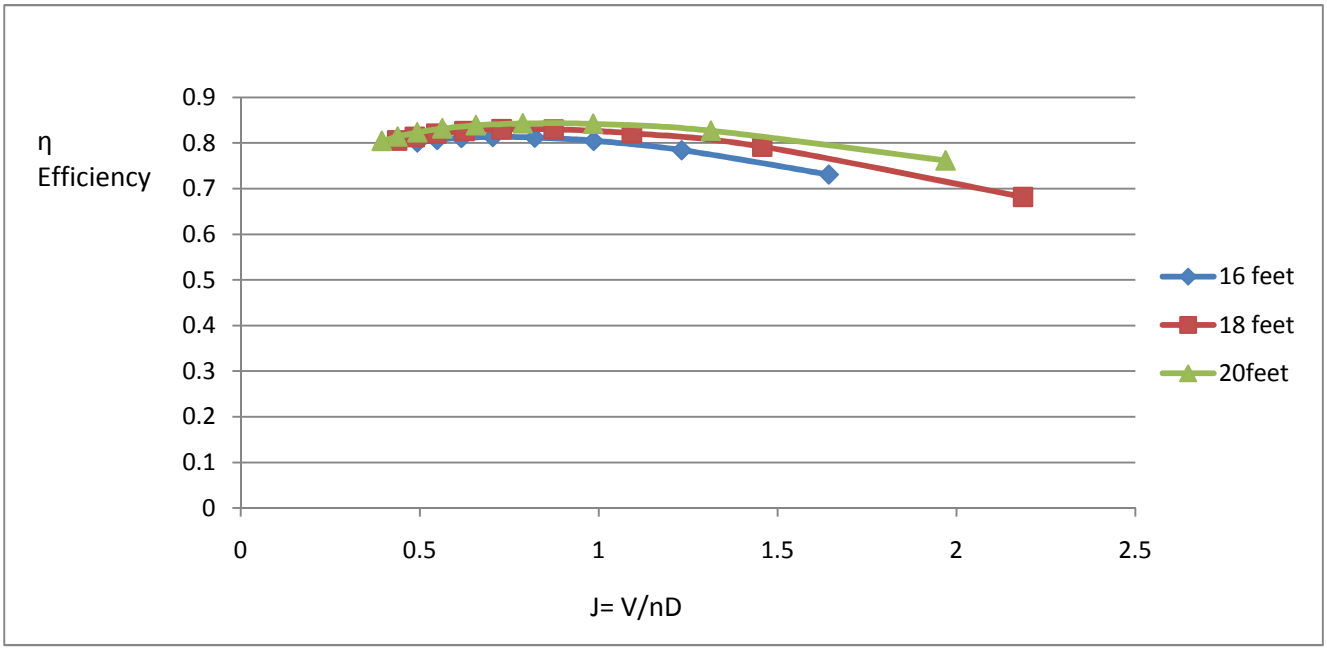

Figure22. Advance ratio Vs efficiency

The values which were the input conditions are given below in table 2.

Table 3: Input conditions of NACA 6412

Diameter	4.878 m
Spinner Diameter	0.5m
Speed of rotation	120[1/min]
Velocity	8m/s
Blade tip	round
Airfoil	NACA 6412

The NACA 6412 airfoil at a 16feet of a diameter and rpm of 120 was found have the following output of thurst, torque and power

Thrust= 49.9(lbs)

Torque= 124.1(ft-lb)

Power= 2.8(HP)

Efficiency= 84.5%

Table 4: The various output for NACA 6412 as the propeller

Advance ratio	1.2378	0.9902	0.8252	0.7073	0.6189
Coefficient of thrust	0.0178	0.0516	0.0731	0.0874	0.0846
Coefficient of power	0.0254	0.0577	0.0713	0.0775	0.1102
Coefficient of torque	0.0040	0.0092	0.0114	0.0123	0.0175
Efficiency	0.8700	0.8800	0.8400	0.7970	0.4800

CHAPTER 5

DESIGN OF PROPELLER IN CATIA

The next immediate stage was to design in a design software inorder to carry out further analysis. The following steps below leads to the 3-D design of the propeller in a modeling software known as CATIA.

5.1 Airfoil coordinates

The airfoils coordinates were imported from an airfoil database the lower and upper surface were imported into the software. The table 4 in the appendix is the coordinates of the NACA 6412 airfoil.

5.2 Steps to design

Step1. Get the airfoil coordinates from any airfoil database, then save the file as .DAT file

Step 2.Use any software to convert the .DAT file to .IGS file

Step3. Open the .IGS file in CATIA

Step4. Join the coordinates of the airfoil

Step5. Create a plane at distance of radius length mentioned in design geometry of the propeller in table 4 of the appendix.

Step6. Project the object onto next plane and scale the airfoil

Step7. Insert the chord length for the airfoil and rotate at each blade angle

Step8. Exit Sketch

Step9. Repeat the steps from step5 to 8 at varying radius to the corresponding chord length and blade angle.

Step10. Then Use mulitsection solid dialogue and in the first window select all the airfoil

Step11. Create the hub by sketching a circle and extruding it.

5.3Final Design

The figures from 13-15 shows the final design of the propeller is to be constructed. Figure 14 shows a 2-D view of the propeller and Figure 15 shows a 3-D view of the propeller.

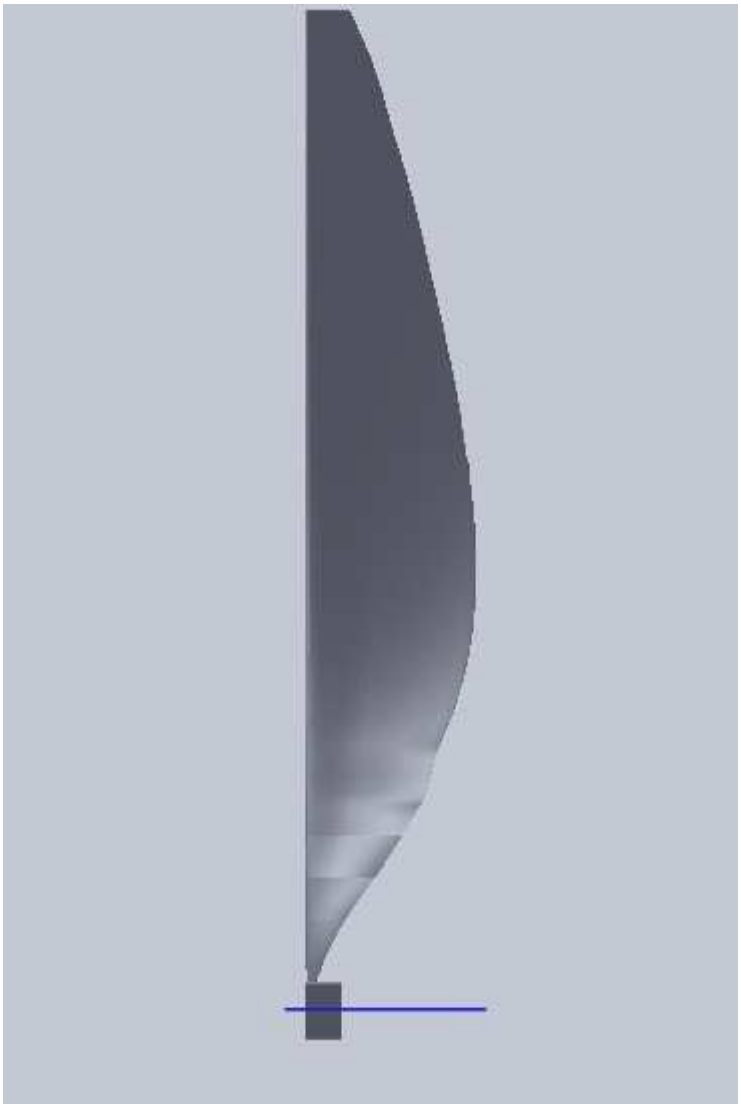

Figure23. 2-D view of the one blade of the propeller

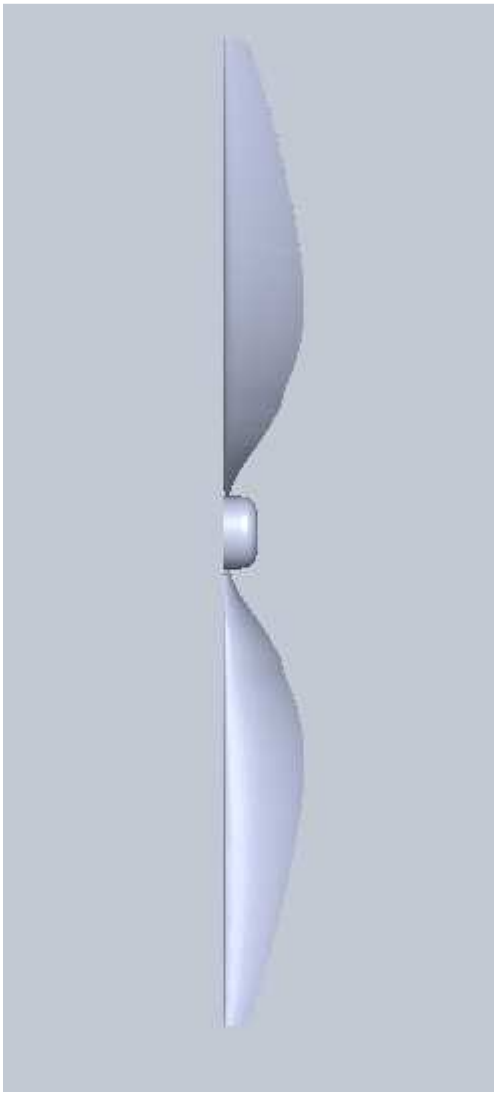

Figure24. 2 D view of the propeller

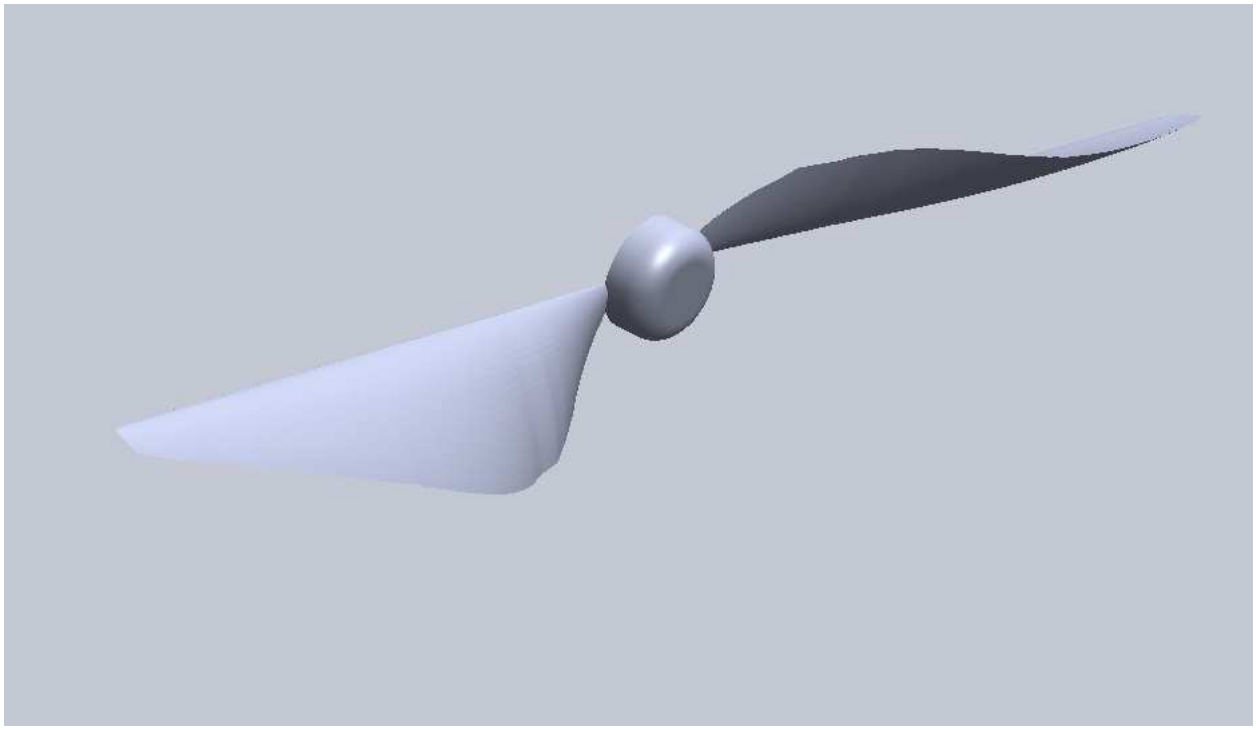

Figure 25: 3-D view of the propeller

CHAPTER 6. RESULTS

The design of the propeller with NACA 6412 airfoil was found to be more efficient at a speed of 120 rotations per minute as compared to the other airfoil. This propeller performed the best at an advance ratio of 1.2. In comparison to the propellers those are designed using the Clark-Y airfoil, NACA 9412 and the MH 114 airfoil.

CHAPTER 7.Conclutions and recommendations

The flow field around a propeller is fully three dimensional and quite complex with boundary layers, Mach number effects and local flow separation - this is even difficult to model accurately with the today's most sophisticated tools like Navier-Stokes solvers like Computational fluid dynamics. *JavaProp* on the other hand can give first answer in fractions of a second bit at the price of accuracy.

The propeller that will be constructed could be converted to a variable pitch propeller. The purpose of varying pitch angle with a variable pitch propeller is to maintain an optimal angle of attack (maximum lift to drag ratio) on the propeller blades as aircraft speed varies. Having a variable pitch would allow the propeller to be able to maintain speeds.

A computational analysis using computational software will help inorder to view the velocity contours, pressure profiles and wakes that occur right behind the propeller tips.

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APPENDICES

APPENDIX A

Table 5. Propeller geometry using NACA 6412

Radius (ft)	Chord (ft)	β (deg)	L.E(ft)	T.E (ft)
0.57500	0.18983	80.12490	0.04746	0.14237
0.72500	0.31718	76.89058	0.07929	0.23788
0.87500	0.46091	73.75922	0.11523	0.34568
1.02500	0.61252	70.74371	0.15313	0.45939
1.17500	0.76452	67.85350	0.19113	0.57339
1.32500	0.91077	65.09468	0.22769	0.68308
1.47500	1.04670	62.47044	0.26168	0.78503
1.62500	1.16922	59.98132	0.29230	0.87691
1.77500	1.27652	57.62588	0.31913	0.95739
1.92500	1.36789	55.40093	0.34197	1.02592
2.07500	1.44340	53.30211	0.36085	1.08255
2.22500	1.50373	51.32415	0.37593	1.12779
2.37500	1.54988	49.46123	0.38747	1.16241
2.52500	1.58312	47.70721	0.39578	1.18734
2.67500	1.60476	46.05583	0.40119	1.20357
2.82500	1.61616	44.50084	0.40404	1.21212
2.97500	1.61860	43.03614	0.40465	1.21395
3.12500	1.61330	41.65586	0.40332	1.20997
3.27500	1.60135	40.35435	0.40034	1.20101
3.42500	1.58373	39.12632	0.39593	1.18780
3.57500	1.56133	37.96673	0.39033	1.17100
3.72500	1.53491	36.87091	0.38373	1.15118
3.87500	1.50513	35.83446	0.37628	1.12884
4.02500	1.47255	34.85332	0.36814	1.10441
4.17500	1.43766	33.92371	0.35942	1.07825
4.32500	1.40088	33.04211	0.35022	1.05066
4.47500	1.36254	32.20531	0.34063	1.02190
4.62500	1.32293	31.41029	0.33073	0.99219
4.77500	1.28228	30.65429	0.32057	0.96171
4.92500	1.24078	29.93474	0.31019	0.93058
5.07500	1.19858	29.24929	0.29964	0.89893
5.22500	1.15579	28.59575	0.28895	0.86684
5.37500	1.11249	27.97211	0.27812	0.83437
5.52500	1.06875	27.37649	0.26719	0.80156
5.67500	1.02457	26.80716	0.25614	0.76843
5.82500	0.97997	26.26254	0.24499	0.73497
5.97500	0.93491	25.74113	0.23373	0.70118
6.12500	0.88934	25.24157	0.22234	0.66701
6.27500	0.84319	24.76258	0.21080	0.63239
6.42500	0.79632	24.30298	0.19908	0.59724
6.57500	0.74857	23.86167	0.18714	0.56143
6.72500	0.69974	23.43764	0.17493	0.52480
6.87500	0.64951	23.02992	0.16238	0.48713
7.02500	0.59748	22.63764	0.14937	0.44811
7.17500	0.54305	22.25996	0.13576	0.40729
7.32500	0.48533	21.89613	0.12133	0.36400
7.47500	0.42290	21.54542	0.10572	0.31717
7.62500	0.35312	21.20715	0.08828	0.26484
7.77500	0.27023	20.88070	0.06756	0.20267
7.92500	0.15414	20.56549	0.03853	0.11560

APPENDIX B

Table 6. Airfoil coordinates s of NACA 6412

NACA 6412

1.00025	0.00124
0.99758	0.00216
0.98961	0.00490
0.97640	0.00935
0.95808	0.01538
0.93481	0.02278
0.90682	0.03130
0.87436	0.04068
0.83777	0.05062
0.79740	0.06082
0.75366	0.07097
0.70702	0.08079
0.65797	0.08998
0.60703	0.09827
0.55477	0.10543
0.50176	0.11124
0.44863	0.11554
0.39587	0.11817
0.34306	0.11841
0.29199	0.11583
0.24336	0.11060
0.19780	0.10302

0.15592	0.09344
0.11825	0.08231
0.08524	0.07012
0.05726	0.05736

0.03460	0.04452
0.01745	0.03204
0.00595	0.02029
0.00014	0.00955
0.00000	0.00000
0.00534	-0.00792
0.01590	-0.01383
0.03149	-0.01781
0.05186	-0.01999
0.07672	-0.02054
0.10574	-0.01967
0.13861	-0.01763
0.17495	-0.01470
0.21441	-0.01121
0.25664	-0.00748
0.30127	-0.00384
0.34792	-0.00064
0.39622	0.00182
0.44685	0.00370
0.49824	0.00542
0.54976	0.00684
0.60088	0.00786
0.65105	0.00843
0.69972	0.00853
0.74634	0.00819
0.79039	0.00747
0.83137	0.00643
0.86878	0.00520
0.90220	0.00386
0.93121	0.00252
0.95546	0.00129
0.97465	0.00024
0.98854	-0.00057
0.99694	-0.00107
0.99975	-0.00124
1.00000	0.00000

B)16 feet Propeller

Table 7. 16 feet input values 60 rpm

Diameter D	4.87 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	60 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	1.643	v/(ΩR)	0.523
Efficiency η	73.07%	loading	medium
Thrust T	200 N	Ct	0.2912
Power P	2.19 kW	Cp	0.6547
β at 75%R	44.5°	Pitch H	11.29 m

Table 8. Propeller Geometry at rpm 60

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0654	84.4	3.227	243.5	159.2	15716.5	interpolated
0.15	0.1384	80.3	2.75	365.25	337	13393.3	interpolated
0.2	0.2272	76.2	2.567	487	553.2	12500.9	interpolated
0.25	0.3224	72.4	2.473	608.75	785	12041.8	interpolated
0.3	0.4156	68.7	2.417	730.5	1012	11770.9	Clark Y, Re=500'000
0.35	0.5002	65.2	2.382	852.25	1218	11598.7	Clark Y, Re=500'000
0.4	0.5716	61.9	2.358	974	1391.8	11484.7	interpolated
0.45	0.6272	58.9	2.342	1095.75	1527.2	11407.7	interpolated
0.5	0.666	56	2.332	1217.5	1621.7	11356	interpolated
0.55	0.688	53.4	2.325	1339.25	1675.2	11322	interpolated
0.6	0.6938	50.9	2.321	1461	1689.4	11301.2	interpolated
0.65	0.6845	48.6	2.318	1582.75	1666.7	11290.2	Clark Y, Re=500'000
0.7	0.6608	46.5	2.318	1704.5	1609.1	11287	Clark Y, Re=500'000
0.75	0.6233	44.5	2.318	1826.25	1517.8	11289.8	interpolated
0.8	0.5719	42.7	2.32	1948	1392.5	11297.4	interpolated
0.85	0.505	41	2.322	2069.75	1229.6	11309.1	interpolated
0.9	0.4184	39.4	2.325	2191.5	1018.8	11324	interpolated
0.95	0.299	38	2.329	2313.25	728.1	11341.7	interpolated
1	0.015	36.6	2.333	2435	36.4	11361.7	Clark Y, Re=500'000

Table 9. Single Analysis at 60 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.338449	0.651622	0	999999	0	0	100.00 !	0	60	2.179	232.4	346.88
0.1	0.032	0.321549	0.63028	0.109671	1604.994	5.1	18.97	100.00 !	0.49	60	2.108	220.8	335.52
0.2	0.064	0.33103	0.640616	0.21863	203.9143	10.33	33.6	100.00 !	0.97	60	2.143	227.4	341.02
0.3	0.095	0.339134	0.649037	0.32709	61.21332	15.68	44.95	100.00 !	1.46	60	2.171	232.9	345.5
0.4	0.127	0.34517	0.654611	0.435375	26.04614	21.09	53.86	100.00 !	1.95	60	2.189	237.1	348.47
0.5	0.159	0.349514	0.658405	0.54359	13.41291	26.54	60.91	100	2.43	60	2.202	240	350.49
0.6	0.191	0.351789	0.662684	0.651463	7.812555	31.85	66.58	100	2.92	60	2.216	241.6	352.77
0.7	0.223	0.352605	0.668541	0.758704	4.963339	36.92	71.15	100	3.41	60	2.236	242.2	355.88
0.8	0.255	0.355835	0.674432	0.86557	3.35435	42.21	74.71	78	3.9	60	2.256	244.4	359.02
0.9	0.286	0.362964	0.687247	0.970108	2.40063	47.53	77.39	52	4.38	60	2.299	249.3	365.84
1	0.318	0.371051	0.705547	1.072247	1.79666	52.59	79.52	5	4.87	60	2.36	254.8	375.58
1.1	0.35	0.373265	0.722342	1.173935	1.38199	56.84	81.49	5	5.36	60	2.416	256.4	384.52
1.2	0.382	0.370554	0.732865	1.276958	1.079991	60.67	83.29	5	5.84	60	2.451	254.5	390.13
1.3	0.414	0.364378	0.739419	1.38091	0.857039	64.06	84.91	5	6.33	60	2.473	250.3	393.61
1.4	0.446	0.354316	0.740156	1.486837	0.686878	67.02	86.42	0	6.82	60	2.476	243.3	394.01
1.5	0.477	0.329014	0.708747	1.606915	0.534758	69.63	88.19	0	7.3	60	2.371	226	377.29
1.6	0.509	0.303146	0.672564	1.732101	0.418132	72.12	89.77	0	7.79	60	2.25	208.2	358.03
1.7	0.541	0.275402	0.62997	1.864597	0.326523	74.32	91.21	0	8.28	60	2.107	189.1	335.35
1.8	0.573	0.247568	0.583791	2.004569	0.254906	76.33	92.51	0	8.77	60	1.953	170	310.77
1.9	0.605	0.217696	0.53048	2.156849	0.196947	77.97	93.72	0	9.25	60	1.774	149.5	282.39
2	0.637	0.189016	0.476023	2.320087	0.151523	79.41	94.79	0	9.74	60	1.592	129.8	253.4
2.1	0.668	0.156979	0.411496	2.508108	0.113148	80.11	95.85	0	10.23	60	1.376	107.8	219.05
2.2	0.7	0.125774	0.345313	2.721322	0.082582	80.13	96.8	0	10.71	60	1.155	86.4	183.82
2.3	0.732	0.09266	0.271679	2.984809	0.056861	78.44	97.73	0	11.2	60	0.909	63.6	144.62
2.32	0.738	0.086083	0.256662	3.045199	0.05234	77.81	97.9	0	11.3	60	0.858	59.1	136.63
2.34	0.745	0.079471	0.241439	3.10924	0.047984	77.02	98.08	0	11.4	60	0.808	54.6	128.53
2.36	0.751	0.072816	0.225988	3.177568	0.043781	76.04	98.25	0	11.49	60	0.756	50	120.3
2.38	0.758	0.066119	0.210315	3.250896	0.039726	74.82	98.42	0	11.59	60	0.703	45.4	111.96
2.4	0.764	0.059386	0.194427	3.330119	0.035815	73.31	98.59	0	11.69	60	0.65	40.8	103.5
2.42	0.77	0.052609	0.178313	3.41648	0.032039	71.4	98.76	0	11.79	60	0.596	36.1	94.92
2.44	0.777	0.045794	0.161978	3.511546	0.028394	68.98	98.93	0	11.88	60	0.542	31.5	86.23
2.46	0.783	0.038945	0.145439	3.617422	0.024878	65.87	99.09	0	11.98	60	0.486	26.7	77.42
2.48	0.789	0.032064	0.128697	3.737128	0.021486	61.79	99.26	0	12.08	60	0.43	22	68.51
2.5	0.796	0.025131	0.111702	3.875502	0.018205	56.25	99.42	0	12.18	60	0.374	17.3	59.46
2.52	0.802	0.018155	0.094474	4.039598	0.015033	48.43	99.58	0	12.27	60	0.316	12.5	50.29
2.54	0.809	0.011165	0.077087	4.240696	0.011979	36.79	99.75	0	12.37	60	0.258	7.7	41.04
2.56	0.815	0.004135	0.059477	4.501639	0.009027	17.8	99.91	0	12.47	60	0.199	2.8	31.66
2.58	0.821	-0.00309	0.041239	4.881555	0.006115	0	99.99	0	12.56	60	0.138	-2.1	21.95
2.6	0.828	-0.01027	0.023002	5.528659	0.003333	0	99.99	0	12.66	60	0.077	-7.1	12.24
2.62	0.834	-0.01744	0.004664	7.665504	0.00066	0	99.99	0	12.76	60	0.016	-12	2.48
2.64	0.84	-0.02459	-0.01376	6.221545	-0.0019	0.19	43.13	0	12.86	60	-0.046	-16.9	-7.32

Table 10. Multi Analysis at rpm of 60

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.0229	28.79	88609	0.024	0.00463	0.20937	0.65522	0.07557	2.3	4.5	0.16641	0.04392	0.146	0.04346
0.15	3	0.659	0.02289	28.79	191314	0.024	0.01114	0.20435	0.64779	0.12287	3.3	6.5	0.16566	0.03978	0.14591	0.03981
0.2	3	0.659	0.02288	28.79	322696	0.025	0.01996	0.1975	0.63732	0.16802	4.2	8.3	0.16404	0.03568	0.1456	0.03617
0.25	3	0.658	0.02286	28.78	473399	0.026	0.03058	0.18922	0.62397	0.21036	5	9.7	0.16127	0.03164	0.14487	0.03255
0.3	3	0.657	0.02283	28.77	633968	0.027	0.04259	0.18011	0.60823	0.24946	5.7	10.8	0.15716	0.02771	0.14348	0.02897
0.35	3	0.655	0.02278	28.76	795552	0.028	0.05541	0.17029	0.59044	0.28496	6.2	11.6	0.15158	0.02393	0.1412	0.02544
0.4	3	0.658	0.02286	28.78	950106	0.029	0.06773	0.15943	0.57553	0.31981	6.5	12.1	0.14449	0.02031	0.13778	0.02199
0.45	3	0.658	0.02287	28.78	1091774	0.031	0.0806	0.14928	0.55774	0.35015	6.8	12.5	0.13587	0.01692	0.13299	0.01867
0.5	2.9	0.648	0.02258	28.7	1216355	0.032	0.09558	0.14059	0.53206	0.37088	7	12.7	0.12582	0.01377	0.12668	0.0155
0.55	3	0.658	0.02287	28.78	1316543	0.034	0.10518	0.12983	0.52165	0.40218	7	12.7	0.11461	0.01091	0.11886	0.01253
0.6	2.9	0.644	0.02245	28.66	1394189	0.035	0.12047	0.12203	0.49366	0.41357	7.1	12.7	0.10215	0.00835	0.10926	0.0098
0.65	3	0.659	0.02288	28.78	1439970	0.037	0.12739	0.11238	0.48672	0.44425	7.1	12.6	0.08904	0.00613	0.09827	0.00734
0.7	3	0.659	0.02288	28.79	1456286	0.039	0.13735	0.10448	0.46997	0.46201	7	12.4	0.07505	0.00425	0.08551	0.0052
0.75	2.8	0.639	0.02231	28.62	1440295	0.041	0.15291	0.09827	0.4416	0.46187	7	12.2	0.06075	0.00273	0.07145	0.00342
0.8	3	0.659	0.02288	28.79	1379310	0.043	0.15515	0.09043	0.43843	0.49221	6.8	11.9	0.04681	0.00156	0.05687	0.00199
0.85	3	0.659	0.02289	28.79	1272234	0.044	0.16307	0.08424	0.4237	0.50505	6.7	11.7	0.03298	0.00074	0.04134	0.00096
0.9	3	0.659	0.02289	28.79	1099769	0.046	0.17016	0.07851	0.40962	0.51647	6.6	11.4	0.0201	0.00023	0.02599	0.00031
0.95	3	0.659	0.02289	28.79	819167	0.048	0.17683	0.0733	0.39627	0.52684	6.5	11.1	0.00887	0.00001	0.01183	0.00002
1	3	0.659	0.02289	28.79	42658	0.05	0.18349	0.06809	0.38293	0.5372	6.3	10.8	0.00044	0	0.00062	0

Table 11. Input values at rpm of 80

Diameter D	4.87 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	80 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	1.232	v/(ΩR)	0.392
Efficiency η	78.42%	loading	medium
Thrust T	199.99 N	Ct	0.1638
Power P	2.04 kW	Cp	0.2573
β at 75%R	34.7°	Pitch H	7.94 m
Propeller			
v/(nD)	1.232	v/(ΩR)	0.392
Efficiency η	78.42%	loading	medium
Thrust T	199.99 N	Ct	0.1638
Power P	2.04 kW	Cp	0.2573
β at 75%R	34.7°	Pitch H	7.94 m

Table 12. Propeller Geometry at rpm of 80

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0636	80.8	1.94	243.5	154.9	9449	interpolated
0.15	0.1295	75	1.763	365.25	315.3	8585.9	interpolated
0.2	0.2023	69.6	1.691	487	492.5	8236.7	interpolated
0.25	0.2714	64.6	1.655	608.75	660.8	8060	interpolated
0.3	0.3298	60	1.635	730.5	803.2	7961.9	Clark Y, Re=500'000
0.35	0.3744	55.9	1.623	852.25	911.7	7906.2	Clark Y, Re=500'000
0.4	0.4045	52.2	1.617	974	985	7876	interpolated
0.45	0.4213	48.8	1.614	1095.75	1025.8	7862.3	interpolated
0.5	0.4265	45.8	1.614	1217.5	1038.4	7859.9	interpolated
0.55	0.422	43.1	1.615	1339.25	1027.5	7865.6	interpolated
0.6	0.4095	40.6	1.618	1461	997.2	7877.3	interpolated
0.65	0.3905	38.4	1.621	1582.75	950.9	7893.5	Clark Y, Re=500'000
0.7	0.3659	36.5	1.625	1704.5	891	7913.2	Clark Y, Re=500'000
0.75	0.3363	34.7	1.63	1826.25	818.8	7935.8	interpolated
0.8	0.3015	33	1.635	1948	734.2	7960.6	interpolated
0.85	0.261	31.6	1.64	2069.75	635.6	7987.3	interpolated
0.9	0.2126	30.2	1.646	2191.5	517.6	8015.4	interpolated
0.95	0.1496	29	1.652	2313.25	364.4	8044.9	interpolated
1	0.0075	27.8	1.658	2435	18.2	8075.5	Clark Y, Re=500'000

Table 13. Single Analysis at rpm of 80

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.22546	0.294752	0	999999	0	0	100.00 !	0	80	2.337	275.3	278.94
0.1	0.032	0.224738	0.295571	0.127605	752.6658	7.6	22.5	100.00 !	0.65	80	2.343	274.4	279.72
0.2	0.064	0.226043	0.295737	0.255181	94.13603	15.29	39.44	100.00 !	1.3	80	2.345	276	279.87
0.3	0.095	0.226019	0.294692	0.383043	27.79361	23.01	52.2	100.00 !	1.95	80	2.336	276	278.89
0.4	0.127	0.22461	0.293382	0.511179	11.67331	30.62	61.87	100	2.6	80	2.326	274.2	277.65
0.5	0.159	0.223039	0.291614	0.639747	5.940719	38.24	69.16	89	3.25	80	2.312	272.3	275.97
0.6	0.191	0.223412	0.291047	0.767995	3.431225	46.06	74.52	68	3.9	80	2.307	272.8	275.44
0.7	0.223	0.224721	0.294777	0.893716	2.188464	53.36	78.55	42	4.55	80	2.337	274.4	278.97
0.8	0.255	0.224801	0.299816	1.017933	1.491162	59.98	81.72	5	5.19	80	2.377	274.5	283.73
0.9	0.286	0.220725	0.302488	1.143144	1.056625	65.67	84.43	0	5.84	80	2.398	269.5	286.26
1	0.318	0.213445	0.302507	1.270144	0.770328	70.56	86.73	0	6.49	80	2.398	260.6	286.28
1.1	0.35	0.197403	0.292159	1.406918	0.558961	74.32	89.01	0	7.14	80	2.316	241	276.49
1.2	0.382	0.172053	0.266398	1.563418	0.39258	77.5	91.3	0	7.79	80	2.112	210.1	252.11
1.3	0.414	0.14596	0.236597	1.734369	0.274233	80.2	93.24	0	8.44	80	1.876	178.2	223.91
1.4	0.446	0.119219	0.202778	1.9263	0.188181	82.31	94.92	0	9.09	80	1.608	145.6	191.9
1.5	0.477	0.091548	0.164477	2.152139	0.1241	83.49	96.38	0	9.74	80	1.304	111.8	155.66
1.6	0.509	0.062891	0.121463	2.43911	0.075513	82.85	97.68	0	10.39	80	0.963	76.8	114.95
1.62	0.516	0.057047	0.11229	2.508688	0.067257	82.3	97.93	0	10.52	80	0.89	69.7	106.27
1.64	0.522	0.051166	0.102925	2.584281	0.05942	81.53	98.17	0	10.65	80	0.816	62.5	97.4
1.66	0.528	0.045248	0.093368	2.667278	0.051977	80.45	98.4	0	10.78	80	0.74	55.2	88.36
1.68	0.535	0.039285	0.083605	2.759709	0.0449	78.94	98.63	0	10.91	80	0.663	48	79.12
1.7	0.541	0.033293	0.073658	2.864214	0.038178	76.84	98.85	0	11.04	80	0.584	40.6	69.71
1.72	0.547	0.027258	0.063506	2.985149	0.031781	73.83	99.07	0	11.17	80	0.503	33.3	60.1
1.74	0.554	0.021189	0.053162	3.129164	0.025698	69.35	99.29	0	11.3	80	0.421	25.9	50.31
1.76	0.56	0.015088	0.042628	3.30806	0.019911	62.29	99.5	0	11.43	80	0.338	18.4	40.34
1.78	0.567	0.00895	0.031896	3.54546	0.014402	49.95	99.71	0	11.56	80	0.253	10.9	30.19
1.8	0.573	0.002727	0.020877	3.902479	0.009116	23.52	99.91	0	11.69	80	0.166	3.3	19.76
1.82	0.579	-0.00354	0.00963	4.606203	0.004068	0	99.99	0	11.82	80	0.076	-4.3	9.11
1.84	0.586	-0.00985	-0.00181	6.502531	-0.00074	0.07	48.2	0	11.95	80	-0.014	-12	-1.72

Table 14. Multi Analysis at rpm of 80

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	87391	0.024	0.00675	0.14671	0.649	0.11695	2.1	4.2	0.06794	0.01714	0.08213	0.02368
0.15	3	0.659	0.02289	28.79	184324	0.025	0.01531	0.13952	0.63375	0.18149	3	5.9	0.06753	0.01545	0.08205	0.02163
0.2	3	0.658	0.02288	28.78	301537	0.026	0.0261	0.13042	0.61346	0.24031	3.7	7.2	0.06664	0.01378	0.0818	0.01959
0.25	3	0.658	0.02286	28.78	427027	0.028	0.03819	0.12037	0.58966	0.29263	4.2	8.1	0.06517	0.01215	0.08122	0.01756
0.3	3	0.657	0.02283	28.77	550727	0.029	0.05065	0.10995	0.56364	0.33813	4.6	8.7	0.06306	0.01058	0.08017	0.01555
0.35	3	0.656	0.0228	28.76	665275	0.031	0.06284	0.09972	0.53685	0.37725	4.8	9	0.06029	0.00907	0.07852	0.01359
0.4	3	0.655	0.02277	28.76	765957	0.033	0.07454	0.09018	0.51037	0.4107	4.9	9.1	0.05691	0.00765	0.07614	0.01169
0.45	3	0.654	0.02274	28.75	849998	0.036	0.08516	0.08128	0.48479	0.43919	4.9	9.1	0.05296	0.00632	0.07296	0.00986
0.5	3	0.653	0.02272	28.74	916141	0.038	0.09492	0.07328	0.46057	0.46354	4.9	8.9	0.04852	0.00511	0.06894	0.00814
0.55	2.9	0.653	0.02271	28.74	963871	0.04	0.1039	0.06618	0.43792	0.48445	4.8	8.7	0.04369	0.00402	0.06408	0.00654
0.6	2.9	0.652	0.0227	28.74	992824	0.043	0.11122	0.05967	0.41675	0.50232	4.7	8.5	0.03854	0.00306	0.05839	0.00508
0.65	3	0.658	0.02286	28.78	1002602	0.045	0.11607	0.05365	0.40018	0.52279	4.6	8.2	0.03319	0.00223	0.05194	0.00378
0.7	3	0.658	0.02286	28.78	993196	0.048	0.12194	0.04868	0.38188	0.53633	4.4	8	0.0277	0.00153	0.04476	0.00266
0.75	2.9	0.652	0.0227	28.74	963275	0.05	0.12963	0.04464	0.36235	0.54306	4.3	7.7	0.02221	0.00098	0.03705	0.00173
0.8	2.9	0.653	0.02271	28.74	909534	0.053	0.13421	0.04072	0.34688	0.55334	4.2	7.5	0.01687	0.00056	0.02905	0.00101
0.85	3	0.653	0.02272	28.74	827424	0.056	0.13829	0.03726	0.33258	0.5624	4.1	7.2	0.0118	0.00026	0.02096	0.00048
0.9	3	0.653	0.02273	28.74	706774	0.059	0.14194	0.03419	0.31933	0.5704	3.9	7	0.00715	0.00008	0.01309	0.00016
0.95	3	0.658	0.02286	28.78	520900	0.061	0.14246	0.03124	0.30862	0.58145	3.8	6.7	0.00314	0	0.00594	0.00001
1	3	0.662	0.02299	28.81	27229	0.064	0.14298	0.02829	0.2979	0.59251	3.6	6.4	0.00016	0	0.00031	0

Table 15. Input values at 100rpm

Diameter D	4.87 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	100 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.986	v/(ΩR)	0.314
Efficiency η	80.46%	loading	medium
Thrust T	199.99 N	Ct	0.1048
Power P	1.99 kW	Cp	0.1284
β at 75%R	28.5°	Pitch H	6.24 m
Propeller			
v/(nD)	0.986	v/(ΩR)	0.314
Efficiency η	80.46%	loading	medium
Thrust T	199.99 N	Ct	0.1048
Power P	1.99 kW	Cp	0.1284
β at 75%R	28.5°	Pitch H	6.24 m

Table 16. Propeller Geometry at 100 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0642	77.4	1.407	243.5	156.3	6849.8	interpolated
0.15	0.1246	70.3	1.315	365.25	303.4	6405.4	interpolated
0.2	0.1841	63.8	1.279	487	448.2	6228.4	interpolated
0.25	0.233	58.1	1.262	608.75	567.4	6145.2	interpolated
0.3	0.2679	53.1	1.254	730.5	652.4	6105.9	Clark Y, Re=500'000
0.35	0.2891	48.7	1.251	852.25	703.9	6090.6	Clark Y, Re=500'000
0.4	0.2986	44.9	1.25	974	727.2	6089.8	interpolated
0.45	0.2993	41.5	1.252	1095.75	728.7	6098.5	interpolated
0.5	0.2932	38.6	1.255	1217.5	713.9	6113.7	interpolated
0.55	0.2823	36.1	1.259	1339.25	687.3	6133.6	interpolated
0.6	0.2678	33.9	1.264	1461	652	6156.9	interpolated
0.65	0.2506	31.9	1.27	1582.75	610.1	6182.9	Clark Y, Re=500'000
0.7	0.2312	30.1	1.275	1704.5	562.9	6211	Clark Y, Re=500'000
0.75	0.2098	28.5	1.281	1826.25	510.8	6240.8	interpolated
0.8	0.1862	27.1	1.288	1948	453.4	6271.8	interpolated
0.85	0.1599	25.9	1.294	2069.75	389.3	6303.9	interpolated
0.9	0.1293	24.7	1.301	2191.5	314.9	6337	interpolated
0.95	0.0906	23.7	1.308	2313.25	220.6	6370.8	interpolated
1	0.0045	22.7	1.315	2435	11	6405.2	Clark Y, Re=500'000

Table 17. Single Analysis at 100 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.151721	0.151378	0	999999	0	0	78.00 !	0	100	2.344	289.5	223.84
0.1	0.032	0.155025	0.154684	0.145248	393.9005	10.02	26.62	100.00 !	0.81	100	2.395	295.8	228.73
0.2	0.064	0.15382	0.153803	0.290829	48.95693	20	45.75	100.00 !	1.62	100	2.382	293.5	227.43
0.3	0.095	0.151758	0.151671	0.437462	14.30474	30.02	59.4	89	2.44	100	2.349	289.5	224.28
0.4	0.127	0.150569	0.150002	0.584575	5.968404	40.15	68.98	73	3.25	100	2.323	287.3	221.81
0.5	0.159	0.149849	0.149955	0.730765	3.054851	49.96	75.74	52	4.06	100	2.322	285.9	221.74
0.6	0.191	0.148554	0.151519	0.875101	1.786293	58.83	80.66	21	4.87	100	2.346	283.4	224.05
0.7	0.223	0.145144	0.152705	1.01936	1.133702	66.53	84.43	0	5.68	100	2.365	276.9	225.8
0.8	0.255	0.138665	0.152217	1.165729	0.757064	72.88	87.47	0	6.49	100	2.357	264.5	225.08
0.9	0.286	0.123368	0.143453	1.327091	0.501097	77.4	90.36	0	7.3	100	2.221	235.4	212.12
1	0.318	0.101671	0.125657	1.514127	0.319984	80.91	93.01	0	8.12	100	1.946	194	185.81
1.1	0.35	0.079197	0.104368	1.728537	0.199679	83.47	95.17	0	8.93	100	1.616	151.1	154.33
1.2	0.382	0.055847	0.079302	1.992163	0.116863	84.51	96.94	0	9.74	100	1.228	106.5	117.26
1.3	0.414	0.031671	0.050323	2.363687	0.058328	81.81	98.43	0	10.55	100	0.779	60.4	74.41
1.32	0.42	0.026739	0.044046	2.464859	0.048767	80.13	98.7	0	10.71	100	0.682	51	65.13
1.34	0.427	0.021776	0.037606	2.582575	0.0398	77.59	98.96	0	10.88	100	0.582	41.5	55.61
1.36	0.433	0.016782	0.031004	2.724296	0.031387	73.62	99.21	0	11.04	100	0.48	32	45.85
1.38	0.439	0.011761	0.024242	2.903802	0.023489	66.95	99.46	0	11.2	100	0.375	22.4	35.85
1.4	0.446	0.006701	0.017301	3.151472	0.016056	54.22	99.7	0	11.36	100	0.268	12.8	25.58
1.42	0.452	0.001588	0.010162	3.55543	0.009038	22.19	99.93	0	11.53	100	0.157	3	15.03
1.44	0.458	-0.0036	0.002791	4.668699	0.002381	0	99.99	0	11.69	100	0.043	-6.9	4.13
1.46	0.465	-0.00879	-0.00471	4.263429	-0.00385	0.39	50.87	0	11.85	100	-0.073	-16.8	-6.96

Table 18. Multi Analysis at 100 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	89652	0.025	0.00903	0.11682	0.6408	0.15512	2.1	4.2	0.03483	0.00851	0.05259	0.01486
0.15	3	0.659	0.02288	28.79	183644	0.026	0.01952	0.10772	0.6165	0.23329	2.9	5.7	0.03456	0.00765	0.05252	0.01355
0.2	3	0.658	0.02287	28.78	290026	0.028	0.03179	0.097	0.58599	0.30084	3.4	6.6	0.03399	0.0068	0.0523	0.01224
0.25	3	0.658	0.02286	28.78	395719	0.03	0.04447	0.08604	0.55259	0.35755	3.8	7.2	0.03307	0.00597	0.05184	0.01094
0.3	3	0.657	0.02284	28.77	492169	0.032	0.05647	0.07557	0.5186	0.40418	3.9	7.4	0.0318	0.00518	0.05102	0.00967
0.35	3	0.657	0.02282	28.77	574981	0.035	0.06745	0.06615	0.4858	0.44229	4	7.4	0.0302	0.00442	0.04977	0.00842
0.4	3	0.656	0.02281	28.77	642561	0.038	0.07704	0.05783	0.45502	0.47335	3.9	7.3	0.02831	0.00371	0.04804	0.00722
0.45	3	0.656	0.02281	28.77	694934	0.041	0.08544	0.05069	0.4267	0.4988	3.8	7.1	0.02616	0.00306	0.04581	0.00608
0.5	3	0.656	0.0228	28.76	732755	0.044	0.09239	0.0445	0.40085	0.51969	3.7	6.8	0.02381	0.00246	0.04306	0.005
0.55	3	0.656	0.0228	28.76	756880	0.047	0.09834	0.03924	0.37741	0.537	3.6	6.6	0.0213	0.00193	0.03981	0.004
0.6	3	0.656	0.02281	28.77	767950	0.051	0.10343	0.03478	0.35621	0.55145	3.4	6.3	0.01869	0.00147	0.03609	0.0031
0.65	3	0.656	0.02281	28.77	766239	0.054	0.1078	0.03097	0.33703	0.5636	3.3	6	0.01601	0.00106	0.03194	0.0023
0.7	3	0.656	0.02282	28.77	751513	0.057	0.11156	0.02772	0.31965	0.57388	3.2	5.8	0.01331	0.00073	0.02743	0.00162
0.75	3	0.657	0.02283	28.77	722852	0.061	0.11481	0.02493	0.30388	0.58264	3.1	5.5	0.01065	0.00047	0.02265	0.00105
0.8	3	0.657	0.02283	28.77	678306	0.064	0.11764	0.02252	0.28955	0.59017	2.9	5.3	0.00806	0.00026	0.01769	0.00061
0.85	3	0.657	0.02284	28.77	614125	0.068	0.11977	0.02041	0.27644	0.59655	2.8	5.1	0.00562	0.00012	0.01271	0.00029
0.9	3	0.657	0.02284	28.78	522714	0.071	0.12192	0.01859	0.26448	0.60218	2.7	4.9	0.00339	0.00004	0.00791	0.00009
0.95	3	0.658	0.02285	28.78	384363	0.075	0.12382	0.017	0.25353	0.6071	2.6	4.7	0.00149	0	0.00357	0
1	3	0.658	0.02285	28.78	20139	0.078	0.12572	0.01541	0.24257	0.61202	2.5	4.5	0.00007	0	0.00019	0

Table 19. Input vlaues at 120 rpm

Diameter D	4.87 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	120 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.821	v/(ΩR)	0.261
Efficiency η	81.20%	loading	medium
Thrust T	200 N	Ct	0.0728
Power P	1.97 kW	Cp	0.0736
β at 75%R	24.4°	Pitch H	5.2 m
Propeller			
v/(nD)	0.821	v/(ΩR)	0.261
Efficiency η	81.20%	loading	medium
Thrust T	200 N	Ct	0.0728
Power P	1.97 kW	Cp	0.0736
β at 75%R	24.4°	Pitch H	5.2 m

Table 20. Propeller Geometry at 120 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.065	74.2	1.109	243.5	158.4	5400.5	interpolated
0.15	0.1198	65.9	1.055	365.25	291.6	5136.7	interpolated
0.2	0.1669	58.7	1.034	487	406.5	5037.5	interpolated
0.25	0.2	52.6	1.026	608.75	486.9	4997.7	interpolated
0.3	0.2189	47.4	1.024	730.5	533	4985.9	Clark Y, Re=500'000
0.35	0.2266	43	1.025	852.25	551.7	4989.7	Clark Y, Re=500'000
0.4	0.2263	39.3	1.027	974	550.9	5002.8	interpolated
0.45	0.2206	36.1	1.031	1095.75	537.1	5022.2	interpolated
0.5	0.2114	33.4	1.036	1217.5	514.8	5045.9	interpolated
0.55	0.2001	31.1	1.042	1339.25	487.1	5072.6	interpolated
0.6	0.1872	29.1	1.048	1461	455.9	5101.6	interpolated
0.65	0.1734	27.3	1.054	1582.75	422.3	5132.4	Clark Y, Re=500'000
0.7	0.1588	25.7	1.06	1704.5	386.6	5164.5	Clark Y, Re=500'000
0.75	0.1432	24.4	1.067	1826.25	348.8	5197.7	interpolated
0.8	0.1266	23.1	1.074	1948	308.3	5231.8	interpolated
0.85	0.1084	22	1.081	2069.75	264	5266.6	interpolated
0.9	0.0876	21.1	1.089	2191.5	213.2	5302	interpolated
0.95	0.0613	20.2	1.096	2313.25	149.2	5337.9	interpolated
1	0.0031	19.4	1.104	2435	7.5	5374.2	Clark Y, Re=500'000

Table 21. Single Analysis at 120 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.108082	0.086916	0	999999	0	0	63.00 !	0	120	2.326	296.9	185.07
0.05	0.016	0.111031	0.089599	0.081005	1825.296	6.2	16.88	100.00 !	0.49	120	2.397	305	190.78
0.1	0.032	0.11041	0.089438	0.162067	227.7528	12.34	30.82	100.00 !	0.97	120	2.393	303.3	190.44
0.15	0.048	0.10963	0.088881	0.243405	67.06196	18.5	42.3	94.00 !	1.46	120	2.378	301.2	189.26
0.2	0.064	0.109029	0.087858	0.325292	27.96618	24.82	51.65	84.00 !	1.95	120	2.351	299.5	187.08
0.25	0.08	0.108413	0.08695	0.407461	14.17067	31.17	59.26	73	2.43	120	2.327	297.8	185.14
0.3	0.095	0.107848	0.086705	0.48923	8.177475	37.32	65.46	68	2.92	120	2.32	296.3	184.62
0.35	0.111	0.107291	0.086417	0.571147	5.132569	43.45	70.51	52	3.41	120	2.312	294.8	184.01
0.4	0.127	0.106568	0.086497	0.652619	3.441621	49.28	74.66	42	3.9	120	2.314	292.8	184.18
0.45	0.143	0.105616	0.086829	0.733634	2.426429	54.74	78.1	36	4.38	120	2.323	290.1	184.89
0.5	0.159	0.10451	0.087101	0.814639	1.774412	59.99	80.97	15	4.87	120	2.331	287.1	185.47
0.55	0.175	0.102928	0.087412	0.895466	1.337892	64.76	83.4	0	5.36	120	2.339	282.8	186.13
0.6	0.191	0.100618	0.087445	0.976798	1.030908	69.04	85.52	0	5.84	120	2.34	276.4	186.2
0.65	0.207	0.09775	0.087249	1.058671	0.809025	72.82	87.36	0	6.33	120	2.335	268.5	185.78
0.7	0.223	0.093612	0.086304	1.142594	0.640732	75.93	89.03	0	6.82	120	2.309	257.2	183.77
0.75	0.239	0.085654	0.082009	1.236771	0.495013	78.33	90.81	0	7.3	120	2.194	235.3	174.62
0.8	0.255	0.076683	0.076296	1.338411	0.379465	80.41	92.43	0	7.79	120	2.042	210.7	162.46
0.85	0.271	0.067533	0.069873	1.447297	0.289727	82.15	93.84	0	8.28	120	1.87	185.5	148.78
0.9	0.286	0.058184	0.062696	1.56601	0.219004	83.52	95.08	0	8.77	120	1.678	159.8	133.5
0.95	0.302	0.048644	0.054746	1.698449	0.162602	84.41	96.18	0	9.25	120	1.465	133.6	116.57
1	0.318	0.038919	0.046003	1.851153	0.117146	84.6	97.15	0	9.74	120	1.231	106.9	97.96
1.05	0.334	0.029017	0.036449	2.03635	0.080178	83.59	98.01	0	10.23	120	0.975	79.7	77.61
1.06	0.337	0.027014	0.034438	2.07921	0.073631	83.15	98.17	0	10.32	120	0.921	74.2	73.33
1.07	0.341	0.025008	0.032397	2.124626	0.067343	82.6	98.33	0	10.42	120	0.867	68.7	68.98
1.08	0.344	0.022991	0.030319	2.173107	0.061289	81.9	98.48	0	10.52	120	0.811	63.2	64.56
1.09	0.347	0.020972	0.028211	2.225066	0.055473	81.03	98.63	0	10.62	120	0.755	57.6	60.07
1.1	0.35	0.018941	0.026065	2.281286	0.049869	79.94	98.78	0	10.71	120	0.697	52	55.5
1.11	0.353	0.016908	0.02389	2.342502	0.044482	78.56	98.93	0	10.81	120	0.639	46.4	50.87
1.12	0.357	0.014865	0.021677	2.410005	0.03929	76.8	99.07	0	10.91	120	0.58	40.8	46.16
1.13	0.36	0.012818	0.019433	2.485253	0.034296	74.53	99.2	0	11.01	120	0.52	35.2	41.38
1.14	0.363	0.01075	0.017139	2.57104	0.029458	71.51	99.34	0	11.1	120	0.459	29.5	36.49
1.15	0.366	0.008678	0.014812	2.670378	0.024801	67.38	99.47	0	11.2	120	0.396	23.8	31.54
1.16	0.369	0.006598	0.012448	2.788918	0.020308	61.48	99.6	0	11.3	120	0.333	18.1	26.51
1.17	0.372	0.00451	0.010049	2.93606	0.015977	52.51	99.73	0	11.4	120	0.269	12.4	21.4
1.18	0.376	0.002433	0.007633	3.128516	0.011831	37.61	99.86	0	11.49	120	0.204	6.7	16.25
1.19	0.379	0.000347	0.00518	3.409374	0.007828	7.96	99.98	0	11.59	120	0.139	1	11.03
1.2	0.382	-0.00178	0.002658	3.928908	0.003917	0	99.99	0	11.69	120	0.071	-4.9	5.66
1.21	0.385	-0.00391	0.000095	7.719844	0.000136	0	99.99	0	11.79	120	0.003	-10.7	0.2
1.22	0.388	-0.00601	-0.00246	4.057248	-0.00345	0.34	52.6	0	11.88	120	-0.066	-16.5	-5.23

Table 22. Multi Analysis at 120 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	92699	0.025	0.01147	0.09901	0.63102	0.19092	2.1	4.2	0.02036	0.00486	0.03653	0.01018
0.15	3	0.659	0.02288	28.79	183611	0.027	0.02371	0.08815	0.59682	0.27941	2.8	5.5	0.02016	0.00436	0.03647	0.00927
0.2	3	0.658	0.02287	28.78	279375	0.029	0.037	0.07642	0.55686	0.35185	3.2	6.2	0.01976	0.00387	0.03628	0.00836
0.25	3	0.658	0.02286	28.78	367659	0.032	0.04965	0.06527	0.51564	0.40921	3.4	6.5	0.01914	0.00339	0.03589	0.00746
0.3	3	0.657	0.02285	28.78	442716	0.036	0.06073	0.05538	0.47612	0.45394	3.4	6.5	0.01832	0.00293	0.03523	0.00658
0.35	3	0.657	0.02284	28.77	503156	0.039	0.07016	0.04702	0.43985	0.48888	3.4	6.3	0.01731	0.0025	0.03427	0.00573
0.4	3	0.657	0.02284	28.77	549698	0.043	0.07806	0.04011	0.40725	0.51632	3.3	6.1	0.01614	0.00209	0.03297	0.0049
0.45	3	0.657	0.02284	28.77	583750	0.047	0.08445	0.03439	0.37822	0.53797	3.1	5.8	0.01485	0.00172	0.03134	0.00412
0.5	3	0.657	0.02284	28.78	606745	0.051	0.08973	0.02969	0.3525	0.55528	3	5.5	0.01347	0.00138	0.02937	0.00338
0.55	3	0.657	0.02285	28.78	619793	0.055	0.0941	0.02582	0.32973	0.56927	2.8	5.2	0.01201	0.00108	0.02708	0.00271
0.6	3	0.658	0.02285	28.78	623587	0.059	0.09774	0.02262	0.30953	0.5807	2.7	5	0.01051	0.00082	0.02449	0.0021
0.65	3	0.658	0.02285	28.78	618352	0.063	0.10059	0.01994	0.29152	0.59003	2.6	4.7	0.00899	0.0006	0.02163	0.00155
0.7	3	0.658	0.02286	28.78	603836	0.067	0.10316	0.0177	0.27547	0.59787	2.5	4.5	0.00746	0.00041	0.01854	0.00109
0.75	3	0.658	0.02286	28.78	579157	0.071	0.10534	0.01581	0.26109	0.60448	2.3	4.3	0.00596	0.00026	0.01529	0.00071
0.8	3	0.658	0.02287	28.78	542581	0.076	0.10704	0.01419	0.24811	0.60995	2.2	4.1	0.00451	0.00015	0.01193	0.00041
0.85	3	0.658	0.02287	28.78	490944	0.08	0.10864	0.01282	0.23643	0.61473	2.2	3.9	0.00315	0.00007	0.00857	0.0002
0.9	3	0.658	0.02287	28.78	417931	0.084	0.10988	0.01162	0.2258	0.61873	2.1	3.8	0.0019	0.00002	0.00533	0.00006
0.95	3	0.658	0.02287	28.78	307553	0.088	0.11109	0.01059	0.21615	0.62228	2	3.6	0.00083	0	0.0024	0
1	3	0.658	0.02288	28.78	16135	0.093	0.11229	0.00956	0.2065	0.62584	1.9	3.4	0.00004	0	0.00013	0

Table 23. Input values at 140 rpm

Diameter D	4.87 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation	140 [1/min]		
Velocity v	8 [m/s]		
Number of Blades	2 [-]		
Propeller			
v/(nD)	0.704	v/(ΩR)	0.224
Efficiency η	81.31%	loading	medium
Thrust T	200 N	Ct	0.0535
Power P	1.97 kW	Cp	0.0463
β at 75%R	21.4°	Pitch H	4.49 m
Propeller			
v/(nD)	0.704	v/(ΩR)	0.224
Efficiency η	81.31%	loading	medium
Thrust T	200 N	Ct	0.0535
Power P	1.97 kW	Cp	0.0463
β at 75%R	21.4°	Pitch H	4.49 m

Table 24. Propeller Geometry at 140 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0656	71.1	0.918	243.5	159.9	4469.7	interpolated
0.15	0.1142	61.9	0.883	365.25	278	4300.9	interpolated
0.2	0.1503	54.2	0.871	487	366.1	4243.8	interpolated
0.25	0.1712	47.9	0.868	608.75	416.9	4227.7	interpolated
0.3	0.1798	42.7	0.869	730.5	437.8	4231.2	Clark Y, Re=500'00
0.35	0.1801	38.4	0.872	852.25	438.5	4245.5	Clark Y, Re=500'00
0.4	0.1753	34.9	0.876	974	426.8	4266.5	interpolated
0.45	0.1676	31.9	0.881	1095.75	408	4291.9	interpolated
0.5	0.1583	29.5	0.887	1217.5	385.4	4320.3	interpolated
0.55	0.1481	27.3	0.893	1339.25	360.7	4350.9	interpolated
0.6	0.1376	25.5	0.9	1461	334.9	4383.1	interpolated
0.65	0.1267	23.9	0.907	1582.75	308.5	4416.5	Clark Y, Re=500'00
0.7	0.1156	22.6	0.914	1704.5	281.4	4450.9	Clark Y, Re=500'00
0.75	0.104	21.4	0.921	1826.25	253.4	4486.1	interpolated
0.8	0.0919	20.3	0.929	1948	223.8	4521.9	interpolated
0.85	0.0787	19.3	0.936	2069.75	191.6	4558.2	interpolated
0.9	0.0636	18.5	0.944	2191.5	154.9	4594.9	interpolated
0.95	0.0446	17.7	0.951	2313.25	108.6	4632	interpolated
1	0.0022	17	0.959	2435	5.4	4669.4	Clark Y, Re=500'00

Table 25. Single Analysis at 140 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.080273	0.054297	0	999999	0	0	52.00 !	0	140	2.307	300.2	157.37
0.05	0.016	0.072375	0.045123	0.092916	919.2346	8.02	20.54	89.00 !	0.57	140	1.917	270.6	130.78
0.1	0.032	0.08201	0.055259	0.178451	140.7162	14.84	34.85	84.00 !	1.14	140	2.348	306.7	160.15
0.15	0.048	0.081594	0.054645	0.268276	41.23036	22.4	47.13	73.00 !	1.7	140	2.322	305.1	158.37
0.2	0.064	0.081071	0.054428	0.357986	17.32484	29.79	56.83	68.00 !	2.27	140	2.313	303.1	157.74
0.25	0.08	0.080558	0.054114	0.448	8.819188	37.22	64.48	52	2.84	140	2.299	301.2	156.83
0.3	0.095	0.079867	0.054029	0.53777	5.095656	44.35	70.55	42	3.41	140	2.296	298.6	156.59
0.35	0.111	0.078942	0.054204	0.626993	3.219316	50.97	75.41	36	3.98	140	2.303	295.2	157.09
0.4	0.127	0.077833	0.054363	0.716142	2.163045	57.27	79.32	26	4.55	140	2.31	291	157.56
0.45	0.143	0.076442	0.054533	0.805156	1.523933	63.08	82.5	5	5.11	140	2.317	285.8	158.05
0.5	0.159	0.074565	0.054632	0.894294	1.112956	68.24	85.14	0	5.68	140	2.321	278.8	158.34
0.55	0.175	0.072174	0.054579	0.983916	0.835364	72.73	87.37	0	6.25	140	2.319	269.9	158.18
0.6	0.191	0.068397	0.053794	1.076476	0.634194	76.29	89.37	0	6.82	140	2.286	255.8	155.91
0.65	0.207	0.061603	0.050714	1.180015	0.47025	78.96	91.39	0	7.39	140	2.155	230.4	146.98
0.7	0.223	0.054098	0.046664	1.292118	0.346438	81.15	93.16	0	7.95	140	1.983	202.3	135.24
0.75	0.239	0.046413	0.042003	1.413859	0.253531	82.88	94.67	0	8.52	140	1.785	173.6	121.73
0.8	0.255	0.038555	0.036706	1.549325	0.182561	84.03	95.95	0	9.09	140	1.56	144.2	106.38
0.85	0.271	0.030532	0.030755	1.705442	0.127524	84.38	97.06	0	9.66	140	1.307	114.2	89.13
0.9	0.286	0.022352	0.024129	1.89554	0.084287	83.37	98.02	0	10.23	140	1.025	83.6	69.93
0.91	0.29	0.020698	0.022722	1.939778	0.076783	82.89	98.19	0	10.34	140	0.965	77.4	65.85
0.92	0.293	0.019038	0.021287	1.986857	0.069612	82.28	98.37	0	10.45	140	0.904	71.2	61.69
0.93	0.296	0.017372	0.019824	2.037253	0.06276	81.5	98.53	0	10.57	140	0.842	65	57.45
0.94	0.299	0.0157	0.018332	2.091626	0.056205	80.5	98.69	0	10.68	140	0.779	58.7	53.13
0.95	0.302	0.014022	0.016813	2.150775	0.049936	79.23	98.85	0	10.8	140	0.714	52.4	48.73
0.96	0.306	0.01234	0.015266	2.215779	0.043939	77.6	99	0	10.91	140	0.649	46.1	44.24
0.97	0.309	0.010643	0.013683	2.288431	0.038176	75.45	99.15	0	11.02	140	0.581	39.8	39.66
0.98	0.312	0.008935	0.012065	2.370955	0.032642	72.58	99.3	0	11.14	140	0.513	33.4	34.97
0.99	0.315	0.007229	0.010424	2.466185	0.027358	68.65	99.44	0	11.25	140	0.443	27	30.21
1	0.318	0.005521	0.008759	2.579346	0.022304	63.03	99.58	0	11.36	140	0.372	20.6	25.39
1.01	0.321	0.003808	0.007066	2.71949	0.017464	54.44	99.71	0	11.48	140	0.3	14.2	20.48
1.02	0.325	0.002094	0.005348	2.903811	0.012832	39.95	99.85	0	11.59	140	0.227	7.8	15.5
1.03	0.328	0.000332	0.003556	3.181599	0.008287	9.63	99.98	0	11.7	140	0.151	1.2	10.31
1.04	0.331	-0.00139	0.00178	3.689293	0.00403	0	99.99	0	11.82	140	0.076	-5.2	5.16
1.05	0.334	-0.00312	-2.8E-05	8.529503	-6.2E-05	0.01	53.83	0	11.93	140	-0.001	-11.7	-0.08

Table 26. Multi analysis at 140 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	95678	0.026	0.01406	0.08684	0.61987	0.22454	2.2	4.3	0.01298	0.00305	0.02684	0.00741
0.15	3	0.659	0.02288	28.79	182740	0.028	0.0278	0.07452	0.57583	0.32048	2.8	5.4	0.01283	0.00273	0.02678	0.00674
0.2	3	0.658	0.02287	28.78	267895	0.031	0.04156	0.06215	0.52733	0.39454	3	5.8	0.01254	0.00242	0.02662	0.00608
0.25	3	0.658	0.02286	28.78	341015	0.035	0.05376	0.0513	0.48038	0.45022	3.1	5.9	0.0121	0.00211	0.02629	0.00542
0.3	3	0.658	0.02286	28.78	399446	0.039	0.06379	0.0423	0.43755	0.49169	3	5.7	0.01153	0.00182	0.02576	0.00477
0.35	3	0.658	0.02285	28.78	444115	0.043	0.07177	0.03506	0.39974	0.52277	2.9	5.5	0.01085	0.00155	0.025	0.00415
0.4	3	0.658	0.02286	28.78	477028	0.048	0.07813	0.02933	0.36686	0.5464	2.8	5.2	0.01009	0.0013	0.024	0.00355
0.45	3	0.658	0.02286	28.78	500134	0.053	0.0832	0.02478	0.33835	0.56461	2.6	4.9	0.00926	0.00107	0.02276	0.00298
0.5	3	0.658	0.02286	28.78	514955	0.057	0.08727	0.02114	0.31362	0.57887	2.5	4.6	0.00838	0.00086	0.0213	0.00245
0.55	3	0.658	0.02287	28.78	522506	0.062	0.09056	0.01822	0.2921	0.59018	2.3	4.3	0.00747	0.00067	0.01961	0.00196
0.6	3	0.658	0.02287	28.78	523324	0.067	0.09312	0.01583	0.27324	0.59919	2.2	4.1	0.00653	0.00051	0.01771	0.00152
0.65	3	0.658	0.02287	28.78	517506	0.072	0.09534	0.01388	0.25668	0.60661	2.1	3.9	0.00558	0.00037	0.01563	0.00112
0.7	3	0.658	0.02287	28.78	504681	0.077	0.09707	0.01225	0.24202	0.61262	2	3.7	0.00463	0.00026	0.0134	0.00079
0.75	3	0.658	0.02287	28.78	483967	0.082	0.09862	0.0109	0.22901	0.61772	1.9	3.5	0.00371	0.00016	0.01105	0.00051
0.8	3	0.659	0.02288	28.78	453747	0.087	0.09993	0.00976	0.21738	0.62202	1.8	3.3	0.00281	0.00009	0.00863	0.0003
0.85	3	0.658	0.02288	28.78	411169	0.092	0.10094	0.00879	0.20692	0.62555	1.7	3.2	0.00196	0.00004	0.0062	0.00014
0.9	3	0.659	0.02288	28.78	350736	0.097	0.1019	0.00795	0.1975	0.62867	1.7	3	0.00119	0.00001	0.00386	0.00005
0.95	3	0.659	0.02288	28.79	258737	0.102	0.10273	0.00724	0.18897	0.63137	1.6	2.9	0.00052	0	0.00174	0
1	3	0.659	0.02288	28.79	13585	0.107	0.10356	0.00652	0.18043	0.63407	1.5	2.8	0.00003	0	0.00009	0

Table 27. Input values at 160 rpm

Diameter D	4.87 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	160 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.616	v/(ΩR)	0.196
Efficiency η	81.09%	loading	medium
Thrust T	200 N	Ct	0.041
Power P	1.97 kW	Cp	0.0311
β at 75%R	19.1°	Pitch H	3.97 m
Propeller			
v/(nD)	0.616	v/(ΩR)	0.196
Efficiency η	81.09%	loading	medium
Thrust T	200 N	Ct	0.041
Power P	1.97 kW	Cp	0.0311
β at 75%R	19.1°	Pitch H	3.97 m

Table 28. Propeller Geometry at 160 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0658	68.2	0.784	243.5	160.1	3819.2	interpolated
0.15	0.1079	58.2	0.761	365.25	262.7	3706.6	interpolated
0.2	0.1346	50.2	0.755	487	327.6	3675	interpolated
0.25	0.1466	43.8	0.754	608.75	356.9	3673.4	interpolated
0.3	0.1487	38.8	0.757	730.5	362.1	3686.2	Clark Y, Re=500'000
0.35	0.1451	34.7	0.761	852.25	353.4	3707.1	Clark Y, Re=500'000
0.4	0.1386	31.4	0.767	974	337.4	3732.9	interpolated
0.45	0.1306	28.7	0.772	1095.75	318.1	3762	interpolated
0.5	0.1221	26.4	0.779	1217.5	297.4	3793.3	interpolated
0.55	0.1135	24.5	0.786	1339.25	276.4	3826.3	interpolated
0.6	0.1049	22.8	0.793	1461	255.4	3860.4	interpolated
0.65	0.0964	21.4	0.8	1582.75	234.6	3895.5	Clark Y, Re=500'000
0.7	0.0878	20.2	0.807	1704.5	213.8	3931.4	Clark Y, Re=500'000
0.75	0.079	19.1	0.815	1826.25	192.4	3967.8	interpolated
0.8	0.0699	18.1	0.822	1948	170.1	4004.6	interpolated
0.85	0.0599	17.3	0.83	2069.75	146	4041.9	interpolated
0.9	0.0486	16.5	0.838	2191.5	118.3	4079.5	interpolated
0.95	0.0341	15.8	0.845	2313.25	83.1	4117.3	interpolated
1	0.0017	15.2	0.853	2435	4.2	4155.4	Clark Y, Re=500'000

Table 29. Single Analysis at 160 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.061527	0.036125	0	999999	0.01	0	47.00 !	0	160	2.291	300.5	136.75
0.05	0.016	0.063669	0.036333	0.097031	740.1773	8.76	21.76	73.00 !	0.65	160	2.304	311	137.54
0.1	0.032	0.063301	0.036176	0.19423	92.12158	17.5	38.61	68.00 !	1.3	160	2.294	309.2	136.94
0.15	0.048	0.043366	0.021309	0.323877	16.07773	30.53	57.97	57	1.95	160	1.352	211.8	80.66
0.2	0.064	0.06238	0.035904	0.389047	11.42847	34.75	61.43	47	2.6	160	2.277	304.7	135.91
0.25	0.08	0.061626	0.035965	0.486143	5.861394	42.84	69.04	42	3.25	160	2.281	301	136.14
0.3	0.095	0.060731	0.036022	0.583187	3.397389	50.58	74.92	31	3.9	160	2.285	296.6	136.36
0.35	0.111	0.059604	0.036151	0.679898	2.147129	57.71	79.5	21	4.55	160	2.293	291.1	136.85
0.4	0.127	0.058227	0.036288	0.776437	1.443873	64.18	83.12	0	5.19	160	2.302	284.4	137.37
0.45	0.143	0.056433	0.03637	0.873097	1.01637	69.82	86.04	0	5.84	160	2.307	275.6	137.68
0.5	0.159	0.054019	0.036274	0.970623	0.738971	74.46	88.46	0	6.49	160	2.301	263.8	137.31
0.55	0.175	0.049224	0.034789	1.076649	0.532469	77.82	90.77	0	7.14	160	2.207	240.4	131.69
0.6	0.191	0.042986	0.032083	1.193705	0.378232	80.39	92.85	0	7.79	160	2.035	209.9	121.45
0.65	0.207	0.036575	0.028864	1.320812	0.267647	82.36	94.58	0	8.44	160	1.831	178.6	109.26
0.7	0.223	0.030006	0.025115	1.462555	0.186456	83.63	96.01	0	9.09	160	1.593	146.5	95.07
0.75	0.239	0.02329	0.020815	1.626996	0.125641	83.92	97.2	0	9.74	160	1.32	113.7	78.79
0.8	0.255	0.016437	0.015947	1.830436	0.079314	82.46	98.21	0	10.39	160	1.011	80.3	60.37
0.81	0.258	0.01505	0.014904	1.878563	0.071414	81.8	98.39	0	10.52	160	0.945	73.5	56.42
0.82	0.261	0.013658	0.013837	1.930215	0.063906	80.94	98.57	0	10.65	160	0.878	66.7	52.38
0.83	0.264	0.012262	0.012747	1.986079	0.056769	79.84	98.74	0	10.78	160	0.808	59.9	48.25
0.84	0.267	0.010859	0.011631	2.047168	0.049972	78.42	98.9	0	10.91	160	0.738	53	44.03
0.85	0.271	0.009446	0.010488	2.114852	0.043489	76.55	99.06	0	11.04	160	0.665	46.1	39.7
0.86	0.274	0.008029	0.009321	2.190794	0.037319	74.08	99.22	0	11.17	160	0.591	39.2	35.29
0.87	0.277	0.006613	0.008135	2.27745	0.031458	70.72	99.37	0	11.3	160	0.516	32.3	30.79
0.88	0.28	0.005194	0.006926	2.378972	0.02588	65.99	99.51	0	11.43	160	0.439	25.4	26.22
0.89	0.283	0.003752	0.005676	2.503682	0.020503	58.83	99.65	0	11.56	160	0.36	18.3	21.49
0.9	0.286	0.00231	0.004406	2.663403	0.01539	47.18	99.79	0	11.69	160	0.279	11.3	16.68
0.91	0.29	0.000878	0.003124	2.884611	0.010558	25.57	99.92	0	11.82	160	0.198	4.3	11.83
0.92	0.293	-0.00056	0.001816	3.25072	0.005938	0	99.99	0	11.95	160	0.115	-2.7	6.87
0.93	0.296	-0.00203	0.000457	4.330276	0.001447	0	99.99	0	12.08	160	0.029	-9.9	1.73
0.94	0.299	-0.00348	-0.0009	3.820891	-0.00276	0.28	54.62	0	12.21	160	-0.057	-17	-3.41

Table 30. Multi Analysis at 160 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	98240	0.026	0.01671	0.07769	0.60751	0.25595	2.2	4.4	0.00881	0.00204	0.02055	0.00564
0.15	3	0.659	0.02288	28.78	180680	0.03	0.03166	0.06419	0.55404	0.35674	2.7	5.3	0.00869	0.00183	0.0205	0.00513
0.2	3	0.658	0.02287	28.78	255592	0.033	0.04554	0.05165	0.49866	0.43032	2.9	5.5	0.00846	0.00162	0.02035	0.00462
0.25	3	0.658	0.02286	28.78	315840	0.038	0.05692	0.04132	0.44764	0.48283	2.9	5.4	0.00814	0.00141	0.02007	0.00412
0.3	3	0.658	0.02286	28.78	361512	0.043	0.06585	0.03328	0.40318	0.52051	2.7	5.1	0.00773	0.00122	0.01964	0.00363
0.35	3	0.658	0.02286	28.78	395026	0.048	0.07266	0.02709	0.36518	0.54786	2.6	4.8	0.00726	0.00104	0.01903	0.00315
0.4	3	0.658	0.02287	28.78	418934	0.053	0.07791	0.02234	0.33296	0.56812	2.4	4.5	0.00674	0.00087	0.01824	0.00269
0.45	3	0.658	0.02287	28.78	435244	0.059	0.08199	0.01867	0.30557	0.58345	2.3	4.2	0.00618	0.00071	0.01728	0.00226
0.5	3	0.658	0.02287	28.78	445335	0.064	0.08519	0.0158	0.28219	0.59525	2.1	3.9	0.00558	0.00057	0.01615	0.00186
0.55	3	0.658	0.02287	28.78	450033	0.07	0.08764	0.01352	0.26205	0.6044	2	3.7	0.00497	0.00045	0.01486	0.00149
0.6	3	0.658	0.02288	28.78	449714	0.076	0.08969	0.0117	0.24464	0.61177	1.9	3.5	0.00435	0.00034	0.01342	0.00115
0.65	3	0.658	0.02288	28.78	444335	0.081	0.09127	0.01021	0.22943	0.61763	1.8	3.3	0.00372	0.00025	0.01185	0.00085
0.7	3	0.659	0.02288	28.78	433466	0.087	0.09265	0.00899	0.2161	0.62251	1.7	3.1	0.00309	0.00017	0.01016	0.0006
0.75	3	0.659	0.02288	28.79	416204	0.093	0.0938	0.00798	0.20432	0.62657	1.6	2.9	0.00248	0.00011	0.00839	0.00039
0.8	3	0.659	0.02288	28.79	391008	0.099	0.09468	0.00713	0.19381	0.62986	1.5	2.8	0.00188	0.00006	0.00656	0.00023
0.85	3	0.659	0.02288	28.79	355251	0.104	0.0955	0.00641	0.18444	0.63273	1.5	2.7	0.00131	0.00003	0.00472	0.00011
0.9	3	0.659	0.02288	28.79	303968	0.11	0.0962	0.0058	0.17601	0.63519	1.4	2.6	0.0008	0.00001	0.00294	0.00003
0.95	3	0.659	0.02288	28.79	224991	0.116	0.09673	0.00527	0.16838	0.6372	1.3	2.4	0.00035	0	0.00133	0
1	3	0.659	0.02288	28.79	11819	0.122	0.09725	0.00474	0.16074	0.63921	1.3	2.3	0.00002	0	0.00007	0

Table 31. Input values at 180 rpm

Diameter D	4.87 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	180 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.548	v/(ΩR)	0.174
Efficiency η	80.68%	loading	medium
Thrust T	200 N	Ct	0.0324
Power P	1.98 kW	Cp	0.022
β at 75%R	17.3°	Pitch H	3.57 m
Propeller			
v/(nD)	0.548	v/(ΩR)	0.174
Efficiency η	80.68%	loading	medium
Thrust T	200 N	Ct	0.0324
Power P	1.98 kW	Cp	0.022
β at 75%R	17.3°	Pitch H	3.57 m

Table 32. Propeller Geometry at 180 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0654	65.4	0.685	243.5	159.1	3338.2	interpolated
0.15	0.1012	54.9	0.67	365.25	246.3	3261.7	interpolated
0.2	0.12	46.7	0.667	487	292.2	3246.6	interpolated
0.25	0.1258	40.4	0.668	608.75	306.2	3254.5	interpolated
0.3	0.124	35.5	0.672	730.5	302	3273.5	Clark Y, Re=500'000
0.35	0.1186	31.6	0.677	852.25	288.7	3298.7	Clark Y, Re=500'000
0.4	0.1116	28.5	0.683	974	271.7	3327.7	interpolated
0.45	0.1041	26	0.69	1095.75	253.5	3359.3	interpolated
0.5	0.0966	23.9	0.697	1217.5	235.3	3392.5	interpolated
0.55	0.0894	22.2	0.704	1339.25	217.7	3427.1	interpolated
0.6	0.0824	20.7	0.711	1461	200.7	3462.6	interpolated
0.65	0.0756	19.4	0.718	1582.75	184.1	3498.8	Clark Y, Re=500'000
0.7	0.0689	18.3	0.726	1704.5	167.7	3535.5	Clark Y, Re=500'000
0.75	0.0621	17.3	0.734	1826.25	151.2	3572.8	interpolated
0.8	0.055	16.4	0.741	1948	133.9	3610.3	interpolated
0.85	0.0473	15.7	0.749	2069.75	115.2	3648.2	interpolated
0.9	0.0385	15	0.757	2191.5	93.6	3686.3	interpolated
0.95	0.0271	14.4	0.765	2313.25	66	3724.7	interpolated
1	0.0014	13.8	0.773	2435	3.3	3763.2	Clark Y, Re=500'000

Table 33. Single Analysis at 180 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.048429	0.025117	0	999999	0.01	0	36.00 !	0	180	2.268	299.4	120.33
0.05	0.016	0.05053	0.025022	0.104545	509.7521	10.1	24.1	57.00 !	0.73	180	2.26	312.3	119.88
0.1	0.032	0.036947	0.015795	0.229242	40.22249	23.39	47.1	57.00 !	1.46	180	1.426	228.4	75.67
0.15	0.048	0.049691	0.024998	0.313697	18.86134	29.82	55.61	47.00 !	2.19	180	2.258	307.2	119.76
0.2	0.064	0.049079	0.024973	0.418346	7.949189	39.31	65.57	36	2.92	180	2.255	303.4	119.65
0.25	0.08	0.04821	0.025085	0.522464	4.088254	48.05	73.03	31	3.65	180	2.265	298	120.18
0.3	0.095	0.047205	0.025191	0.626429	2.375872	56.22	78.62	21	4.38	180	2.275	291.8	120.69
0.35	0.111	0.045958	0.02532	0.730086	1.503859	63.53	82.9	10	5.11	180	2.287	284.1	121.31
0.4	0.127	0.044396	0.025432	0.833648	1.011918	69.83	86.22	0	5.84	180	2.297	274.4	121.85
0.45	0.143	0.041966	0.025265	0.939097	0.706014	74.75	88.96	0	6.57	180	2.282	259.4	121.04
0.5	0.159	0.037428	0.02393	1.054832	0.487489	78.2	91.5	0	7.3	180	2.161	231.4	114.65
0.55	0.175	0.032093	0.021849	1.181614	0.334416	80.79	93.64	0	8.04	180	1.973	198.4	104.68
0.6	0.191	0.026609	0.01933	1.321001	0.227891	82.59	95.36	0	8.77	180	1.746	164.5	92.61
0.65	0.207	0.020986	0.016353	1.479772	0.151633	83.42	96.76	0	9.5	180	1.477	129.7	78.35
0.7	0.223	0.015239	0.0129	1.671013	0.095772	82.69	97.9	0	10.23	180	1.165	94.2	61.8
0.71	0.226	0.014075	0.012151	1.715296	0.086449	82.25	98.1	0	10.37	180	1.097	87	58.21
0.72	0.229	0.012906	0.011381	1.762362	0.077648	81.65	98.3	0	10.52	180	1.028	79.8	54.53
0.73	0.232	0.011733	0.010592	1.812694	0.069337	80.86	98.49	0	10.67	180	0.957	72.5	50.75
0.74	0.236	0.010559	0.009786	1.866848	0.061498	79.85	98.67	0	10.81	180	0.884	65.3	46.89
0.75	0.239	0.00937	0.008951	1.926123	0.054031	78.51	98.84	0	10.96	180	0.808	57.9	42.89
0.76	0.242	0.00818	0.008099	1.991256	0.046982	76.76	99.01	0	11.1	180	0.731	50.6	38.8
0.77	0.245	0.006989	0.007229	2.063857	0.04032	74.45	99.17	0	11.25	180	0.653	43.2	34.63
0.78	0.248	0.005796	0.006339	2.146296	0.034016	71.32	99.33	0	11.4	180	0.572	35.8	30.37
0.79	0.251	0.004587	0.00542	2.243012	0.027992	66.86	99.48	0	11.54	180	0.489	28.4	25.97
0.8	0.255	0.003375	0.004481	2.359495	0.022286	60.26	99.62	0	11.69	180	0.405	20.9	21.47
0.81	0.258	0.002171	0.00353	2.505747	0.016913	49.81	99.76	0	11.83	180	0.319	13.4	16.91
0.82	0.261	0.000959	0.002555	2.705946	0.011802	30.78	99.9	0	11.98	180	0.231	5.9	12.24
0.83	0.264	-0.00028	0.001545	3.02902	0.00688	0	99.99	0	12.13	180	0.14	-1.7	7.4
0.84	0.267	-0.00149	0.000529	3.798074	0.002273	0	99.99	0	12.27	180	0.048	-9.2	2.54
0.85	0.271	-0.00273	-0.00052	3.857795	-0.00215	0.22	55.25	0	12.42	180	-0.047	-16.9	-2.49

Table 34. Multi Analysis at 180 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	100277	0.027	0.0194	0.07038	0.59428	0.28522	2.3	4.4	0.00626	0.00144	0.01623	0.00444
0.15	3	0.658	0.02288	28.78	177549	0.031	0.03522	0.05597	0.53205	0.38858	2.7	5.1	0.00617	0.00129	0.01619	0.00403
0.2	3	0.658	0.02287	28.78	242941	0.036	0.0489	0.04358	0.47129	0.46015	2.7	5.2	0.00599	0.00114	0.01606	0.00363
0.25	3	0.658	0.02287	28.78	292528	0.041	0.05945	0.03397	0.41787	0.50901	2.6	5	0.00575	0.00099	0.01582	0.00324
0.3	3	0.658	0.02287	28.78	328485	0.047	0.06728	0.02681	0.37288	0.54281	2.5	4.7	0.00545	0.00086	0.01546	0.00285
0.35	3	0.658	0.02287	28.78	354038	0.053	0.07311	0.02152	0.3355	0.56676	2.3	4.3	0.00511	0.00073	0.01496	0.00248
0.4	3	0.658	0.02287	28.78	371851	0.059	0.07747	0.01756	0.30441	0.58416	2.1	4	0.00473	0.00061	0.01433	0.00212
0.45	3	0.658	0.02288	28.78	383780	0.065	0.0808	0.01456	0.2784	0.59713	2	3.7	0.00433	0.0005	0.01357	0.00178
0.5	3	0.658	0.02288	28.78	390999	0.071	0.08328	0.01225	0.25641	0.60689	1.9	3.4	0.00392	0.0004	0.01268	0.00146
0.55	3	0.659	0.02288	28.78	394159	0.078	0.0853	0.01044	0.23771	0.61456	1.7	3.2	0.00349	0.00032	0.01166	0.00117
0.6	3	0.659	0.02288	28.79	393493	0.084	0.08691	0.009	0.22164	0.62064	1.6	3	0.00306	0.00024	0.01054	0.00091
0.65	3	0.659	0.02288	28.79	388875	0.091	0.08814	0.00783	0.20767	0.62541	1.5	2.8	0.00262	0.00018	0.00931	0.00067
0.7	3	0.659	0.02288	28.79	379828	0.097	0.08921	0.00689	0.19549	0.6294	1.5	2.7	0.00218	0.00012	0.00799	0.00047
0.75	3	0.659	0.02288	28.79	365455	0.104	0.09009	0.0061	0.18477	0.63269	1.4	2.5	0.00175	0.00008	0.0066	0.00031
0.8	3	0.659	0.02288	28.79	344276	0.11	0.09076	0.00544	0.17524	0.63534	1.3	2.4	0.00133	0.00004	0.00517	0.00018
0.85	3	0.659	0.02288	28.79	313820	0.117	0.09139	0.00489	0.16676	0.63767	1.3	2.3	0.00093	0.00002	0.00373	0.00009
0.9	3	0.659	0.02288	28.79	269504	0.124	0.09192	0.00442	0.15916	0.63966	1.2	2.2	0.00057	0.00001	0.00233	0.00003
0.95	3	0.659	0.02289	28.79	200262	0.13	0.09238	0.00402	0.1523	0.64137	1.1	2.1	0.00025	0	0.00105	0
1	3	0.659	0.02289	28.79	10524	0.137	0.09284	0.00361	0.14544	0.64308	1.1	2	0.00001	0	0.00006	0

Table 35: Input values at 200rpm

Diameter D	4.87 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation	200 [1/min]		
Velocity v	8 [m/s]		
Number of Blades	2 [-]		
Propeller			
v/(nD)	0.493	v/(ΩR)	0.157
Efficiency η	80.15%	loading	medium
Thrust T	199.98 N	Ct	0.0262
Power P	2 kW	Cp	0.0161
β at 75%R	15.9°	Pitch H	3.26 m
Propeller			
v/(nD)	0.493	v/(ΩR)	0.157
Efficiency η	80.15%	loading	medium
Thrust T	199.98 N	Ct	0.0262
Power P	2 kW	Cp	0.0161
β at 75%R	15.9°	Pitch H	3.26 m

Table 36. Propeller Geometry at 200 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0645	62.7	0.609	243.5	157	2967.6	interpolated
0.15	0.0943	51.8	0.599	365.25	229.6	2915.8	interpolated
0.2	0.1069	43.6	0.598	487	260.2	2912.1	interpolated
0.25	0.1083	37.4	0.601	608.75	263.8	2926.5	interpolated
0.3	0.1044	32.7	0.606	730.5	254.1	2949.8	Clark Y, Re=500'000
0.35	0.0982	29.1	0.612	852.25	239.1	2978	Clark Y, Re=500'000
0.4	0.0914	26.2	0.618	974	222.4	3009.3	interpolated
0.45	0.0846	23.8	0.625	1095.75	205.9	3042.5	interpolated
0.5	0.0781	21.9	0.632	1217.5	190.2	3077.1	interpolated
0.55	0.072	20.3	0.639	1339.25	175.4	3112.8	interpolated
0.6	0.0663	18.9	0.647	1461	161.4	3149.2	interpolated
0.65	0.0608	17.8	0.654	1582.75	148.1	3186.2	Clark Y, Re=500'000
0.7	0.0555	16.8	0.662	1704.5	135	3223.6	Clark Y, Re=500'000
0.75	0.0501	15.9	0.67	1826.25	121.9	3261.4	interpolated
0.8	0.0445	15.1	0.678	1948	108.3	3299.5	interpolated
0.85	0.0384	14.4	0.685	2069.75	93.4	3337.8	interpolated
0.9	0.0313	13.8	0.693	2191.5	76.2	3376.3	interpolated
0.95	0.0222	13.2	0.701	2313.25	54	3415	interpolated
1	0.0011	12.7	0.709	2435	2.7	3453.8	Clark Y, Re=500'000

Table 37. Single Analysis at 200 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.038928	0.018226	0	999999	0.01	0	36.00 !	0	200	2.258	297.1	107.8
0.05	0.016	0.040969	0.017991	0.111676	366.5132	11.39	26.4	52.00 !	0.81	200	2.229	312.6	106.41
0.1	0.032	0.040591	0.018009	0.223307	45.85904	22.54	45.56	47.00 !	1.62	200	2.231	309.8	106.52
0.15	0.048	0.040078	0.018046	0.334821	13.61621	33.31	59.34	42	2.44	200	2.236	305.8	106.74
0.2	0.064	0.039317	0.018099	0.446168	5.761153	43.45	69.29	31	3.25	200	2.242	300	107.05
0.25	0.08	0.038464	0.018194	0.557126	2.965191	52.85	76.48	21	4.06	200	2.254	293.5	107.61
0.3	0.095	0.037395	0.018323	0.667612	1.728073	61.23	81.75	10	4.87	200	2.27	285.4	108.37
0.35	0.111	0.036081	0.01846	0.777718	1.096392	68.41	85.7	0	5.68	200	2.287	275.3	109.19
0.4	0.127	0.033986	0.018384	0.889555	0.731469	73.95	88.84	0	6.49	200	2.277	259.3	108.74
0.45	0.143	0.030111	0.017427	1.011502	0.487003	77.75	91.63	0	7.3	200	2.159	229.8	103.08
0.5	0.159	0.02554	0.015867	1.145177	0.323234	80.48	93.92	0	8.12	200	1.966	194.9	93.85
0.55	0.175	0.020833	0.013929	1.292948	0.213186	82.26	95.7	0	8.93	200	1.725	159	82.38
0.6	0.191	0.016005	0.011595	1.463179	0.136696	82.82	97.12	0	9.74	200	1.436	122.1	68.58
0.65	0.207	0.011066	0.00885	1.673121	0.08206	81.28	98.25	0	10.55	200	1.096	84.4	52.34
0.66	0.21	0.010066	0.00825	1.722865	0.073075	80.53	98.44	0	10.71	200	1.022	76.8	48.8
0.67	0.213	0.009057	0.00763	1.776511	0.064603	79.53	98.63	0	10.88	200	0.945	69.1	45.13
0.68	0.216	0.008047	0.006994	1.834678	0.056645	78.24	98.81	0	11.04	200	0.866	61.4	41.37
0.69	0.22	0.007034	0.006342	1.898491	0.049158	76.53	98.99	0	11.2	200	0.786	53.7	37.51
0.7	0.223	0.006019	0.005673	1.969425	0.042115	74.27	99.15	0	11.36	200	0.703	45.9	33.55
0.71	0.226	0.005002	0.004987	2.049689	0.035483	71.21	99.31	0	11.53	200	0.618	38.2	29.5
0.72	0.229	0.003963	0.004271	2.144001	0.029139	66.81	99.47	0	11.69	200	0.529	30.2	25.26
0.73	0.232	0.002938	0.00355	2.255689	0.023238	60.43	99.61	0	11.85	200	0.44	22.4	21
0.74	0.236	0.001909	0.00281	2.396008	0.017659	50.28	99.75	0	12.01	200	0.348	14.6	16.62
0.75	0.239	0.000861	0.002041	2.588859	0.012317	31.65	99.89	0	12.18	200	0.253	6.6	12.07
0.76	0.242	-0.00018	0.001265	2.886849	0.007336	0	99.99	0	12.34	200	0.157	-1.3	7.48
0.77	0.245	-0.00122	0.000469	3.566602	0.002616	0	99.99	0	12.5	200	0.058	-9.3	2.77
0.78	0.248	-0.00227	-0.00035	3.834632	-0.00187	0.19	55.74	0	12.66	200	-0.043	-17.3	-2.06

Table 38. Multi Analysis at 200 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02288	28.79	101752	0.028	0.02208	0.06427	0.58044	0.31239	2.3	4.5	0.00462	0.00106	0.01315	0.00358
0.15	3	0.658	0.02288	28.78	173563	0.032	0.0385	0.04928	0.51046	0.41659	2.6	5	0.00454	0.00094	0.01311	0.00326
0.2	3	0.658	0.02287	28.78	230361	0.038	0.05172	0.03721	0.44562	0.4851	2.6	4.9	0.0044	0.00083	0.01299	0.00293
0.25	3	0.658	0.02287	28.78	271239	0.044	0.06142	0.02838	0.39098	0.53013	2.4	4.6	0.00421	0.00073	0.01279	0.00261
0.3	3	0.658	0.02287	28.78	299802	0.051	0.06834	0.02205	0.34632	0.56037	2.3	4.2	0.00399	0.00063	0.01248	0.0023
0.35	3	0.658	0.02288	28.78	319599	0.057	0.07334	0.0175	0.31	0.58137	2.1	3.9	0.00373	0.00053	0.01207	0.002
0.4	3	0.658	0.02288	28.78	333176	0.064	0.07693	0.01416	0.28023	0.59628	1.9	3.6	0.00346	0.00045	0.01155	0.00171
0.45	3	0.659	0.02288	28.78	342173	0.071	0.07968	0.01167	0.25565	0.60733	1.8	3.3	0.00317	0.00037	0.01093	0.00144
0.5	3	0.659	0.02288	28.78	347566	0.078	0.08171	0.00977	0.23506	0.61558	1.6	3.1	0.00286	0.0003	0.01022	0.00118
0.55	3	0.659	0.02288	28.79	349856	0.086	0.08334	0.0083	0.21767	0.62202	1.5	2.9	0.00255	0.00023	0.0094	0.00095
0.6	3	0.659	0.02288	28.79	349179	0.093	0.08464	0.00714	0.20279	0.6271	1.4	2.7	0.00224	0.00018	0.0085	0.00073
0.65	3	0.659	0.02288	28.79	345359	0.1	0.08568	0.00621	0.18996	0.63117	1.4	2.5	0.00192	0.00013	0.00752	0.00055
0.7	3	0.659	0.02288	28.79	337900	0.107	0.08646	0.00545	0.17876	0.63437	1.3	2.4	0.0016	0.00009	0.00646	0.00038
0.75	3	0.659	0.02288	28.79	325920	0.115	0.08716	0.00483	0.16894	0.6371	1.2	2.2	0.00129	0.00006	0.00535	0.00025
0.8	3	0.659	0.02288	28.79	307995	0.122	0.08775	0.0043	0.16026	0.63939	1.2	2.1	0.00098	0.00003	0.00419	0.00015
0.85	3	0.659	0.02289	28.79	281776	0.129	0.08825	0.00387	0.15254	0.64132	1.1	2	0.00069	0.00002	0.00303	0.00007
0.9	3	0.659	0.02289	28.79	242962	0.137	0.08867	0.00349	0.14562	0.64296	1.1	1.9	0.00042	0	0.0019	0.00002
0.95	3	0.659	0.02289	28.79	181307	0.144	0.08903	0.00317	0.13939	0.64438	1	1.9	0.00019	0	0.00086	0
1	3	0.659	0.02289	28.79	9531	0.152	0.0894	0.00285	0.13316	0.64579	1	1.8	0.00001	0	0.00005	0

C) 18 feet

Table 39. Input at 200 rpm

Diameter D	5.49 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	200 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.437	v/(ΩR)	0.139
Efficiency η	80.56%	loading	low
Thrust T	199.99 N	Ct	0.0162
Power P	1.99 kW	Cp	0.0088
β at 75%R	14.2°	Pitch H	3.28 m

Table 40. Propeller Geometry at 200 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0502	59.1	0.525	274.5	137.7	2883.1	interpolated
0.15	0.068	47.8	0.519	411.75	186.8	2851.6	interpolated
0.2	0.0729	39.7	0.521	549	200.2	2860.1	interpolated
0.25	0.0711	33.8	0.525	686.25	195.3	2883.7	interpolated
0.3	0.0668	29.4	0.531	823.5	183.3	2914.7	Clark Y, Re=500'000
0.35	0.0617	26	0.537	960.75	169.5	2949.9	Clark Y, Re=500'000
0.4	0.0568	23.4	0.544	1098	155.8	2987.6	interpolated
0.45	0.0521	21.3	0.551	1235.25	143.1	3027	interpolated
0.5	0.0479	19.6	0.559	1372.5	131.5	3067.5	interpolated
0.55	0.0441	18.1	0.566	1509.75	121	3109	interpolated
0.6	0.0405	16.9	0.574	1647	111.2	3151	interpolated
0.65	0.0372	15.9	0.582	1784.25	102.1	3193.6	Clark Y, Re=500'000
0.7	0.034	15	0.59	1921.5	93.3	3236.5	Clark Y, Re=500'000
0.75	0.0308	14.2	0.597	2058.75	84.5	3279.8	interpolated
0.8	0.0275	13.5	0.605	2196	75.4	3323.3	interpolated
0.85	0.0238	12.9	0.613	2333.25	65.4	3366.9	interpolated
0.9	0.0195	12.4	0.621	2470.5	53.7	3410.8	interpolated
0.95	0.0139	11.9	0.629	2607.75	38.2	3454.8	interpolated
1	0.0007	11.5	0.637	2745	1.9	3498.9	Clark Y, Re=500'000

Table 41. Single Analysis at 200 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.023857	0.009788	0	999999	0.01	0	26.00 !	0	200	2.208	294	105.4
0.05	0.016	0.02556	0.009587	0.126657	195.3139	13.33	32.15	47.00 !	0.92	200	2.162	315	103.24
0.1	0.032	0.025224	0.009611	0.253192	24.47297	26.25	53.52	42.00 !	1.83	200	2.168	310.9	103.49
0.15	0.048	0.024753	0.009633	0.379613	7.268074	38.55	67.59	31	2.75	200	2.173	305.1	103.73
0.2	0.064	0.024134	0.009714	0.505305	3.091957	49.69	76.9	26	3.66	200	2.191	297.4	104.6
0.25	0.08	0.023417	0.009804	0.630467	1.597744	59.72	83.15	15	4.58	200	2.211	288.6	105.57
0.3	0.095	0.02254	0.009919	0.75479	0.93552	68.17	87.47	0	5.49	200	2.237	277.8	106.81
0.35	0.111	0.021159	0.00994	0.880212	0.590391	74.5	90.66	0	6.4	200	2.242	260.8	107.04
0.4	0.127	0.018556	0.009452	1.016139	0.376093	78.53	93.32	0	7.32	200	2.132	228.7	101.79
0.45	0.143	0.015411	0.00855	1.166318	0.238935	81.11	95.38	0	8.24	200	1.928	189.9	92.07
0.5	0.159	0.01218	0.007384	1.334466	0.150433	82.47	96.92	0	9.15	200	1.665	150.1	79.52
0.55	0.175	0.008873	0.005942	1.533099	0.090953	82.12	98.09	0	10.06	200	1.34	109.4	63.99
0.56	0.178	0.008204	0.00562	1.578487	0.081491	81.75	98.28	0	10.25	200	1.268	101.1	60.52
0.57	0.181	0.007532	0.005286	1.626474	0.072687	81.22	98.47	0	10.43	200	1.192	92.8	56.92
0.58	0.185	0.006855	0.004939	1.677636	0.064462	80.5	98.65	0	10.61	200	1.114	84.5	53.19
0.59	0.188	0.006177	0.004581	1.732444	0.0568	79.56	98.82	0	10.8	200	1.033	76.1	49.33
0.6	0.191	0.005497	0.004211	1.791724	0.049646	78.32	98.98	0	10.98	200	0.95	67.7	45.35
0.61	0.194	0.004816	0.00383	1.856469	0.04297	76.69	99.13	0	11.16	200	0.864	59.3	41.24
0.62	0.197	0.004132	0.003437	1.928193	0.036726	74.53	99.27	0	11.35	200	0.775	50.9	37.01
0.63	0.201	0.003439	0.003028	2.009647	0.030833	71.56	99.41	0	11.53	200	0.683	42.4	32.6
0.64	0.204	0.002751	0.002611	2.102915	0.025362	67.44	99.54	0	11.71	200	0.589	33.9	28.12
0.65	0.207	0.00206	0.002181	2.213989	0.020225	61.39	99.66	0	11.9	200	0.492	25.4	23.49
0.66	0.21	0.001364	0.001737	2.352674	0.015389	51.83	99.78	0	12.08	200	0.392	16.8	18.71
0.67	0.213	0.000666	0.001281	2.538402	0.010846	34.81	99.9	0	12.26	200	0.289	8.2	13.8
0.68	0.216	-3.7E-05	0.000811	2.823235	0.006565	0	99.99	0	12.44	200	0.183	-0.5	8.73
0.69	0.22	-0.00073	0.000333	3.421791	0.002584	0	99.99	0	12.63	200	0.075	-9.1	3.59
0.7	0.223	-0.00144	-0.00016	4.036119	-0.00117	0.12	56.27	0	12.81	200	-0.035	-17.7	-1.69

Table 42. Multi Analysis at 200 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	92717	0.029	0.02066	0.04614	0.55964	0.34842	1.9	3.6	0.00254	0.00058	0.00814	0.00221
0.15	3	0.659	0.02288	28.79	150144	0.035	0.0341	0.03362	0.48026	0.45147	2	3.9	0.00249	0.00051	0.00811	0.00201
0.2	3	0.659	0.02288	28.79	191627	0.041	0.04395	0.02443	0.41163	0.51474	1.9	3.7	0.00241	0.00045	0.00803	0.00181
0.25	3	0.659	0.02288	28.79	219597	0.048	0.05069	0.01813	0.35663	0.55424	1.8	3.4	0.0023	0.0004	0.0079	0.00161
0.3	3	0.659	0.02288	28.79	238311	0.056	0.05529	0.01384	0.31326	0.57989	1.6	3.1	0.00217	0.00034	0.0077	0.00142
0.35	3	0.659	0.02288	28.79	250935	0.064	0.05851	0.01085	0.27886	0.59725	1.5	2.8	0.00203	0.00029	0.00744	0.00123
0.4	3	0.659	0.02289	28.79	259463	0.071	0.06081	0.00871	0.25119	0.60944	1.4	2.6	0.00188	0.00024	0.00711	0.00106
0.45	3	0.659	0.02289	28.79	265084	0.08	0.06251	0.00714	0.2286	0.6183	1.2	2.3	0.00172	0.0002	0.00673	0.00089
0.5	3	0.659	0.02289	28.79	268462	0.088	0.06378	0.00595	0.20989	0.62493	1.2	2.2	0.00156	0.00016	0.00629	0.00073
0.55	3	0.659	0.02289	28.79	269907	0.096	0.06477	0.00504	0.19418	0.63001	1.1	2	0.00139	0.00013	0.00579	0.00059
0.6	3	0.659	0.02289	28.79	269468	0.104	0.06554	0.00433	0.18082	0.63399	1	1.9	0.00122	0.0001	0.00524	0.00046
0.65	3	0.659	0.02289	28.79	266956	0.112	0.06616	0.00376	0.16935	0.63717	0.9	1.8	0.00105	0.00007	0.00464	0.00034
0.7	3	0.659	0.02289	28.79	261930	0.121	0.06666	0.0033	0.15939	0.63974	0.9	1.7	0.00088	0.00005	0.004	0.00024
0.75	3	0.659	0.02289	28.79	253635	0.129	0.06707	0.00292	0.15067	0.64186	0.8	1.6	0.00071	0.00003	0.00332	0.00016
0.8	3	0.659	0.02289	28.79	240856	0.137	0.06741	0.0026	0.14298	0.64363	0.8	1.5	0.00054	0.00002	0.00261	0.00009
0.85	3	0.659	0.02289	28.79	221603	0.145	0.0677	0.00233	0.13615	0.64512	0.8	1.4	0.00038	0.00001	0.00189	0.00004
0.9	3	0.659	0.02289	28.79	192273	0.154	0.06795	0.00211	0.13005	0.64639	0.7	1.4	0.00023	0	0.00119	0.00001
0.95	3	0.659	0.02289	28.79	144426	0.162	0.06815	0.00192	0.12456	0.64748	0.7	1.3	0.0001	0	0.00054	0
1	3	0.659	0.02289	28.79	7594	0.171	0.06836	0.00172	0.11907	0.64857	0.7	1.2	0.00001	0	0.00003	0

Table 43. Input values at 180 rpm

Diameter D	5.49 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation	180 [1/min]		
Velocity v	8 [m/s]		
Number of Blades	2 [-]		
Propeller			
v/(nD)	0.486	v/(ΩR)	0.155
Efficiency η	81.33%	loading	low
Thrust T	199.99 N	Ct	0.02
Power P	1.97 kW	Cp	0.012
β at 75%R	15.5°	Pitch H	3.58 m

Table 44. Propeller Geometry at 180 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil	
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]		
0	Spinner	-	-	-	-	-	-	
0.05	Spinner	-	-	-	-	-	-	
0.1	0.0514	61.9	0.589	274.5	141.2	3231.7	interpolated	
0.15	0.0742	50.9	0.579	411.75	203.6	3180.2	interpolated	
0.2	0.0831	42.7	0.579	549	228.1	3179.3	interpolated	
0.25	0.0836	36.6	0.582	686.25	229.5	3197.5	interpolated	
0.3	0.0801	31.9	0.587	823.5	219.9	3225	Clark Y, Re=500'000	
0.35	0.0751	28.4	0.593	960.75	206.1	3257.6	Clark Y, Re=500'000	
0.4	0.0697	25.5	0.6	1098	191.3	3293.5	interpolated	
0.45	0.0644	23.2	0.607	1235.25	176.8	3331.5	interpolated	
0.5	0.0594	21.4	0.614	1372.5	163.1	3370.9	interpolated	
0.55	0.0548	19.8	0.621	1509.75	150.4	3411.4	interpolated	
0.6	0.0504	18.5	0.629	1647	138.4	3452.7	interpolated	
0.65	0.0463	17.3	0.637	1784.25	127	3494.6	Clark Y, Re=500'000	
0.7	0.0422	16.3	0.644	1921.5	115.8	3537	Clark Y, Re=500'000	
0.75	0.0381	15.5	0.652	2058.75	104.7	3579.8	interpolated	
0.8	0.0339	14.7	0.66	2196	93.1	3622.9	interpolated	
0.85	0.0293	14	0.668	2333.25	80.4	3666.2	interpolated	
0.9	0.0239	13.4	0.676	2470.5	65.7	3709.7	interpolated	
0.95	0.017	12.9	0.684	2607.75	46.6	3753.4	interpolated	
1	0.0008	12.4	0.692	2745	2.3	3797.3	Clark Y, Re=500'000	

Table 45: Single Analysis at 180 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.029784	0.0135	0	999999	0.01	0	31.00 !	0	180	2.22	297.3	117.75
0.05	0.016	0.031681	0.013353	0.118538	272.018	11.86	29.43	52.00 !	0.82	180	2.195	316.3	116.47
0.1	0.032	0.031346	0.01335	0.237086	33.99436	23.48	49.83	47.00 !	1.65	180	2.195	312.9	116.44
0.15	0.048	0.0309	0.013368	0.355533	10.08607	34.67	63.83	42	2.47	180	2.198	308.5	116.6
0.2	0.064	0.030276	0.013394	0.473857	4.263453	45.21	73.49	31	3.29	180	2.202	302.2	116.83
0.25	0.08	0.029575	0.01346	0.591736	2.193712	54.93	80.18	21	4.12	180	2.213	295.2	117.41
0.3	0.095	0.028703	0.013564	0.708996	1.279276	63.48	84.93	10	4.94	180	2.23	286.5	118.31
0.35	0.111	0.027633	0.013678	0.825776	0.812393	70.71	88.38	0	5.76	180	2.249	275.9	119.31
0.4	0.127	0.025889	0.013608	0.944716	0.541444	76.1	91.09	0	6.59	180	2.237	258.4	118.7
0.45	0.143	0.022683	0.012829	1.075418	0.358492	79.57	93.46	0	7.41	180	2.109	226.4	111.9
0.5	0.159	0.018962	0.011576	1.219717	0.235822	81.9	95.35	0	8.24	180	1.903	189.3	100.97
0.55	0.175	0.015144	0.010011	1.381228	0.153228	83.2	96.81	0	9.06	180	1.646	151.2	87.32
0.6	0.191	0.011241	0.008121	1.571175	0.095746	83.05	97.95	0	9.88	180	1.335	112.2	70.84
0.61	0.194	0.01045	0.007703	1.614353	0.086419	82.75	98.14	0	10.05	180	1.266	104.3	67.19
0.62	0.197	0.009657	0.007271	1.659862	0.07769	82.34	98.33	0	10.21	180	1.195	96.4	63.42
0.63	0.201	0.008861	0.006826	1.708091	0.069513	81.78	98.51	0	10.38	180	1.122	88.5	59.54
0.64	0.204	0.008063	0.006367	1.759513	0.06185	81.05	98.67	0	10.54	180	1.047	80.5	55.54
0.65	0.207	0.007258	0.005892	1.814934	0.054634	80.07	98.84	0	10.71	180	0.969	72.5	51.39
0.66	0.21	0.006452	0.005404	1.875011	0.047864	78.8	98.99	0	10.87	180	0.888	64.4	47.13
0.67	0.213	0.005644	0.004902	1.940856	0.041507	77.14	99.14	0	11.03	180	0.806	56.3	42.76
0.68	0.216	0.004835	0.004387	2.014048	0.035531	74.94	99.28	0	11.2	180	0.721	48.3	38.27
0.69	0.22	0.004023	0.003858	2.096893	0.029906	71.94	99.42	0	11.36	180	0.634	40.2	33.65
0.7	0.223	0.003199	0.003308	2.193718	0.02456	67.69	99.55	0	11.53	180	0.544	31.9	28.86
0.71	0.226	0.002382	0.00275	2.308775	0.019568	61.49	99.67	0	11.69	180	0.452	23.8	23.99
0.72	0.229	0.001562	0.002178	2.453153	0.014859	51.64	99.79	0	11.86	180	0.358	15.6	19
0.73	0.232	0.000737	0.001589	2.649064	0.010402	33.85	99.9	0	12.02	180	0.261	7.4	13.86
0.74	0.236	-9.5E-05	0.000982	2.956492	0.006173	0	99.99	0	12.19	180	0.162	-0.9	8.57
0.75	0.239	-0.00093	0.000361	3.659937	0.002181	0	99.99	0	12.35	180	0.059	-9.3	3.15
0.76	0.242	-0.00176	-0.00027	3.937963	-0.00155	0.16	55.87	0	12.52	180	-0.044	-17.5	-2.34

Table 46: Multi Analysis at 180 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	91961	0.028	0.0183	0.05079	0.57598	0.32065	1.8	3.6	0.00344	0.00078	0.01005	0.00274
0.15	3	0.659	0.02288	28.79	155045	0.033	0.03152	0.03849	0.50382	0.42489	2.1	4	0.00338	0.0007	0.01002	0.00249
0.2	3	0.659	0.02288	28.79	203921	0.038	0.04194	0.02881	0.43801	0.49244	2	3.9	0.00327	0.00062	0.00993	0.00224
0.25	3	0.659	0.02288	28.79	238562	0.045	0.04943	0.02182	0.38311	0.53619	1.9	3.7	0.00313	0.00054	0.00977	0.00199
0.3	3	0.659	0.02288	28.79	262516	0.051	0.05474	0.01688	0.33863	0.56535	1.8	3.4	0.00296	0.00047	0.00953	0.00176
0.35	3	0.659	0.02288	28.79	279007	0.058	0.05853	0.01335	0.30267	0.58543	1.6	3.1	0.00277	0.0004	0.00921	0.00153
0.4	3	0.659	0.02288	28.79	290271	0.065	0.0613	0.01079	0.27337	0.59972	1.5	2.8	0.00256	0.00033	0.00882	0.00131
0.45	3	0.659	0.02288	28.79	297720	0.072	0.06336	0.00888	0.24922	0.6102	1.4	2.6	0.00235	0.00027	0.00834	0.0011
0.5	3	0.659	0.02288	28.79	302181	0.08	0.06493	0.00743	0.22906	0.61809	1.3	2.4	0.00212	0.00022	0.00779	0.0009
0.55	3	0.659	0.02289	28.79	304069	0.087	0.06614	0.00631	0.21205	0.62417	1.2	2.3	0.00189	0.00017	0.00718	0.00072
0.6	3	0.659	0.02289	28.79	303487	0.094	0.06711	0.00542	0.19752	0.62894	1.1	2.1	0.00166	0.00013	0.00649	0.00056
0.65	3	0.659	0.02289	28.79	300265	0.102	0.06788	0.00471	0.185	0.63277	1.1	2	0.00142	0.0001	0.00574	0.00042
0.7	3	0.659	0.02289	28.79	293955	0.109	0.0685	0.00414	0.1741	0.63587	1	1.9	0.00119	0.00007	0.00493	0.00029
0.75	3	0.659	0.02289	28.79	283772	0.116	0.06902	0.00366	0.16454	0.63843	1	1.8	0.00096	0.00004	0.00408	0.00019
0.8	3	0.659	0.02289	28.79	268445	0.124	0.06945	0.00326	0.1561	0.64057	0.9	1.7	0.00073	0.00002	0.0032	0.00011
0.85	3	0.659	0.02289	28.79	245891	0.131	0.06981	0.00293	0.14858	0.64237	0.9	1.6	0.00051	0.00001	0.00232	0.00005
0.9	3	0.659	0.02289	28.79	212303	0.139	0.07012	0.00265	0.14185	0.6439	0.8	1.5	0.00031	0	0.00145	0.00002
0.95	3	0.659	0.02289	28.79	158651	0.146	0.07039	0.00241	0.1358	0.64522	0.8	1.5	0.00014	0	0.00066	0
1	3	0.659	0.02289	28.79	8340	0.154	0.07065	0.00216	0.12974	0.64654	0.7	1.4	0.00001	0	0.00003	0

Table 47: Input values at 160 rpm

Diameter D	5.49 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation	160 [1/min]		
Velocity v	8 [m/s]		
Number of Blades	2 [-]		
Propeller			
v/(nD)	0.546	v/(ΩR)	0.174
Efficiency η	82.04%	loading	low
Thrust T	199.99 N	Ct	0.0254
Power P	1.95 kW	Cp	0.0169
β at 75%R	17°	Pitch H	3.96 m

Table 48: Propeller Geometry at 160 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0656	71.1	0.918	243.5	159.9	4469.7	interpolated
0.15	0.1142	61.9	0.883	365.25	278	4300.9	interpolated
0.2	0.1503	54.2	0.871	487	366.1	4243.8	interpolated
0.25	0.1712	47.9	0.868	608.75	416.9	4227.7	interpolated
0.3	0.1798	42.7	0.869	730.5	437.8	4231.2	Clark Y, Re=500'000
0.35	0.1801	38.4	0.872	852.25	438.5	4245.5	Clark Y, Re=500'000
0.4	0.1753	34.9	0.876	974	426.8	4266.5	interpolated
0.45	0.1676	31.9	0.881	1095.75	408	4291.9	interpolated
0.5	0.1583	29.5	0.887	1217.5	385.4	4320.3	interpolated
0.55	0.1481	27.3	0.893	1339.25	360.7	4350.9	interpolated
0.6	0.1376	25.5	0.9	1461	334.9	4383.1	interpolated
0.65	0.1267	23.9	0.907	1582.75	308.5	4416.5	Clark Y, Re=500'000
0.7	0.1156	22.6	0.914	1704.5	281.4	4450.9	Clark Y, Re=500'000
0.75	0.104	21.4	0.921	1826.25	253.4	4486.1	interpolated
0.8	0.0919	20.3	0.929	1948	223.8	4521.9	interpolated
0.85	0.0787	19.3	0.936	2069.75	191.6	4558.2	interpolated
0.9	0.0636	18.5	0.944	2191.5	154.9	4594.9	interpolated
0.95	0.0446	17.7	0.951	2313.25	108.6	4632	interpolated
1	0.0022	17	0.959	2435	5.4	4669.4	Clark Y, Re=500'000

Table 49: Single Analysis at 160 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.038059	0.01936	0	999999	0.01	0	36.00 !	0	160	2.236	300.2	133.42
0.05	0.016	0.040113	0.019446	0.109952	396.1505	10.31	26.64	63.00 !	0.73	160	2.246	316.4	134.02
0.1	0.032	0.039783	0.019378	0.220057	49.34688	20.53	45.89	57.00 !	1.46	160	2.238	313.8	133.55
0.15	0.048	0.039383	0.01925	0.330526	14.5242	30.69	59.65	47	2.2	160	2.223	310.6	132.67
0.2	0.064	0.038772	0.019268	0.440619	6.133147	40.25	69.52	42	2.93	160	2.225	305.8	132.79
0.25	0.08	0.038132	0.019271	0.550755	3.140708	49.47	76.6	31	3.66	160	2.225	300.8	132.81
0.3	0.095	0.037305	0.019345	0.660401	1.8245	57.85	81.78	21	4.39	160	2.234	294.2	133.32
0.35	0.111	0.036289	0.019451	0.769626	1.155254	65.3	85.64	10	5.12	160	2.246	286.2	134.05
0.4	0.127	0.035025	0.019546	0.878719	0.777695	71.68	88.57	0	5.86	160	2.257	276.3	134.71
0.45	0.143	0.033136	0.019462	0.989405	0.543869	76.62	90.92	0	6.59	160	2.247	261.4	134.13
0.5	0.159	0.029472	0.018446	1.111198	0.375771	79.89	93.09	0	7.32	160	2.13	232.5	127.12
0.55	0.175	0.025036	0.016756	1.246025	0.256467	82.18	94.91	0	8.05	160	1.935	197.5	115.48
0.6	0.191	0.02049	0.014697	1.395416	0.17327	83.65	96.36	0	8.78	160	1.697	161.6	101.29
0.65	0.207	0.015846	0.012255	1.567667	0.113631	84.05	97.52	0	9.52	160	1.415	125	84.46
0.7	0.223	0.011112	0.009414	1.779695	0.069889	82.63	98.46	0	10.25	160	1.087	87.6	64.88
0.71	0.226	0.010154	0.008796	1.82977	0.062586	81.96	98.62	0	10.39	160	1.016	80.1	60.62
0.72	0.229	0.009195	0.008163	1.883476	0.055694	81.1	98.78	0	10.54	160	0.943	72.5	56.26
0.73	0.232	0.008227	0.00751	1.941735	0.049163	79.97	98.93	0	10.69	160	0.867	64.9	51.76
0.74	0.236	0.007259	0.006843	2.005338	0.043	78.51	99.08	0	10.83	160	0.79	57.3	47.16
0.75	0.239	0.006283	0.006154	2.076016	0.037146	76.57	99.22	0	10.98	160	0.711	49.6	42.41
0.76	0.242	0.005309	0.005452	2.155249	0.031629	74	99.35	0	11.13	160	0.63	41.9	37.58
0.77	0.245	0.004334	0.004735	2.246089	0.026411	70.47	99.48	0	11.27	160	0.547	34.2	32.63
0.78	0.248	0.003355	0.004	2.353323	0.021465	65.41	99.61	0	11.42	160	0.462	26.5	27.57
0.79	0.251	0.002367	0.003243	2.485568	0.016752	57.65	99.73	0	11.57	160	0.375	18.7	22.35
0.8	0.255	0.001374	0.002468	2.658394	0.012275	44.55	99.85	0	11.71	160	0.285	10.8	17.01
0.81	0.258	0.000387	0.001681	2.906355	0.008057	18.62	99.96	0	11.86	160	0.194	3	11.59
0.82	0.261	-0.00061	0.000871	3.355584	0.004025	0	99.99	0	12	160	0.101	-4.8	6.01
0.83	0.264	-0.00161	0.000045	6.155745	0.000198	0	99.99	0	12.15	160	0.005	-12.7	0.31
0.84	0.267	-0.00261	-0.0008	3.50021	-0.00342	0.34	55.32	0	12.3	160	-0.092	-20.6	-5.49

Table 50: Multi Analysis at 160 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	90604	0.027	0.01589	0.05629	0.59196	0.29032	1.8	3.6	0.00483	0.00111	0.01272	0.00347
0.15	3	0.659	0.02288	28.79	159342	0.031	0.02863	0.04447	0.52835	0.39406	2.1	4.1	0.00475	0.00099	0.01268	0.00316
0.2	3	0.659	0.02288	28.79	216793	0.036	0.03948	0.03442	0.46678	0.46523	2.2	4.2	0.00461	0.00087	0.01258	0.00284
0.25	3	0.659	0.02288	28.79	259932	0.041	0.0478	0.02672	0.41307	0.51349	2.1	4	0.00442	0.00076	0.01239	0.00253
0.3	3	0.659	0.02288	28.79	290992	0.047	0.05392	0.02103	0.36805	0.54664	2	3.7	0.00419	0.00066	0.0121	0.00223
0.35	3	0.659	0.02288	28.79	312955	0.053	0.05844	0.01683	0.33079	0.56999	1.8	3.5	0.00392	0.00056	0.01171	0.00194
0.4	3	0.659	0.02288	28.79	328214	0.059	0.06181	0.01372	0.2999	0.58689	1.7	3.2	0.00363	0.00047	0.01121	0.00166
0.45	3	0.659	0.02288	28.79	338408	0.065	0.06437	0.01136	0.27411	0.59943	1.6	3	0.00333	0.00039	0.01061	0.00139
0.5	3	0.659	0.02288	28.79	344562	0.071	0.06629	0.00955	0.25235	0.60884	1.5	2.8	0.00301	0.00031	0.00992	0.00114
0.55	3	0.659	0.02288	28.79	347235	0.078	0.06782	0.00813	0.23388	0.61622	1.4	2.6	0.00268	0.00024	0.00912	0.00092
0.6	3	0.659	0.02288	28.79	346618	0.084	0.06905	0.00701	0.21801	0.62205	1.3	2.4	0.00235	0.00019	0.00824	0.00071
0.65	3	0.659	0.02289	28.79	342589	0.091	0.07004	0.0061	0.20427	0.62674	1.2	2.3	0.00201	0.00013	0.00728	0.00053
0.7	3	0.659	0.02289	28.79	334713	0.097	0.07084	0.00536	0.19227	0.63056	1.2	2.2	0.00168	0.00009	0.00625	0.00037
0.75	3	0.659	0.02289	28.79	322183	0.104	0.07151	0.00475	0.18171	0.63371	1.1	2.1	0.00134	0.00006	0.00517	0.00024
0.8	3	0.659	0.02289	28.79	303676	0.111	0.07207	0.00424	0.17235	0.63635	1	2	0.00102	0.00003	0.00405	0.00014
0.85	3	0.659	0.02289	28.79	276987	0.117	0.07254	0.00381	0.16401	0.63857	1	1.9	0.00072	0.00002	0.00292	0.00007
0.9	3	0.659	0.02289	28.79	238039	0.124	0.07295	0.00344	0.15653	0.64047	1	1.8	0.00044	0.00001	0.00182	0.00002
0.95	3	0.659	0.02289	28.79	177012	0.13	0.07329	0.00312	0.14979	0.6421	0.9	1.7	0.00019	0	0.00083	0
1	3	0.659	0.02289	28.79	9302	0.137	0.07364	0.00281	0.14305	0.64373	0.9	1.6	0.00001	0	0.00004	0

Table 51: Input Values 140 rpm

Diameter D	5.49 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	140 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.625	v/(ΩR)	0.199
Efficiency η	82.62%	loading	low
Thrust T	199.98 N	Ct	0.0331
Power P	1.94 kW	Cp	0.025
β at 75%R	19°	Pitch H	4.45 m

Table 52. Propeller Geometry at 140 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0527	68.1	0.78	274.5	144.8	4280.5	interpolated
0.15	0.0866	58.1	0.757	411.75	237.6	4155.5	interpolated
0.2	0.108	50.1	0.751	549	296.5	4120.7	interpolated
0.25	0.1177	43.7	0.75	686.25	323.1	4119.5	interpolated
0.3	0.1195	38.6	0.753	823.5	327.9	4134.3	Clark Y, Re=500'000
0.35	0.1166	34.6	0.757	960.75	320.1	4158	Clark Y, Re=500'000
0.4	0.1114	31.3	0.763	1098	305.7	4187.3	interpolated
0.45	0.105	28.5	0.769	1235.25	288.3	4220.2	interpolated
0.5	0.0982	26.3	0.775	1372.5	269.6	4255.7	interpolated
0.55	0.0913	24.3	0.782	1509.75	250.6	4292.9	interpolated
0.6	0.0844	22.7	0.789	1647	231.7	4331.5	interpolated
0.65	0.0775	21.3	0.796	1784.25	212.8	4371.1	Clark Y, Re=500'000
0.7	0.0706	20.1	0.804	1921.5	193.9	4411.6	Clark Y, Re=500'000
0.75	0.0636	19	0.811	2058.75	174.6	4452.6	interpolated
0.8	0.0563	18	0.819	2196	154.4	4494.2	interpolated
0.85	0.0483	17.2	0.826	2333.25	132.5	4536.3	interpolated
0.9	0.0391	16.4	0.834	2470.5	107.4	4578.7	interpolated
0.95	0.0275	15.8	0.842	2607.75	75.5	4621.3	interpolated
1	0.0014	15.1	0.85	2745	3.8	4664.3	Clark Y, Re=500'000

Table 53. Single Analysis at 140 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.050003	0.029216	0	999999	0.01	0	47.00 !	0	140	2.26	302	154.16
0.05	0.016	0.052246	0.029717	0.101011	605.383	8.79	23.75	78.00 !	0.64	140	2.299	315.5	156.8
0.1	0.032	0.051896	0.029527	0.202282	75.18931	17.58	41.65	73.00 !	1.28	140	2.284	313.4	155.8
0.15	0.048	0.051529	0.029213	0.304071	22.04174	26.46	54.98	57.00 !	1.92	140	2.26	311.2	154.15
0.2	0.064	0.051016	0.029116	0.405699	9.267923	35.04	64.91	52	2.56	140	2.252	308.1	153.63
0.25	0.08	0.050392	0.029003	0.507516	4.726824	43.44	72.32	42	3.2	140	2.244	304.3	153.04
0.3	0.095	0.04964	0.029062	0.608772	2.740998	51.24	77.91	36	3.84	140	2.248	299.8	153.35
0.35	0.111	0.048757	0.029126	0.709922	1.729904	58.59	82.16	26	4.48	140	2.253	294.4	153.69
0.4	0.127	0.04765	0.029229	0.81077	1.162979	65.21	85.45	10	5.12	140	2.261	287.8	154.23
0.45	0.143	0.046247	0.029306	0.911638	0.81894	71.01	88.06	0	5.76	140	2.267	279.3	154.63
0.5	0.159	0.04445	0.029309	1.012907	0.597079	75.83	90.17	0	6.4	140	2.267	268.4	154.65
0.55	0.175	0.040995	0.028445	1.120884	0.435373	79.27	92.11	0	7.05	140	2.2	247.6	150.09
0.6	0.191	0.035771	0.026281	1.242293	0.30983	81.67	93.93	0	7.69	140	2.033	216	138.67
0.65	0.207	0.030323	0.023617	1.374886	0.218995	83.46	95.43	0	8.33	140	1.827	183.1	124.62
0.7	0.223	0.024757	0.020499	1.523183	0.152187	84.54	96.67	0	8.97	140	1.586	149.5	108.16
0.75	0.239	0.01908	0.016909	1.696041	0.102066	84.63	97.69	0	9.61	140	1.308	115.2	89.22
0.8	0.255	0.013301	0.012835	1.911668	0.063835	82.91	98.54	0	10.25	140	0.993	80.3	67.72
0.81	0.258	0.012133	0.01196	1.963088	0.057308	82.17	98.69	0	10.38	140	0.925	73.3	63.11
0.82	0.261	0.010962	0.011066	2.018456	0.051106	81.23	98.84	0	10.5	140	0.856	66.2	58.39
0.83	0.264	0.00979	0.010154	2.078507	0.045221	80.03	98.99	0	10.63	140	0.785	59.1	53.58
0.84	0.267	0.0086	0.00921	2.145017	0.039568	78.44	99.13	0	10.76	140	0.712	51.9	48.6
0.85	0.271	0.007418	0.008255	2.218603	0.034228	76.38	99.26	0	10.89	140	0.639	44.8	43.56
0.86	0.274	0.00622	0.007268	2.302553	0.0291	73.59	99.39	0	11.02	140	0.562	37.6	38.35
0.87	0.277	0.005029	0.006271	2.399107	0.024251	69.77	99.52	0	11.14	140	0.485	30.4	33.09
0.88	0.28	0.003836	0.005254	2.514147	0.019631	64.25	99.64	0	11.27	140	0.406	23.2	27.72
0.89	0.283	0.002639	0.004216	2.657147	0.015228	55.71	99.75	0	11.4	140	0.326	15.9	22.24
0.9	0.286	0.001429	0.003148	2.848622	0.010996	40.86	99.87	0	11.53	140	0.244	8.6	16.61
0.91	0.29	0.000216	0.00206	3.135246	0.006961	9.56	99.98	0	11.66	140	0.159	1.3	10.87
0.92	0.293	-0.00099	0.000957	3.69461	0.003131	0	99.99	0	11.79	140	0.074	-6	5.05
0.93	0.296	-0.00222	-0.00018	5.241971	-0.00056	0.06	54.69	0	11.91	140	-0.014	-13.4	-0.93

Table 54. Input values at 120rpm

Diameter D	5.49 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	120 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.729	v/(ΩR)	0.232
Efficiency η	83.00%	loading	low
Thrust T	200 N	Ct	0.0451
Power P	1.93 kW	Cp	0.0396
β at 75%R	21.6°	Pitch H	5.12 m

Table 55. Propeller Geometry at 120 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0526	71.4	0.933	274.5	144.4	5124.7	interpolated
0.15	0.0923	62.3	0.897	411.75	253.3	4926.3	interpolated
0.2	0.1225	54.6	0.885	549	336.2	4858.3	interpolated
0.25	0.1405	48.3	0.881	686.25	385.6	4838.1	interpolated
0.3	0.1483	43.1	0.882	823.5	407.2	4840.7	Clark Y, Re=500'000
0.35	0.1492	38.8	0.885	960.75	409.6	4856	Clark Y, Re=500'000
0.4	0.1457	35.3	0.889	1098	400	4879	interpolated
0.45	0.1397	32.3	0.894	1235.25	383.4	4907.1	interpolated
0.5	0.1322	29.8	0.9	1372.5	362.8	4938.7	interpolated
0.55	0.1239	27.7	0.906	1509.75	340	4972.8	interpolated
0.6	0.1152	25.8	0.912	1647	316.1	5008.8	interpolated
0.65	0.1061	24.2	0.919	1784.25	291.4	5046.3	Clark Y, Re=500'000
0.7	0.0969	22.8	0.926	1921.5	265.9	5084.9	Clark Y, Re=500'000
0.75	0.0872	21.6	0.933	2058.75	239.5	5124.3	interpolated
0.8	0.0771	20.5	0.941	2196	211.6	5164.5	interpolated
0.85	0.066	19.5	0.948	2333.25	181.2	5205.4	interpolated
0.9	0.0534	18.7	0.956	2470.5	146.5	5246.7	interpolated
0.95	0.0374	17.9	0.963	2607.75	102.7	5288.4	interpolated
1	0.0019	17.2	0.971	2745	5.1	5330.4	Clark Y, Re=500'000

Table 56. Single Analysis at 120 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.06807	0.046744	0	999999	0	0	52.00 !	0	120	2.277	302	181.21
0.05	0.016	0.070832	0.048814	0.091466	994.4305	7.26	20.75	100.00 !	0.55	120	2.378	314.3	189.24
0.1	0.032	0.070285	0.048184	0.183408	122.6997	14.59	37.06	89.00 !	1.1	120	2.347	311.8	186.79
0.15	0.048	0.069798	0.047785	0.27557	36.05468	21.91	49.76	84.00 !	1.65	120	2.328	309.7	185.25
0.2	0.064	0.069222	0.047147	0.368416	15.00748	29.36	59.61	73	2.2	120	2.297	307.1	182.77
0.25	0.08	0.068676	0.046694	0.461411	7.609906	36.77	67.22	57	2.74	120	2.275	304.7	181.02
0.3	0.095	0.068009	0.046595	0.553928	4.394577	43.79	73.15	52	3.29	120	2.27	301.7	180.63
0.35	0.111	0.067321	0.0465	0.646513	2.76178	50.67	77.78	42	3.84	120	2.265	298.7	180.26
0.4	0.127	0.066493	0.04656	0.738681	1.85257	57.12	81.44	31	4.39	120	2.268	295	180.5
0.45	0.143	0.065434	0.046706	0.830497	1.305194	63.04	84.38	21	4.94	120	2.275	290.3	181.06
0.5	0.159	0.064083	0.046837	0.922256	0.954162	68.41	86.78	0	5.49	120	2.282	284.3	181.57
0.55	0.175	0.062226	0.046826	1.014533	0.716697	73.09	88.79	0	6.04	120	2.281	276.1	181.53
0.6	0.191	0.059933	0.046691	1.1074	0.550453	77.02	90.48	0	6.59	120	2.275	265.9	181.01
0.65	0.207	0.055419	0.045105	1.208002	0.418242	79.86	92.14	0	7.14	120	2.197	245.9	174.86
0.7	0.223	0.048896	0.041751	1.321189	0.309964	81.98	93.75	0	7.69	120	2.034	216.9	161.85
0.75	0.239	0.04219	0.037826	1.443791	0.228319	83.65	95.11	0	8.24	120	1.843	187.2	146.64
0.8	0.255	0.03535	0.033343	1.579386	0.165836	84.81	96.27	0	8.78	120	1.624	156.8	129.26
0.85	0.271	0.028381	0.028286	1.734217	0.11729	85.28	97.26	0	9.33	120	1.378	125.9	109.66
0.9	0.286	0.021291	0.02264	1.919845	0.079085	84.64	98.11	0	9.88	120	1.103	94.5	87.77
0.91	0.29	0.019859	0.021439	1.962455	0.072448	84.29	98.27	0	9.99	120	1.044	88.1	83.11
0.92	0.293	0.018422	0.020213	2.007521	0.066102	83.85	98.42	0	10.1	120	0.985	81.7	78.36
0.93	0.296	0.01698	0.018963	2.055422	0.060035	83.28	98.56	0	10.21	120	0.924	75.3	73.51
0.94	0.299	0.015534	0.017688	2.106645	0.05423	82.55	98.71	0	10.32	120	0.862	68.9	68.57
0.95	0.302	0.014083	0.016389	2.161792	0.048676	81.64	98.85	0	10.43	120	0.798	62.5	63.53
0.96	0.306	0.012628	0.015064	2.221689	0.043358	80.47	98.98	0	10.54	120	0.734	56	58.4
0.97	0.309	0.011168	0.013715	2.287336	0.038268	78.99	99.11	0	10.65	120	0.668	49.6	53.17
0.98	0.312	0.009708	0.012344	2.360107	0.033399	77.07	99.24	0	10.76	120	0.601	43.1	47.86
0.99	0.315	0.008229	0.010935	2.442715	0.028698	74.5	99.37	0	10.87	120	0.533	36.5	42.39
1	0.318	0.006749	0.009503	2.537651	0.024198	71.02	99.49	0	10.98	120	0.463	29.9	36.84
1.01	0.321	0.005271	0.008051	2.649399	0.0199	66.12	99.61	0	11.09	120	0.392	23.4	31.21
1.02	0.325	0.003788	0.006574	2.786308	0.015776	58.77	99.72	0	11.2	120	0.32	16.8	25.49
1.03	0.328	0.002271	0.005041	2.967163	0.011746	46.41	99.83	0	11.31	120	0.246	10.1	19.54
1.04	0.331	0.000781	0.003513	3.220326	0.007953	23.13	99.94	0	11.42	120	0.171	3.5	13.62
1.05	0.334	-0.00071	0.00196	3.653654	0.004312	0	99.99	0	11.53	120	0.095	-3.2	7.6
1.06	0.337	-0.00221	0.00038	5.122229	0.000811	0	99.99	0	11.64	120	0.018	-9.8	1.47
1.07	0.341	-0.00372	-0.00124	4.083574	-0.00257	0.26	53.69	0	11.75	120	-0.06	-16.5	-4.79

Table 57: Multi Analysis at 120 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	86021	0.026	0.01104	0.07172	0.62109	0.22138	1.8	3.5	0.01109	0.00261	0.02262	0.00625
0.15	3	0.659	0.02288	28.79	164895	0.028	0.02191	0.06175	0.57802	0.31674	2.2	4.4	0.01096	0.00233	0.02257	0.00568
0.2	3	0.659	0.02288	28.78	242604	0.031	0.03289	0.0517	0.53047	0.39093	2.5	4.8	0.01071	0.00206	0.02244	0.00512
0.25	3	0.658	0.02288	28.78	309775	0.034	0.04263	0.04278	0.48404	0.44698	2.5	4.9	0.01034	0.00181	0.02216	0.00457
0.3	3	0.658	0.02287	28.78	363760	0.038	0.05073	0.03537	0.4415	0.48894	2.5	4.7	0.00985	0.00156	0.02171	0.00402
0.35	3	0.658	0.02287	28.78	405223	0.042	0.05728	0.0294	0.40381	0.52055	2.4	4.6	0.00928	0.00133	0.02107	0.0035
0.4	3	0.658	0.02287	28.78	435887	0.047	0.06247	0.02463	0.37084	0.54453	2.3	4.3	0.00862	0.00111	0.02023	0.00299
0.45	3	0.658	0.02288	28.78	457488	0.051	0.06661	0.02083	0.3422	0.56302	2.2	4.1	0.00791	0.00091	0.01919	0.00251
0.5	3	0.659	0.02288	28.78	471404	0.056	0.06994	0.0178	0.3173	0.5775	2.1	3.9	0.00716	0.00073	0.01795	0.00206
0.55	3	0.658	0.02288	28.78	478563	0.06	0.07257	0.01534	0.29555	0.58888	1.9	3.6	0.00638	0.00058	0.01652	0.00165
0.6	3	0.659	0.02288	28.78	479471	0.065	0.07476	0.01334	0.27655	0.59811	1.8	3.4	0.00558	0.00044	0.01493	0.00128
0.65	3	0.659	0.02288	28.79	474219	0.07	0.07657	0.0117	0.25983	0.60564	1.7	3.3	0.00477	0.00032	0.01317	0.00095
0.7	3	0.659	0.02288	28.79	462487	0.075	0.07801	0.01034	0.245	0.61174	1.7	3.1	0.00396	0.00022	0.01129	0.00066
0.75	3	0.659	0.02288	28.79	443478	0.079	0.07927	0.0092	0.23184	0.61691	1.6	2.9	0.00316	0.00014	0.00931	0.00043
0.8	3	0.659	0.02288	28.79	415727	0.084	0.08034	0.00824	0.22008	0.62126	1.5	2.8	0.0024	0.00008	0.00726	0.00025
0.85	3	0.659	0.02288	28.79	376641	0.089	0.08125	0.00742	0.20951	0.62496	1.4	2.7	0.00167	0.00004	0.00522	0.00012
0.9	3	0.659	0.02289	28.79	321201	0.094	0.08203	0.00672	0.19997	0.62812	1.4	2.6	0.00101	0.00001	0.00325	0.00004
0.95	3	0.659	0.02288	28.79	236880	0.099	0.08264	0.00611	0.19131	0.63074	1.3	2.5	0.00044	0	0.00147	0
1	3	0.659	0.02288	28.79	12435	0.104	0.08326	0.0055	0.18265	0.63336	1.3	2.3	0.00002	0	0.00008	0

Table 58: Input values at 100rpm

Diameter D	5.49 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	100 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.874	v/(ΩR)	0.278
Efficiency η	82.98%	loading	low
Thrust T	200 N	Ct	0.0649
Power P	1.93 kW	Cp	0.0684
β at 75%R	25.2°	Pitch H	6.09 m

Table 59. Propeller Geometry at 100 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil	
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]		
0	Spinner	-	-	-	-	-	-	
0.05	Spinner	-	-	-	-	-	-	
0.1	0.052	74.9	1.166	274.5	142.8	6403.4	interpolated	
0.15	0.0972	66.9	1.106	411.75	266.9	6070.2	interpolated	
0.2	0.1377	59.9	1.082	549	378.1	5942.7	interpolated	
0.25	0.1675	53.8	1.073	686.25	459.7	5889	interpolated	
0.3	0.1857	48.6	1.069	823.5	509.7	5870.1	Clark Y, Re=500'000	
0.35	0.1942	44.2	1.069	960.75	533.2	5870.5	Clark Y, Re=500'000	
0.4	0.1956	40.5	1.071	1098	537	5882.5	interpolated	
0.45	0.192	37.3	1.075	1235.25	527.1	5902.1	interpolated	
0.5	0.185	34.5	1.08	1372.5	507.9	5927.1	interpolated	
0.55	0.1758	32.1	1.085	1509.75	482.6	5955.8	interpolated	
0.6	0.1651	30.1	1.091	1647	453.2	5987.3	interpolated	
0.65	0.1533	28.2	1.097	1784.25	420.8	6021	Clark Y, Re=500'000	
0.7	0.1406	26.6	1.103	1921.5	385.9	6056.4	Clark Y, Re=500'000	
0.75	0.127	25.2	1.11	2058.75	348.6	6093.1	interpolated	
0.8	0.1124	24	1.117	2196	308.4	6130.9	interpolated	
0.85	0.0963	22.8	1.124	2333.25	264.3	6169.6	interpolated	
0.9	0.0778	21.8	1.131	2470.5	213.5	6209	interpolated	
0.95	0.0544	20.9	1.138	2607.75	149.5	6249.1	interpolated	
1	0.0027	20	1.146	2745	7.5	6289.6	Clark Y, Re=500'000	

Table 60. Single Analysis at 100 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.096806	0.081709	0	999999	0	0	68.00 !	0	100	2.304	298.3	219.97
0.05	0.016	0.089472	0.072138	0.084594	1469.584	6.2	18.65	94.00 !	0.46	100	2.034	275.7	194.2
0.1	0.032	0.100393	0.084826	0.163793	216.0067	11.84	32.08	100.00 !	0.92	100	2.391	309.3	228.36
0.15	0.048	0.099622	0.084386	0.245945	63.67028	17.71	43.84	100.00 !	1.37	100	2.379	306.9	227.18
0.2	0.064	0.098733	0.083957	0.32826	26.72443	23.52	53.38	100.00 !	1.83	100	2.367	304.2	226.02
0.25	0.08	0.097862	0.082849	0.411417	13.50236	29.53	61.08	89	2.29	100	2.336	301.5	223.04
0.3	0.095	0.097091	0.081781	0.494983	7.713114	35.62	67.27	78	2.74	100	2.306	299.1	220.17
0.35	0.111	0.096456	0.081041	0.578532	4.813263	41.66	72.26	68	3.2	100	2.285	297.2	218.17
0.4	0.127	0.095837	0.080693	0.661748	3.21068	47.51	76.29	52	3.66	100	2.275	295.3	217.24
0.45	0.143	0.095167	0.080833	0.744209	2.258871	52.98	79.59	47	4.12	100	2.279	293.2	217.61
0.5	0.159	0.094444	0.080995	0.826568	1.650014	58.3	82.29	36	4.58	100	2.283	291	218.05
0.55	0.175	0.09351	0.081266	0.908616	1.243834	63.29	84.55	15	5.03	100	2.291	288.1	218.78
0.6	0.191	0.092159	0.081569	0.99048	0.961642	67.79	86.48	0	5.49	100	2.3	283.9	219.59
0.65	0.207	0.090116	0.081575	1.073006	0.756409	71.81	88.16	0	5.95	100	2.3	277.7	219.61
0.7	0.223	0.087563	0.081342	1.156206	0.603893	75.35	89.63	0	6.4	100	2.293	269.8	218.98
0.75	0.239	0.084169	0.080654	1.240897	0.486838	78.27	90.95	0	6.86	100	2.274	259.3	217.13
0.8	0.255	0.077198	0.076794	1.336671	0.381942	80.42	92.38	0	7.32	100	2.165	237.9	206.74
0.85	0.271	0.06897	0.071306	1.441429	0.295673	82.21	93.72	0	7.78	100	2.01	212.5	191.97
0.9	0.286	0.060587	0.065146	1.554049	0.227563	83.7	94.9	0	8.24	100	1.837	186.7	175.38
0.95	0.302	0.05205	0.058292	1.677267	0.173132	84.83	95.93	0	8.69	100	1.643	160.4	156.93
1	0.318	0.043365	0.050725	1.815332	0.129169	85.49	96.84	0	9.15	100	1.43	133.6	136.56
1.05	0.334	0.034534	0.042429	1.975411	0.093332	85.46	97.64	0	9.61	100	1.196	106.4	114.22
1.06	0.337	0.032751	0.04068	2.011079	0.086977	85.34	97.8	0	9.7	100	1.147	100.9	109.52
1.07	0.341	0.030963	0.038903	2.048269	0.080867	85.16	97.94	0	9.79	100	1.097	95.4	104.73
1.08	0.344	0.029168	0.037094	2.08719	0.074986	84.92	98.09	0	9.88	100	1.046	89.9	99.86
1.09	0.347	0.027369	0.035256	2.128036	0.069326	84.61	98.23	0	9.97	100	0.994	84.3	94.91
1.1	0.35	0.025563	0.033388	2.171079	0.063877	84.22	98.36	0	10.07	100	0.941	78.8	89.88
1.11	0.353	0.023752	0.031489	2.216626	0.058631	83.73	98.5	0	10.16	100	0.888	73.2	84.77
1.12	0.357	0.021936	0.029559	2.265054	0.053578	83.12	98.63	0	10.25	100	0.833	67.6	79.58
1.13	0.36	0.020113	0.027598	2.316874	0.048706	82.35	98.76	0	10.34	100	0.778	62	74.3
1.14	0.363	0.018287	0.025608	2.372627	0.044015	81.41	98.89	0	10.43	100	0.722	56.3	68.94
1.15	0.366	0.016452	0.023584	2.433176	0.039488	80.22	99.01	0	10.52	100	0.665	50.7	63.49
1.16	0.369	0.014615	0.021532	2.499433	0.035128	78.74	99.13	0	10.61	100	0.607	45	57.97
1.17	0.372	0.012771	0.019447	2.572859	0.030919	76.83	99.25	0	10.71	100	0.548	39.3	52.35
1.18	0.376	0.010923	0.017333	2.655252	0.026864	74.36	99.37	0	10.8	100	0.489	33.7	46.66
1.19	0.379	0.009056	0.015171	2.750089	0.022925	71.04	99.48	0	10.89	100	0.428	27.9	40.84
1.2	0.382	0.007176	0.012968	2.861593	0.01911	66.41	99.59	0	10.98	100	0.366	22.1	34.91
1.21	0.385	0.005295	0.010737	2.996487	0.015433	59.67	99.7	0	11.07	100	0.303	16.3	28.9
1.22	0.388	0.003417	0.008484	3.166963	0.011897	49.14	99.81	0	11.16	100	0.239	10.5	22.84
1.23	0.392	0.001532	0.006197	3.399925	0.00848	30.41	99.92	0	11.25	100	0.175	4.7	16.68
1.24	0.395	-0.00035	0.003887	3.762712	0.005191	0	99.99	0	11.35	100	0.11	-1.1	10.46
1.25	0.398	-0.00224	0.001546	4.561045	0.002016	0	99.99	0	11.44	100	0.044	-6.9	4.16
1.26	0.401	-0.00413	-0.00083	5.212611	-0.00105	0.11	52.31	0	11.53	100	-0.023	-12.7	-2.22

Table 61. Multi Analysis at 100 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	82971	0.025	0.00871	0.08394	0.6335	0.18275	1.7	3.4	0.01886	0.00452	0.03257	0.00909
0.15	3	0.659	0.02289	28.79	165691	0.027	0.01819	0.07536	0.60172	0.26915	2.3	4.5	0.01869	0.00405	0.03252	0.00828
0.2	3	0.659	0.02288	28.79	254333	0.029	0.02866	0.06591	0.56405	0.3409	2.6	5.1	0.01833	0.00359	0.03236	0.00747
0.25	3	0.658	0.02287	28.78	337473	0.032	0.03877	0.05674	0.5246	0.39852	2.8	5.4	0.01777	0.00315	0.03202	0.00667
0.3	3	0.658	0.02287	28.78	409294	0.034	0.04786	0.04854	0.48636	0.44419	2.9	5.5	0.01701	0.00272	0.03145	0.00588
0.35	3	0.658	0.02287	28.78	467933	0.038	0.05567	0.04148	0.45075	0.48015	2.8	5.4	0.01608	0.00232	0.0306	0.00512
0.4	3	0.658	0.02286	28.78	513638	0.041	0.06218	0.03553	0.41834	0.5085	2.8	5.2	0.01501	0.00195	0.02946	0.00438
0.45	3	0.658	0.02287	28.78	547493	0.045	0.06768	0.03062	0.38934	0.53115	2.7	5	0.01382	0.0016	0.02801	0.00368
0.5	3	0.658	0.02287	28.78	570682	0.048	0.07219	0.02653	0.36341	0.54925	2.5	4.8	0.01253	0.00129	0.02625	0.00303
0.55	3	0.658	0.02287	28.78	584198	0.052	0.07594	0.02314	0.34034	0.56392	2.4	4.5	0.01118	0.00101	0.02421	0.00242
0.6	3	0.658	0.02287	28.78	588679	0.056	0.07897	0.02031	0.31974	0.57581	2.3	4.3	0.00978	0.00076	0.0219	0.00187
0.65	3	0.658	0.02287	28.78	584370	0.06	0.0816	0.01794	0.30139	0.58573	2.2	4.1	0.00837	0.00056	0.01934	0.00139
0.7	3	0.658	0.02287	28.78	571040	0.064	0.08382	0.01596	0.28496	0.594	2.1	3.9	0.00695	0.00038	0.01658	0.00098
0.75	3	0.658	0.02287	28.78	547898	0.067	0.08562	0.01426	0.27016	0.60085	2	3.8	0.00555	0.00024	0.01367	0.00063
0.8	3	0.658	0.02288	28.78	513358	0.071	0.08723	0.01282	0.25686	0.60674	1.9	3.6	0.0042	0.00014	0.01067	0.00037
0.85	3	0.659	0.02288	28.78	464459	0.075	0.08861	0.01159	0.24482	0.61178	1.9	3.4	0.00293	0.00006	0.00766	0.00018
0.9	3	0.659	0.02288	28.78	395287	0.079	0.08973	0.01052	0.23386	0.61601	1.8	3.3	0.00177	0.00002	0.00476	0.00006
0.95	3	0.659	0.02288	28.78	290781	0.084	0.09078	0.00959	0.2239	0.61977	1.7	3.2	0.00077	0	0.00215	0
1	3	0.659	0.02288	28.79	15248	0.088	0.09182	0.00866	0.21394	0.62352	1.6	3	0.00004	0	0.00011	0

Table 62. Input at 80 rpm

Diameter D	5.49 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	80 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	1.093	v/(ΩR)	0.348
Efficiency η	82.15%	loading	low
Thrust T	200 N	Ct	0.1014
Power P	1.95 kW	Cp	0.1349
β at 75%R	30.5°	Pitch H	7.62 m

Table 63. Propeller Geometry at 80 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0512	78.6	1.563	274.5	140.6	8582.2	interpolated
0.15	0.1015	72	1.449	411.75	278.5	7956.6	interpolated
0.2	0.1534	65.9	1.403	549	421.1	7704.6	interpolated
0.25	0.1988	60.4	1.381	686.25	545.8	7582.1	interpolated
0.3	0.2337	55.5	1.37	823.5	641.5	7519.5	Clark Y, Re=500'000
0.35	0.2571	51.1	1.364	960.75	705.9	7489.7	Clark Y, Re=500'000
0.4	0.2702	47.3	1.362	1098	741.7	7479.6	interpolated
0.45	0.2747	44	1.363	1235.25	753.9	7482.4	interpolated
0.5	0.2723	41	1.365	1372.5	747.5	7494.1	interpolated
0.55	0.2647	38.4	1.368	1509.75	726.7	7512.1	interpolated
0.6	0.2532	36.1	1.372	1647	694.9	7534.7	interpolated
0.65	0.2385	34	1.377	1784.25	654.6	7561	Clark Y, Re=500'000
0.7	0.2212	32.2	1.383	1921.5	607.1	7590	Clark Y, Re=500'000
0.75	0.2015	30.5	1.388	2058.75	553.2	7621.3	interpolated
0.8	0.1795	29	1.394	2196	492.7	7654.3	interpolated
0.85	0.1545	27.7	1.401	2333.25	424.1	7688.8	interpolated
0.9	0.1252	26.5	1.407	2470.5	343.8	7724.5	interpolated
0.95	0.0879	25.3	1.414	2607.75	241.2	7761.3	interpolated
1	0.0044	24.3	1.421	2745	12.1	7798.9	Clark Y, Re=500'000

Table 64. Single Analysis at 80 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.146588	0.160978	0	999999	0	0	89.00 !	0	80	2.324	289.1	277.36
0.1	0.032	0.150713	0.165598	0.143281	421.6907	9.1	26.96	100.00 !	0.73	80	2.39	297.2	285.32
0.2	0.064	0.150166	0.164194	0.287051	52.26462	18.29	46.15	100.00 !	1.46	80	2.37	296.1	282.9
0.3	0.095	0.148497	0.162314	0.431569	15.30845	27.45	59.79	100	2.2	80	2.343	292.8	279.66
0.4	0.127	0.146115	0.160144	0.576976	6.371911	36.5	69.5	94	2.93	80	2.312	288.1	275.92
0.5	0.159	0.144582	0.1576	0.723534	3.210598	45.87	76.3	73	3.66	80	2.275	285.1	271.54
0.6	0.191	0.143993	0.15766	0.868174	1.858696	54.8	81.08	52	4.39	80	2.276	283.9	271.64
0.7	0.223	0.143335	0.159513	1.010505	1.184249	62.9	84.58	5	5.12	80	2.302	282.6	274.84
0.8	0.255	0.140196	0.160838	1.152955	0.799942	69.73	87.35	0	5.86	80	2.322	276.5	277.12
0.9	0.286	0.134211	0.16025	1.298025	0.559771	75.38	89.64	0	6.59	80	2.313	264.6	276.1
1	0.318	0.120595	0.151978	1.457618	0.387009	79.35	91.86	0	7.32	80	2.194	237.8	261.85
1.1	0.35	0.099934	0.133513	1.645463	0.255437	82.33	94	0	8.05	80	1.927	197.1	230.04
1.2	0.382	0.078609	0.111641	1.860444	0.164521	84.5	95.77	0	8.78	80	1.611	155	192.35
1.3	0.414	0.056579	0.086164	2.122649	0.09987	85.36	97.24	0	9.52	80	1.244	111.6	148.46
1.4	0.446	0.033865	0.056956	2.483245	0.052857	83.24	98.49	0	10.25	80	0.822	66.8	98.13
1.42	0.452	0.029241	0.050656	2.57847	0.045051	81.97	98.72	0	10.39	80	0.731	57.7	87.28
1.44	0.458	0.024593	0.044205	2.687006	0.037698	80.11	98.94	0	10.54	80	0.638	48.5	76.16
1.46	0.465	0.019917	0.037595	2.814014	0.030762	77.35	99.16	0	10.69	80	0.543	39.3	64.78
1.48	0.471	0.015214	0.030829	2.968044	0.024217	73.04	99.37	0	10.83	80	0.445	30	53.12
1.5	0.477	0.010489	0.02391	3.164999	0.018041	65.8	99.57	0	10.98	80	0.345	20.7	41.2
1.52	0.484	0.005693	0.016766	3.443184	0.012157	51.62	99.77	0	11.13	80	0.242	11.2	28.89
1.54	0.49	0.000854	0.009431	3.913888	0.006576	13.95	99.97	0	11.27	80	0.136	1.7	16.25
1.56	0.497	-0.00397	0.002	5.406345	0.001342	0	99.99	0	11.42	80	0.029	-7.8	3.45
1.58	0.503	-0.00881	-0.00559	4.458884	-0.00361	0.36	50.01	0	11.57	80	-0.081	-17.4	-9.63

Table 65. Multi Analysis at 80 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.02289	28.79	79999	0.024	0.00654	0.10349	0.64413	0.1414	1.7	3.4	0.03635	0.00896	0.05089	0.01446
0.15	3	0.659	0.02289	28.79	165741	0.026	0.01437	0.09653	0.6232	0.21492	2.3	4.6	0.03608	0.00806	0.05083	0.01319
0.2	3	0.659	0.02288	28.79	265264	0.027	0.02381	0.08817	0.59664	0.2799	2.8	5.5	0.03553	0.00717	0.05064	0.01192
0.25	3	0.658	0.02287	28.78	366919	0.029	0.0338	0.0793	0.56679	0.3357	3.2	6.1	0.03462	0.0063	0.05022	0.01066
0.3	3	0.658	0.02287	28.78	462311	0.031	0.0436	0.07065	0.53581	0.38277	3.3	6.4	0.03336	0.00547	0.04947	0.00943
0.35	3	0.658	0.02286	28.78	546414	0.033	0.05274	0.0626	0.50515	0.42198	3.4	6.5	0.03174	0.00468	0.04831	0.00822
0.4	3	0.658	0.02285	28.78	616810	0.036	0.06093	0.05533	0.47574	0.45449	3.4	6.5	0.0298	0.00393	0.04669	0.00705
0.45	3	0.657	0.02285	28.78	672762	0.038	0.06821	0.04894	0.4482	0.48148	3.4	6.4	0.02759	0.00324	0.04458	0.00594
0.5	3	0.657	0.02284	28.78	714380	0.041	0.07444	0.04332	0.42266	0.50388	3.3	6.2	0.02515	0.00261	0.04196	0.00489
0.55	3	0.657	0.02284	28.78	742153	0.044	0.08002	0.03852	0.39927	0.52271	3.2	6	0.02253	0.00205	0.03884	0.00392
0.6	3	0.657	0.02284	28.78	756472	0.047	0.0847	0.03434	0.37782	0.53845	3.1	5.8	0.01979	0.00155	0.03525	0.00304
0.65	3	0.657	0.02285	28.78	757531	0.05	0.08875	0.03073	0.35824	0.55175	3	5.6	0.01697	0.00113	0.03123	0.00226
0.7	3	0.658	0.02285	28.78	745071	0.053	0.09226	0.02762	0.34038	0.56308	2.9	5.4	0.01412	0.00078	0.02684	0.00159
0.75	3	0.658	0.02285	28.78	718179	0.056	0.09512	0.0249	0.32402	0.57266	2.8	5.2	0.0113	0.00049	0.02217	0.00103
0.8	3	0.658	0.02285	28.78	674985	0.059	0.09778	0.02256	0.3091	0.58099	2.7	5	0.00856	0.00028	0.01733	0.0006
0.85	3	0.658	0.02286	28.78	611812	0.062	0.10011	0.02052	0.29544	0.5882	2.6	4.8	0.00597	0.00013	0.01246	0.00029
0.9	3	0.658	0.02286	28.78	521123	0.065	0.10216	0.01874	0.2829	0.59448	2.5	4.6	0.0036	0.00004	0.00775	0.00009
0.95	3	0.658	0.02286	28.78	383349	0.068	0.1038	0.01715	0.27133	0.59985	2.4	4.4	0.00158	0	0.0035	0
1	3	0.658	0.02286	28.78	20065	0.071	0.10544	0.01557	0.25976	0.60523	2.3	4.2	0.00008	0	0.00018	0

Table 66. Input values at 60 rpm

Diameter D	5.49 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	60 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	1.457	v/(ΩR)	0.464
Efficiency η	79.20%	loading	low
Thrust T	200 N	Ct	0.1803
Power P	2.02 kW	Cp	0.3318
β at 75%R	38.9°	Pitch H	10.44 m

Table 67. Propeller Geometry at 60 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil	
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]		
0	Spinner	-	-	-	-	-	-	
0.05	Spinner	-	-	-	-	-	-	
0.1	0.0514	82.6	2.409	274.5	141.1	13223.4	interpolated	
0.15	0.107	77.6	2.137	411.75	293.6	11730.5	interpolated	
0.2	0.1718	72.8	2.028	549	471.5	11134.3	interpolated	
0.25	0.2376	68.3	1.972	686.25	652.2	10827.6	interpolated	
0.3	0.298	64.1	1.94	823.5	818.1	10650.5	Clark Y, Re=500'000	
0.35	0.3488	60.2	1.92	960.75	957.4	10542.5	Clark Y, Re=500'000	
0.4	0.3878	56.6	1.908	1098	1064.6	10475.8	interpolated	
0.45	0.4146	53.4	1.901	1235.25	1138.1	10435.6	interpolated	
0.5	0.4297	50.4	1.897	1372.5	1179.4	10413.5	interpolated	
0.55	0.434	47.6	1.895	1509.75	1191.4	10404.3	interpolated	
0.6	0.429	45.2	1.895	1647	1177.5	10404.6	interpolated	
0.65	0.4156	42.9	1.897	1784.25	1140.7	10412.2	Clark Y, Re=500'000	
0.7	0.3947	40.8	1.899	1921.5	1083.5	10425.4	Clark Y, Re=500'000	
0.75	0.367	38.9	1.902	2058.75	1007.4	10443	interpolated	
0.8	0.3324	37.2	1.906	2196	912.5	10464.1	interpolated	
0.85	0.2903	35.6	1.91	2333.25	796.8	10488.2	interpolated	
0.9	0.2381	34.1	1.915	2470.5	653.6	10514.7	interpolated	
0.95	0.1687	32.8	1.92	2607.75	463.1	10543.3	interpolated	
1	0.0084	31.5	1.926	2745	23.2	10573.5	Clark Y, Re=500'000	

Table 68. Single Analysis at 60 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.240679	0.372447	0	999999	0	0	100.00 !	0	60	2.268	267	360.96
0.1	0.032	0.233905	0.371997	0.121869	947.2815	6.29	22.09	100.00 !	0.55	60	2.265	259.4	360.53
0.2	0.064	0.237793	0.373604	0.243527	118.9219	12.73	38.64	100.00 !	1.1	60	2.275	263.8	362.08
0.3	0.095	0.2404	0.37347	0.365317	35.22347	19.31	51.09	100.00 !	1.65	60	2.274	266.6	361.95
0.4	0.127	0.241468	0.371819	0.487521	14.79422	25.98	60.54	100	2.2	60	2.264	267.8	360.35
0.5	0.159	0.241027	0.369586	0.610136	7.529136	32.61	67.78	100	2.74	60	2.251	267.3	358.19
0.6	0.191	0.239458	0.368503	0.732593	4.344377	38.99	73.38	100	3.29	60	2.244	265.6	357.14
0.7	0.223	0.237954	0.36758	0.855121	2.728967	45.31	77.68	89	3.84	60	2.238	263.9	356.25
0.8	0.255	0.239523	0.369336	0.97635	1.836929	51.88	80.84	63	4.39	60	2.249	265.7	357.95
0.9	0.286	0.242591	0.375679	1.09466	1.312288	58.12	83.23	26	4.94	60	2.288	269.1	364.09
1	0.318	0.243562	0.38342	1.211337	0.976371	63.52	85.23	5	5.49	60	2.335	270.2	371.6
1.1	0.35	0.239776	0.387035	1.329972	0.740479	68.15	87.04	0	6.04	60	2.357	266	375.1
1.2	0.382	0.233166	0.387827	1.450286	0.571523	72.15	88.64	0	6.59	60	2.362	258.6	375.87
1.3	0.414	0.219063	0.378579	1.578745	0.4388	75.22	90.26	0	7.14	60	2.305	243	366.91
1.4	0.446	0.194599	0.349954	1.727133	0.324764	77.85	92	0	7.69	60	2.131	215.8	339.16
1.5	0.477	0.16946	0.317223	1.887202	0.239348	80.13	93.53	0	8.24	60	1.932	188	307.44
1.6	0.509	0.143875	0.280645	2.06295	0.174476	82.03	94.86	0	8.78	60	1.709	159.6	271.99
1.7	0.541	0.117469	0.239614	2.26228	0.124196	83.34	96.06	0	9.33	60	1.459	130.3	232.23
1.8	0.573	0.090217	0.19397	2.498766	0.084695	83.72	97.14	0	9.88	60	1.181	100.1	187.99
1.9	0.605	0.062125	0.143609	2.801025	0.053317	82.19	98.13	0	10.43	60	0.875	68.9	139.18
1.92	0.611	0.056411	0.132972	2.874412	0.047841	81.45	98.32	0	10.54	60	0.81	62.6	128.87
1.94	0.618	0.050658	0.12213	2.954181	0.042595	80.47	98.51	0	10.65	60	0.744	56.2	118.36
1.96	0.624	0.044878	0.111108	3.041634	0.037577	79.17	98.69	0	10.76	60	0.677	49.8	107.68
1.98	0.63	0.039063	0.099886	3.138802	0.032768	77.43	98.87	0	10.87	60	0.608	43.3	96.81
2	0.637	0.033221	0.088481	3.248327	0.028164	75.09	99.05	0	10.98	60	0.539	36.8	85.75
2.02	0.643	0.027338	0.076864	3.374477	0.023747	71.84	99.23	0	11.09	60	0.468	30.3	74.49
2.04	0.649	0.021434	0.065076	3.52327	0.01952	67.19	99.4	0	11.2	60	0.396	23.8	63.07
2.06	0.656	0.015491	0.053078	3.705813	0.015462	60.12	99.57	0	11.31	60	0.323	17.2	51.44
2.08	0.662	0.009523	0.040897	3.942085	0.011573	48.43	99.74	0	11.42	60	0.249	10.6	39.64
2.1	0.668	0.003539	0.028554	4.276486	0.007851	26.03	99.9	0	11.53	60	0.174	3.9	27.67
2.12	0.675	-0.0026	0.015745	4.863014	0.004208	0	99.99	0	11.64	60	0.096	-2.9	15.26
2.14	0.681	-0.00878	0.002724	6.972071	0.000708	0	99.99	0	11.75	60	0.017	-9.7	2.64
2.16	0.688	-0.01491	-0.01032	5.391241	-0.00261	0.26	46.08	0	11.86	60	-0.063	-16.5	-10.01

Table 69. Multi analysis at 60 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.0229	28.79	78955	0.024	0.00457	0.1423	0.65239	0.09692	1.7	3.5	0.08633	0.02216	0.09042	0.02639
0.15	3	0.659	0.02289	28.79	168615	0.025	0.01063	0.13717	0.64121	0.15339	2.5	5	0.08586	0.02001	0.09035	0.02413
0.2	3	0.659	0.02288	28.79	280272	0.026	0.01855	0.13044	0.626	0.20616	3.2	6.2	0.08486	0.01789	0.09011	0.02188
0.25	3	0.658	0.02288	28.78	404118	0.027	0.02775	0.12269	0.60771	0.25454	3.7	7.1	0.08318	0.01581	0.08956	0.01964
0.3	3	0.658	0.02286	28.78	531041	0.028	0.03762	0.1143	0.587	0.29804	4.1	7.8	0.08073	0.0138	0.08853	0.01742
0.35	3	0.657	0.02284	28.78	653481	0.029	0.04774	0.10582	0.56494	0.33672	4.4	8.3	0.07747	0.01186	0.08687	0.01525
0.4	3	0.656	0.02282	28.77	765665	0.031	0.0577	0.09745	0.54226	0.37075	4.5	8.6	0.0734	0.01002	0.08445	0.01314
0.45	3	0.656	0.0228	28.76	863562	0.033	0.06736	0.08953	0.51969	0.40059	4.7	8.7	0.06859	0.00831	0.08116	0.01111
0.5	3	0.655	0.02278	28.76	944412	0.034	0.07631	0.082	0.49759	0.42661	4.7	8.7	0.0631	0.00673	0.07693	0.00919
0.55	3	0.654	0.02276	28.75	1006522	0.036	0.08468	0.07509	0.47635	0.44936	4.7	8.7	0.05704	0.00531	0.07173	0.0074
0.6	3	0.654	0.02275	28.75	1048593	0.038	0.09193	0.0686	0.45606	0.4692	4.6	8.5	0.05051	0.00404	0.06557	0.00576
0.65	3	0.654	0.02274	28.75	1069817	0.04	0.0991	0.06292	0.43696	0.48668	4.6	8.4	0.04364	0.00295	0.05851	0.00429
0.7	3	0.653	0.02273	28.75	1068759	0.042	0.10507	0.05763	0.41894	0.50199	4.5	8.2	0.03658	0.00204	0.05064	0.00303
0.75	3	0.658	0.02286	28.78	1043482	0.044	0.10922	0.05263	0.4045	0.51948	4.4	8	0.02946	0.0013	0.04211	0.00198
0.8	3	0.653	0.02273	28.75	991678	0.047	0.11608	0.04876	0.38628	0.52754	4.3	7.8	0.02241	0.00074	0.03306	0.00115
0.85	3	0.654	0.02273	28.75	906862	0.049	0.12049	0.04492	0.37147	0.53815	4.2	7.6	0.0157	0.00035	0.0239	0.00055
0.9	3	0.654	0.02274	28.75	778028	0.051	0.12448	0.04148	0.35762	0.54761	4.1	7.3	0.00952	0.00011	0.01494	0.00018
0.95	3	0.654	0.02274	28.75	575673	0.053	0.12809	0.03838	0.34468	0.55607	4	7.1	0.00418	0.00001	0.00677	0.00001
1	3	0.654	0.02275	28.75	30028	0.056	0.1317	0.03529	0.33173	0.56453	3.8	6.9	0.00021	0	0.00035	0

Table 70. Input values at 40 rpm

Diameter D	5.49 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	40 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	2.186	v/(ΩR)	0.696
Efficiency η	68.17%	loading	low
Thrust T	200.01 N	Ct	0.4057
Power P	2.35 kW	Cp	1.3009
β at 75%R	54.5°	Pitch H	18.15 m

Table 71. Propeller Geometry at 40 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-
0.1	0.0584	87	5.898	274.5	160.4	32382.3	interpolated
0.15	0.1261	84	4.46	411.75	346.2	24485.2	interpolated
0.2	0.2128	81	3.982	549	584.1	21863.9	interpolated
0.25	0.3121	78.2	3.747	686.25	856.6	20572.2	interpolated
0.3	0.4175	75.4	3.609	823.5	1146.1	19814.1	Clark Y, Re=500'000
0.35	0.5229	72.7	3.52	960.75	1435.4	19323.3	Clark Y, Re=500'000
0.4	0.6226	70	3.458	1098	1709.1	18985.4	interpolated
0.45	0.712	67.5	3.414	1235.25	1954.4	18743.2	interpolated
0.5	0.7873	65.1	3.382	1372.5	2161.3	18564.7	interpolated
0.55	0.8459	62.8	3.357	1509.75	2322	18430.9	interpolated
0.6	0.8856	60.6	3.339	1647	2431	18329.7	interpolated
0.65	0.9051	58.4	3.325	1784.25	2484.5	18252.8	Clark Y, Re=500'000
0.7	0.9032	56.4	3.314	1921.5	2479.2	18194.7	Clark Y, Re=500'000
0.75	0.8785	54.5	3.306	2058.75	2411.5	18151.3	interpolated
0.8	0.8292	52.7	3.3	2196	2276.2	18119.7	interpolated
0.85	0.7516	51	3.296	2333.25	2063.2	18097.8	interpolated
0.9	0.6379	49.4	3.294	2470.5	1751	18083.7	interpolated
0.95	0.466	47.8	3.293	2607.75	1279.3	18076.2	interpolated
1	0.0233	46.3	3.292	2745	64	18074.2	Clark Y, Re=500'000

Table 72. Single Analysis at 40 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.358592	1.030309	0	999999	0	0	100.00 !	0	40	1.859	176.8	443.8
0.1	0.032	0.27685	0.810732	0.104286	2064.511	3.41	20.4	94.00 !	0.37	40	1.463	136.5	349.21
0.2	0.064	0.337267	0.973574	0.201074	309.8983	6.93	33.33	100.00 !	0.73	40	1.757	166.3	419.36
0.3	0.095	0.354795	1.009405	0.299439	95.20102	10.54	44.15	100.00 !	1.1	40	1.821	174.9	434.79
0.4	0.127	0.372135	1.04036	0.396847	41.3946	14.31	52.44	100.00 !	1.46	40	1.877	183.5	448.12
0.5	0.159	0.386502	1.06457	0.493782	21.68725	18.15	58.98	100	1.83	40	1.921	190.5	458.55
0.6	0.191	0.400866	1.084486	0.590346	12.78529	22.18	64.11	100	2.2	40	1.957	197.6	467.13
0.7	0.223	0.412395	1.102388	0.686485	8.184277	26.19	68.29	100	2.56	40	1.989	203.3	474.84
0.8	0.255	0.421346	1.120322	0.782026	5.572025	30.09	71.75	100	2.93	40	2.021	207.7	482.57
0.9	0.286	0.428141	1.138737	0.876916	3.977736	33.84	74.64	100	3.29	40	2.055	211.1	490.5
1	0.318	0.43335	1.160159	0.970726	2.95432	37.35	77.06	94	3.66	40	2.093	213.6	499.73
1.1	0.35	0.439789	1.181796	1.063859	2.261021	40.93	79.01	78	4.03	40	2.132	216.8	509.05
1.2	0.382	0.451411	1.213392	1.154466	1.788123	44.64	80.46	57	4.39	40	2.189	222.5	522.66
1.3	0.414	0.469465	1.256387	1.241992	1.456242	48.58	81.45	5	4.76	40	2.267	231.4	541.18
1.4	0.446	0.479032	1.298813	1.328675	1.205321	51.64	82.53	5	5.12	40	2.343	236.1	559.45
1.5	0.477	0.483324	1.332855	1.416233	1.005656	54.39	83.58	5	5.49	40	2.405	238.3	574.11
1.6	0.509	0.484137	1.359909	1.504589	0.845454	56.96	84.57	5	5.86	40	2.454	238.7	585.77
1.7	0.541	0.482298	1.383368	1.593167	0.71702	59.27	85.5	5	6.22	40	2.496	237.8	595.87
1.8	0.573	0.478257	1.404549	1.681764	0.613281	61.29	86.36	5	6.59	40	2.534	235.8	605
1.9	0.605	0.463259	1.393353	1.778039	0.517298	63.17	87.39	5	6.95	40	2.514	228.4	600.17
2	0.637	0.444108	1.36583	1.879103	0.434757	65.03	88.41	5	7.32	40	2.464	218.9	588.32
2.1	0.668	0.422636	1.330717	1.983363	0.365905	66.7	89.39	0	7.69	40	2.401	208.3	573.19
2.2	0.7	0.401713	1.293176	2.089735	0.309264	68.34	90.28	0	8.05	40	2.333	198	557.02
2.3	0.732	0.380147	1.251086	2.199229	0.261845	69.89	91.1	0	8.42	40	2.257	187.4	538.89
2.4	0.764	0.357766	1.204075	2.312494	0.221799	71.31	91.88	0	8.78	40	2.172	176.4	518.64
2.5	0.796	0.333062	1.147942	2.431958	0.187086	72.53	92.66	0	9.15	40	2.071	164.2	494.46
2.6	0.828	0.311527	1.097033	2.552286	0.158942	73.83	93.32	0	9.52	40	1.979	153.6	472.54
2.7	0.859	0.284711	1.02923	2.684487	0.133156	74.69	94.04	0	9.88	40	1.857	140.4	443.33
2.8	0.891	0.258949	0.961104	2.822305	0.11149	75.44	94.71	0	10.25	40	1.734	127.7	413.99
2.9	0.923	0.232095	0.886837	2.970498	0.092596	75.9	95.36	0	10.61	40	1.6	114.4	382
3	0.955	0.205339	0.809881	3.129227	0.076383	76.06	95.98	0	10.98	40	1.461	101.2	348.85
3.1	0.987	0.17735	0.726267	3.304779	0.06208	75.7	96.59	0	11.35	40	1.31	87.4	312.83
3.12	0.993	0.171735	0.709185	3.341971	0.059462	75.55	96.71	0	11.42	40	1.28	84.7	305.47
3.14	0.999	0.165661	0.690544	3.38136	0.056799	75.33	96.84	0	11.49	40	1.246	81.7	297.44
3.16	1.006	0.159782	0.672436	3.42103	0.054266	75.09	96.96	0	11.57	40	1.213	78.8	289.64
3.18	1.012	0.154071	0.654712	3.461123	0.051845	74.83	97.08	0	11.64	40	1.181	76	282.01
3.2	1.019	0.147914	0.635512	3.503686	0.049387	74.48	97.21	0	11.71	40	1.147	72.9	273.74
3.22	1.025	0.142147	0.617386	3.546047	0.04709	74.14	97.32	0	11.79	40	1.114	70.1	265.93
3.24	1.031	0.136348	0.599052	3.58965	0.044851	73.74	97.44	0	11.86	40	1.081	67.2	258.04
3.26	1.038	0.130519	0.58051	3.634591	0.042668	73.3	97.56	0	11.93	40	1.047	64.3	250.05
3.28	1.044	0.124649	0.561729	3.681023	0.040536	72.78	97.68	0	12	40	1.014	61.4	241.96
3.3	1.05	0.118744	0.542727	3.729046	0.038457	72.2	97.79	0	12.08	40	0.979	58.5	233.77
3.32	1.057	0.112235	0.521622	3.781525	0.036298	71.44	97.92	0	12.15	40	0.941	55.3	224.68
3.34	1.063	0.105951	0.50116	3.834875	0.034251	70.61	98.04	0	12.22	40	0.904	52.2	215.87
3.36	1.07	0.1	0.481678	3.888552	0.032335	69.76	98.16	0	12.3	40	0.869	49.3	207.48
3.38	1.076	0.094208	0.462601	3.943441	0.030507	68.83	98.27	0	12.37	40	0.835	46.4	199.26
3.4	1.082	0.087732	0.441147	4.004629	0.028582	67.62	98.4	0	12.44	40	0.796	43.2	190.02
3.42	1.089	0.081541	0.420562	4.066868	0.026773	66.31	98.51	0	12.52	40	0.759	40.2	181.15
3.44	1.095	0.075729	0.401119	4.129559	0.025092	64.94	98.62	0	12.59	40	0.724	37.3	172.78
3.46	1.101	0.069287	0.379456	4.199946	0.023328	63.18	98.74	0	12.66	40	0.685	34.2	163.45
3.48	1.108	0.063514	0.359965	4.26901	0.02175	61.4	98.85	0	12.74	40	0.649	31.3	155.05
3.5	1.114	0.05718	0.338469	4.346747	0.020103	59.13	98.97	0	12.81	40	0.611	28.2	145.79
3.52	1.12	0.051027	0.317483	4.427908	0.018537	56.57	99.08	0	12.88	40	0.573	25.2	136.75
3.54	1.127	0.044598	0.295441	4.517615	0.016959	53.44	99.2	0	12.96	40	0.533	22	127.26
3.56	1.133	0.038408	0.274127	4.611685	0.015472	49.88	99.31	0	13.03	40	0.495	18.9	118.08
3.58	1.14	0.032194	0.252626	4.713977	0.014021	45.62	99.43	0	13.1	40	0.456	15.9	108.82
3.6	1.146	0.025984	0.231048	4.82572	0.012611	40.49	99.54	0	13.18	40	0.417	12.8	99.52
3.62	1.152	0.019729	0.209209	4.949853	0.01123	34.14	99.65	0	13.25	40	0.377	9.7	90.11
3.64	1.159	0.013455	0.18721	5.089039	0.009885	26.16	99.76	0	13.32	40	0.338	6.6	80.64
3.66	1.165	0.00721	0.165215	5.246516	0.008581	15.97	99.87	0	13.4	40	0.298	3.6	71.16
3.68	1.171	0.00075	0.142355	5.43467	0.007274	1.94	99.99	0	13.47	40	0.257	0.4	61.32
3.7	1.178	-0.0055	0.120163	5.65259	0.006041	0	99.99	0	13.54	40	0.217	-2.7	51.76
3.72	1.184	-0.01184	0.097532	5.925342	0.004825	0	99.99	0	13.62	40	0.176	-5.8	42.01
3.74	1.19	-0.01843	0.07393	6.296627	0.003599	0	99.99	0	13.69	40	0.133	-9.1	31.84
3.76	1.197	-0.0249	0.050635	6.828065	0.002426	0	99.99	0	13.76	40	0.091	-12.3	21.81
3.78	1.203	-0.03132	0.027447	7.758753	0.001294	0	99.99	0	13.83	40	0.05	-15.4	11.82
3.8	1.21	-0.03783	0.003843	11.55738	0.000178	0	99.99	0	13.91	40	0.007	-18.6	1.66
3.82	1.216	-0.04432	-0.01978	8.372242	-0.0009	0.09	37.06	0	13.98	40	-0.036	-21.8	-8.52

Table 73. Multi analysis at 40 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1	3	0.659	0.0229	28.79	88566	0.024	0.00268	0.26071	0.65804	0.04682	2.1	4.3	0.32152	0.08784	0.20364	0.06222
0.15	3	0.659	0.02289	28.79	193335	0.024	0.00689	0.25778	0.65451	0.08094	3.2	6.3	0.32035	0.07983	0.20356	0.05713
0.2	3	0.659	0.02289	28.79	331179	0.024	0.01285	0.25347	0.64931	0.11428	4.1	8.1	0.31779	0.07189	0.20324	0.05205
0.25	3	0.659	0.02288	28.79	495223	0.025	0.02037	0.24798	0.64249	0.14658	5	9.7	0.31337	0.06405	0.20246	0.04699
0.3	3	0.658	0.02287	28.78	677906	0.025	0.02928	0.24161	0.63419	0.17761	5.8	11.1	0.30669	0.05638	0.20094	0.04197
0.35	3	0.657	0.02284	28.77	871315	0.026	0.03931	0.23442	0.62411	0.20699	6.5	12.3	0.29747	0.04895	0.19836	0.03701
0.4	3	0.655	0.02279	28.76	1067538	0.027	0.05024	0.22657	0.61251	0.23455	7.1	13.3	0.2855	0.04181	0.19439	0.03215
0.45	3	0.653	0.02273	28.74	1259045	0.028	0.06211	0.21856	0.59969	0.26021	7.6	14.1	0.27069	0.03504	0.18872	0.02743
0.5	2.9	0.651	0.02265	28.72	1438367	0.029	0.07442	0.21009	0.58591	0.28391	8	14.7	0.25305	0.02872	0.18106	0.0229
0.55	3	0.658	0.02287	28.78	1596910	0.03	0.08484	0.19995	0.58027	0.31172	8.3	15.1	0.23271	0.0229	0.17121	0.01862
0.6	2.9	0.645	0.02248	28.67	1733169	0.031	0.09992	0.19272	0.5567	0.32564	8.6	15.5	0.2096	0.01766	0.15879	0.01465
0.65	3	0.659	0.02288	28.79	1832074	0.032	0.10867	0.18228	0.55535	0.35478	8.7	15.6	0.18465	0.01304	0.1442	0.01105
0.7	3	0.659	0.02289	28.79	1894283	0.033	0.12033	0.17368	0.54273	0.37416	8.9	15.7	0.15744	0.00911	0.12682	0.00788
0.75	3	0.659	0.02289	28.79	1909507	0.034	0.13166	0.1653	0.53012	0.39218	8.9	15.8	0.12895	0.00588	0.10718	0.0052
0.8	3	0.659	0.0229	28.79	1867729	0.035	0.1426	0.15718	0.5176	0.4089	9	15.7	0.09989	0.00339	0.08567	0.00306
0.85	3	0.659	0.0229	28.79	1754054	0.036	0.15307	0.14938	0.50521	0.42439	9	15.6	0.07112	0.00161	0.06295	0.00148
0.9	3	0.66	0.02291	28.79	1541787	0.038	0.16304	0.14189	0.49302	0.43873	9	15.5	0.0438	0.00051	0.03999	0.00048
0.95	3	0.66	0.02292	28.79	1166252	0.039	0.1728	0.13488	0.48117	0.45211	8.9	15.3	0.01952	0.00002	0.01839	0.00002
1	3	0.66	0.02292	28.8	60369	0.041	0.18257	0.12786	0.46932	0.46548	8.8	15.1	0.00097	0	0.00096	0

D) 20 feet

Table 74. Input at 200 rpm

Diameter D	6.09 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	200 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.394	v/(ΩR)	0.125
Efficiency η	80.46%	loading	low
Thrust T	200 N	Ct	0.0107
Power P	1.99 kW	Cp	0.0052
β at 75%R	13°	Pitch H	3.32 m

Table 75. Propeller Geometry at 200 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	0.0162	72.3	0.492	152.25	49.4	2999	interpolated
0.1	0.0397	55.9	0.465	304.5	121	2829.3	interpolated
0.15	0.0504	44.4	0.462	456.75	153.6	2813.3	interpolated
0.2	0.0516	36.5	0.465	609	157.2	2831.5	interpolated
0.25	0.0489	30.9	0.47	761.25	148.9	2862.9	interpolated
0.3	0.045	26.8	0.476	913.5	137.1	2900.6	Clark Y, Re=500'000
0.35	0.0411	23.7	0.483	1065.75	125.2	2942	Clark Y, Re=500'000
0.4	0.0375	21.3	0.49	1218	114.1	2985.6	interpolated
0.45	0.0342	19.4	0.498	1370.25	104.2	3030.7	interpolated
0.5	0.0314	17.8	0.505	1522.5	95.5	3076.8	interpolated
0.55	0.0288	16.5	0.513	1674.75	87.7	3123.6	interpolated
0.6	0.0265	15.4	0.521	1827	80.6	3171	interpolated
0.65	0.0243	14.5	0.529	1979.25	74.1	3218.9	Clark Y, Re=500'000
0.7	0.0223	13.7	0.536	2131.5	67.8	3267	Clark Y, Re=500'000
0.75	0.0202	13	0.544	2283.75	61.6	3315.4	interpolated
0.8	0.0181	12.4	0.552	2436	55.2	3364.1	interpolated
0.85	0.0158	11.9	0.56	2588.25	48.2	3412.9	interpolated
0.9	0.0131	11.4	0.568	2740.5	39.7	3461.9	interpolated
0.95	0.0094	10.9	0.577	2892.75	28.5	3510.9	interpolated
1	0.0005	10.5	0.585	3045	1.4	3560.1	Clark Y, Re=500'000

Table 76. Single Analysis at 200 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.015558	0.005761	0	999999	0.01	0	26.00 !	0	200	2.182	290.3	104.19
0.05	0.016	0.016912	0.005555	0.141265	113.1645	15.22	37.87	42.00 !	1.02	200	2.104	315.6	100.48
0.1	0.032	0.016609	0.00559	0.282175	14.23457	29.71	60.72	36	2.03	200	2.118	309.9	101.11
0.15	0.048	0.016199	0.005626	0.422714	4.245098	43.19	74.38	26	3.05	200	2.131	302.3	101.77
0.2	0.064	0.015711	0.005698	0.562195	1.813698	55.15	82.67	21	4.06	200	2.159	293.2	103.06
0.25	0.08	0.015116	0.005785	0.700608	0.942857	65.32	87.89	10	5.08	200	2.192	282.1	104.64
0.3	0.095	0.014299	0.005867	0.838385	0.553305	73.12	91.36	0	6.09	200	2.222	266.8	106.11
0.35	0.111	0.012658	0.005685	0.984302	0.337625	77.94	94.01	0	7.1	200	2.153	236.2	102.82
0.4	0.127	0.010451	0.005179	1.146065	0.206069	80.72	96.03	0	8.12	200	1.962	195	93.68
0.45	0.143	0.008172	0.004481	1.32718	0.125232	82.06	97.45	0	9.14	200	1.698	152.5	81.06
0.5	0.159	0.005845	0.003588	1.541708	0.073092	81.45	98.48	0	10.15	200	1.359	109.1	64.9
0.51	0.162	0.005375	0.003385	1.590924	0.064988	80.97	98.65	0	10.35	200	1.282	100.3	61.23
0.52	0.166	0.004901	0.003173	1.643241	0.05747	80.31	98.81	0	10.56	200	1.202	91.5	57.4
0.53	0.169	0.004426	0.002954	1.699058	0.050519	79.43	98.96	0	10.76	200	1.119	82.6	53.42
0.54	0.172	0.003951	0.002726	1.759121	0.044081	78.26	99.1	0	10.96	200	1.033	73.7	49.3
0.55	0.175	0.003474	0.00249	1.824437	0.038108	76.74	99.23	0	11.16	200	0.943	64.8	45.03
0.56	0.178	0.002994	0.002244	1.896581	0.032543	74.7	99.36	0	11.37	200	0.85	55.9	40.59
0.57	0.181	0.002512	0.00199	1.977356	0.027369	71.95	99.48	0	11.57	200	0.754	46.9	36
0.58	0.185	0.002031	0.001729	2.069542	0.022564	68.14	99.59	0	11.77	200	0.655	37.9	31.27
0.59	0.188	0.001546	0.001458	2.178352	0.018072	62.6	99.7	0	11.98	200	0.552	28.9	26.36
0.6	0.191	0.001064	0.00118	2.310992	0.013908	54.1	99.8	0	12.18	200	0.447	19.9	21.34
0.61	0.194	0.000576	0.000891	2.485172	0.009996	39.45	99.89	0	12.38	200	0.338	10.8	16.12
0.62	0.197	0.000086	0.000593	2.740048	0.006338	9.02	99.98	0	12.59	200	0.225	1.6	10.73
0.63	0.201	-0.0004	0.000289	3.215781	0.002939	0	99.99	0	12.79	200	0.109	-7.5	5.22
0.64	0.204	-0.00089	-2.6E-05	5.278644	-0.00026	0.03	56.67	0	12.99	200	-0.01	-16.7	-0.47

Table 77. Multi Analysis at 200 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	3	0.658	0.02287	28.78	29245	0.025	0.00627	0.00738	0	0	0.2	0.3	0.00152	0.00038	0.00538	0.0016
0.1	3	0.659	0.02289	28.79	84646	0.03	0.01922	0.0343	0.53948	0.37892	1.5	3	0.00152	0.00034	0.00538	0.00146
0.15	3	0.659	0.02289	28.79	130932	0.037	0.03023	0.0239	0.45305	0.47885	1.6	3.1	0.00149	0.00031	0.00535	0.00133
0.2	3	0.659	0.02289	28.79	161883	0.044	0.0377	0.01684	0.38267	0.53679	1.5	2.9	0.00143	0.00027	0.0053	0.00119
0.25	3	0.659	0.02289	28.79	181703	0.052	0.04254	0.01225	0.32847	0.57155	1.3	2.6	0.00136	0.00024	0.0052	0.00106
0.3	3	0.659	0.02289	28.79	194543	0.061	0.04573	0.00923	0.28686	0.59353	1.2	2.3	0.00129	0.0002	0.00507	0.00094
0.35	3	0.659	0.02289	28.79	203044	0.07	0.04791	0.00718	0.25442	0.60815	1.1	2.1	0.0012	0.00017	0.00489	0.00082
0.4	3	0.659	0.02289	28.79	208742	0.079	0.04947	0.00573	0.22869	0.6184	1	1.9	0.00111	0.00015	0.00468	0.0007
0.45	3	0.659	0.02289	28.79	212503	0.087	0.05059	0.00468	0.20785	0.62571	0.9	1.7	0.00102	0.00012	0.00443	0.00059
0.5	3	0.659	0.02289	28.79	214795	0.097	0.05142	0.00389	0.1907	0.63114	0.8	1.6	0.00093	0.0001	0.00414	0.00048
0.55	3	0.659	0.02289	28.79	215823	0.106	0.05205	0.00329	0.17638	0.63529	0.8	1.5	0.00083	0.00008	0.00382	0.00039
0.6	3	0.659	0.02289	28.79	215598	0.115	0.05255	0.00282	0.16425	0.63852	0.7	1.4	0.00073	0.00006	0.00346	0.0003
0.65	3	0.659	0.02289	28.79	213947	0.124	0.05298	0.00245	0.15387	0.6412	0.7	1.3	0.00063	0.00004	0.00307	0.00023
0.7	3	0.659	0.02289	28.79	210494	0.133	0.0533	0.00215	0.14487	0.64328	0.7	1.2	0.00053	0.00003	0.00265	0.00016
0.75	3	0.659	0.02289	28.79	204593	0.142	0.05356	0.0019	0.13701	0.64499	0.6	1.2	0.00043	0.00002	0.0022	0.0001
0.8	3	0.659	0.02289	28.79	195200	0.152	0.05378	0.00169	0.13009	0.64641	0.6	1.1	0.00033	0.00001	0.00173	0.00006
0.85	3	0.659	0.02289	28.79	180591	0.161	0.05396	0.00152	0.12395	0.64761	0.6	1.1	0.00023	0.00001	0.00126	0.00003
0.9	3	0.659	0.02289	28.79	157655	0.17	0.05415	0.00137	0.11847	0.64874	0.5	1	0.00014	0	0.00079	0.00001
0.95	3	0.659	0.02289	28.79	119195	0.18	0.05427	0.00125	0.11355	0.64961	0.5	1	0.00006	0	0.00036	0
1	3	0.659	0.02289	28.79	6268	0.189	0.0544	0.00112	0.10862	0.65048	0.5	0.9	0	0	0.00002	0

Table 78. Input values at 180 rpm

Diameter D	6.09 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	180 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.438	v/(ΩR)	0.139
Efficiency η	81.43%	loading	low
Thrust T	200 N	Ct	0.0132
Power P	1.96 kW	Cp	0.0071
β at 75%R	14.1°	Pitch H	3.61 m

Table 79. Propeller Geometry at 180 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil	
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]		
0	Spinner	-	-	-	-	-	-	
0.05	0.0156	74.3	0.557	152.25	47.6	3393.5	interpolated	
0.1	0.0412	58.8	0.52	304.5	125.5	3163.8	interpolated	
0.15	0.0557	47.5	0.514	456.75	169.7	3130.8	interpolated	
0.2	0.0596	39.4	0.516	609	181.4	3141	interpolated	
0.25	0.058	33.5	0.52	761.25	176.6	3167.7	interpolated	
0.3	0.0544	29.2	0.526	913.5	165.6	3202.5	Clark Y, Re=500'000	
0.35	0.0502	25.8	0.532	1065.75	153	3241.7	Clark Y, Re=500'000	
0.4	0.0462	23.2	0.539	1218	140.6	3283.7	interpolated	
0.45	0.0424	21.1	0.546	1370.25	129.1	3327.5	interpolated	
0.5	0.039	19.4	0.554	1522.5	118.7	3372.7	interpolated	
0.55	0.0358	18	0.561	1674.75	109.1	3418.7	interpolated	
0.6	0.033	16.8	0.569	1827	100.3	3465.4	interpolated	
0.65	0.0303	15.8	0.577	1979.25	92.1	3512.7	Clark Y, Re=500'000	
0.7	0.0277	14.9	0.585	2131.5	84.2	3560.4	Clark Y, Re=500'000	
0.75	0.0251	14.1	0.593	2283.75	76.3	3608.4	interpolated	
0.8	0.0224	13.4	0.6	2436	68.1	3656.7	interpolated	
0.85	0.0194	12.8	0.608	2588.25	59.1	3705.2	interpolated	
0.9	0.0159	12.3	0.616	2740.5	48.5	3753.8	interpolated	
0.95	0.0114	11.8	0.624	2892.75	34.6	3802.7	interpolated	
1	0.0006	11.4	0.632	3045	1.7	3851.6	Clark Y, Re=500'000	

Table 80. Single Analysis at 180 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.019467	0.007914	0	999999	0.01	0	26.00 !	0	180	2.186	294.3	115.95
0.05	0.016	0.021019	0.007753	0.132154	157.9364	13.56	34.79	47.00 !	0.91	180	2.141	317.7	113.58
0.1	0.032	0.020737	0.007758	0.264269	19.75651	26.73	56.89	42.00 !	1.83	180	2.143	313.5	113.67
0.15	0.048	0.020307	0.007773	0.396252	5.864999	39.19	70.83	31	2.74	180	2.147	307	113.88
0.2	0.064	0.019816	0.007832	0.527543	2.492929	50.6	79.67	26	3.65	180	2.163	299.5	114.74
0.25	0.08	0.019208	0.007905	0.658203	1.288309	60.75	85.44	15	4.57	180	2.183	290.3	115.81
0.3	0.095	0.018477	0.008001	0.787942	0.754592	69.28	89.31	0	5.48	180	2.21	279.3	117.22
0.35	0.111	0.017376	0.008038	0.918405	0.477426	75.66	92.1	0	6.39	180	2.22	262.7	117.77
0.4	0.127	0.015236	0.007662	1.059729	0.304849	79.55	94.39	0	7.31	180	2.116	230.3	112.25
0.45	0.143	0.012581	0.006913	1.216951	0.193197	81.89	96.17	0	8.22	180	1.909	190.2	101.29
0.5	0.159	0.009862	0.005941	1.393771	0.121038	82.99	97.48	0	9.13	180	1.641	149.1	87.05
0.55	0.175	0.007088	0.004736	1.604296	0.072484	82.32	98.46	0	10.05	180	1.308	107.1	69.38
0.56	0.178	0.006527	0.004466	1.652766	0.064753	81.85	98.63	0	10.23	180	1.233	98.7	65.43
0.57	0.181	0.005966	0.004187	1.704098	0.057573	81.22	98.78	0	10.41	180	1.156	90.2	61.34
0.58	0.185	0.0054	0.003896	1.759141	0.05085	80.38	98.93	0	10.6	180	1.076	81.6	57.08
0.59	0.188	0.004833	0.003597	1.818334	0.044594	79.29	99.07	0	10.78	180	0.993	73.1	52.69
0.6	0.191	0.004265	0.003287	1.882741	0.038752	77.85	99.2	0	10.96	180	0.908	64.5	48.16
0.61	0.194	0.00369	0.002965	1.954047	0.03326	75.93	99.33	0	11.14	180	0.819	55.8	43.43
0.62	0.197	0.003119	0.002635	2.033408	0.028158	73.38	99.45	0	11.33	180	0.728	47.1	38.61
0.63	0.201	0.002546	0.002296	2.124033	0.023378	69.87	99.56	0	11.51	180	0.634	38.5	33.63
0.64	0.204	0.001969	0.001944	2.230595	0.018888	64.81	99.67	0	11.69	180	0.537	29.8	28.49
0.65	0.207	0.001394	0.001585	2.359859	0.014701	57.17	99.77	0	11.88	180	0.438	21.1	23.23
0.66	0.21	0.000808	0.00121	2.529404	0.010714	44.08	99.87	0	12.06	180	0.334	12.2	17.72
0.67	0.213	0.00023	0.00083	2.768781	0.007025	18.53	99.96	0	12.24	180	0.229	3.5	12.16
0.68	0.216	-0.00035	0.000439	3.191373	0.003557	0	99.99	0	12.42	180	0.121	-5.3	6.43
0.69	0.22	-0.00094	0.000036	5.345776	0.000278	0	99.99	0	12.61	180	0.01	-14.2	0.52
0.7	0.223	-0.00153	-0.00038	3.383787	-0.00281	0.28	56.27	0	12.79	180	-0.105	-23.1	-5.55

Table 81: Multi Analysis at 180 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	3	0.658	0.02287	28.78	27817	0.025	0.0053	0.00632	0	0	0.1	0.3	0.00205	0.00052	0.00664	0.00197
0.1	3	0.659	0.02289	28.79	84520	0.029	0.01717	0.03799	0.55804	0.35113	1.5	3	0.00205	0.00047	0.00664	0.0018
0.15	3	0.659	0.02289	28.79	136331	0.034	0.0282	0.02757	0.47798	0.454	1.7	3.2	0.00201	0.00042	0.00661	0.00164
0.2	3	0.659	0.02289	28.79	173506	0.041	0.03624	0.01998	0.40916	0.51686	1.6	3.1	0.00194	0.00037	0.00655	0.00148
0.25	3	0.659	0.02289	28.79	198455	0.048	0.04171	0.0148	0.35418	0.55594	1.5	2.8	0.00186	0.00032	0.00644	0.00131
0.3	3	0.659	0.02289	28.79	215098	0.056	0.04544	0.01128	0.31093	0.58124	1.3	2.5	0.00175	0.00028	0.00627	0.00116
0.35	3	0.659	0.02289	28.79	226305	0.063	0.04803	0.00884	0.27667	0.59832	1.2	2.3	0.00164	0.00024	0.00606	0.00101
0.4	3	0.659	0.02289	28.79	233871	0.071	0.04991	0.00709	0.24918	0.61041	1.1	2.1	0.00152	0.0002	0.0058	0.00086
0.45	3	0.659	0.02289	28.79	238856	0.079	0.05128	0.00581	0.22674	0.6191	1	1.9	0.00139	0.00016	0.00549	0.00072
0.5	3	0.659	0.02289	28.79	241854	0.087	0.0523	0.00484	0.20815	0.6256	0.9	1.8	0.00126	0.00013	0.00513	0.0006
0.55	3	0.659	0.02289	28.79	243141	0.096	0.05309	0.0041	0.19256	0.63057	0.9	1.7	0.00112	0.0001	0.00472	0.00048
0.6	3	0.659	0.02289	28.79	242756	0.104	0.05371	0.00352	0.17931	0.63446	0.8	1.6	0.00099	0.00008	0.00427	0.00037
0.65	3	0.659	0.02289	28.79	240526	0.112	0.0542	0.00306	0.16793	0.63757	0.8	1.5	0.00085	0.00006	0.00378	0.00028
0.7	3	0.659	0.02289	28.79	236052	0.12	0.0546	0.00268	0.15806	0.64008	0.7	1.4	0.00071	0.00004	0.00326	0.0002
0.75	3	0.659	0.02289	28.79	228648	0.129	0.05496	0.00237	0.14943	0.64226	0.7	1.3	0.00057	0.00003	0.0027	0.00013
0.8	3	0.659	0.02289	28.79	217213	0.137	0.05523	0.00211	0.14181	0.64398	0.7	1.3	0.00044	0.00001	0.00213	0.00007
0.85	3	0.659	0.02289	28.79	199941	0.145	0.05546	0.0019	0.13504	0.64543	0.6	1.2	0.00031	0.00001	0.00154	0.00004
0.9	3	0.659	0.02289	28.79	173565	0.154	0.05565	0.00172	0.12899	0.64666	0.6	1.1	0.00019	0	0.00097	0.00001
0.95	3	0.659	0.02289	28.79	130443	0.162	0.05582	0.00156	0.12355	0.64772	0.6	1.1	0.00008	0	0.00044	0
1	3	0.659	0.02289	28.79	6859	0.17	0.05598	0.0014	0.11811	0.64877	0.5	1	0	0	0.00002	0

Table 82: Input values at 160 rpm

Diameter D	6.09 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	160 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	0.493	v/(ΩR)	0.157
Efficiency η	82.35%	loading	low
Thrust T	199.99 N	Ct	0.0167
Power P	1.94 kW	Cp	0.01
β at 75%R	15.5°	Pitch H	3.98 m

Table 83: Propeller Geometry at 160 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil	
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]		
0	Spinner	-	-	-	-	-	-	
0.05	0.015	76.3	0.642	152.25	45.6	3910.4	interpolated	
0.1	0.0424	62	0.59	304.5	129.2	3592.3	interpolated	
0.15	0.0613	50.9	0.58	456.75	186.8	3534.8	interpolated	
0.2	0.0689	42.7	0.58	609	209.9	3533.6	interpolated	
0.25	0.0695	36.6	0.584	761.25	211.5	3553.6	interpolated	
0.3	0.0666	32	0.589	913.5	202.9	3584	Clark Y, Re=500'000	
0.35	0.0625	28.4	0.594	1065.75	190.4	3620.2	Clark Y, Re=500'000	
0.4	0.0581	25.6	0.601	1218	176.8	3659.9	interpolated	
0.45	0.0537	23.3	0.608	1370.25	163.5	3702	interpolated	
0.5	0.0496	21.4	0.615	1522.5	150.9	3745.8	interpolated	
0.55	0.0457	19.8	0.622	1674.75	139.1	3790.7	interpolated	
0.6	0.0421	18.5	0.63	1827	128	3836.5	interpolated	
0.65	0.0386	17.3	0.638	1979.25	117.5	3882.9	Clark Y, Re=500'000	
0.7	0.0352	16.4	0.645	2131.5	107.2	3930	Clark Y, Re=500'000	
0.75	0.0318	15.5	0.653	2283.75	96.9	3977.4	interpolated	
0.8	0.0283	14.7	0.661	2436	86.1	4025.1	interpolated	
0.85	0.0244	14.1	0.669	2588.25	74.4	4073.2	interpolated	
0.9	0.02	13.5	0.677	2740.5	60.8	4121.5	interpolated	
0.95	0.0141	12.9	0.685	2892.75	43.1	4170	interpolated	
1	0.0007	12.4	0.693	3045	2.2	4218.6	Clark Y, Re=500'000	

Table 84: Single Analysis at 160 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.02496	0.011334	0	999999	0.01	0	31.00 !	0	160	2.198	298.1	131.2
0.05	0.016	0.02673	0.011299	0.122564	230.1798	11.83	31.57	57.00 !	0.81	160	2.192	319.2	130.8
0.1	0.032	0.026443	0.01122	0.245474	28.57034	23.57	52.72	47.00 !	1.62	160	2.176	315.8	129.88
0.15	0.048	0.02606	0.011217	0.368227	8.463414	34.85	66.73	42	2.44	160	2.176	311.2	129.85
0.2	0.064	0.025539	0.011245	0.490729	3.579243	45.43	76.07	36	3.25	160	2.181	305	130.17
0.25	0.08	0.024948	0.011282	0.613004	1.838674	55.28	82.38	26	4.06	160	2.188	298	130.6
0.3	0.095	0.024218	0.011357	0.734625	1.071162	63.97	86.75	15	4.87	160	2.203	289.2	131.47
0.35	0.111	0.023336	0.011448	0.855697	0.679949	71.34	89.87	0	5.68	160	2.22	278.7	132.53
0.4	0.127	0.022034	0.011455	0.977821	0.455788	76.94	92.24	0	6.5	160	2.222	263.2	132.61
0.45	0.143	0.019472	0.010895	1.111126	0.304473	80.42	94.29	0	7.31	160	2.113	232.6	126.13
0.5	0.159	0.016267	0.009845	1.259861	0.20057	82.61	95.97	0	8.12	160	1.91	194.3	113.97
0.55	0.175	0.01299	0.008526	1.426311	0.130495	83.8	97.24	0	8.93	160	1.654	155.1	98.7
0.6	0.191	0.009648	0.006926	1.622002	0.081656	83.58	98.23	0	9.74	160	1.343	115.2	80.18
0.61	0.194	0.008972	0.006571	1.66647	0.073724	83.28	98.4	0	9.91	160	1.275	107.2	76.07
0.62	0.197	0.008296	0.006206	1.713283	0.06631	82.88	98.56	0	10.07	160	1.204	99.1	71.84
0.63	0.201	0.007615	0.005828	1.762954	0.059349	82.32	98.71	0	10.23	160	1.13	90.9	67.46
0.64	0.204	0.006933	0.005438	1.815899	0.052825	81.59	98.86	0	10.39	160	1.055	82.8	62.95
0.65	0.207	0.006247	0.005035	1.872884	0.046689	80.64	99	0	10.56	160	0.977	74.6	58.29
0.66	0.21	0.005559	0.004621	1.934654	0.040927	79.4	99.13	0	10.72	160	0.896	66.4	53.49
0.67	0.213	0.004871	0.004195	2.002316	0.035516	77.79	99.26	0	10.88	160	0.814	58.2	48.56
0.68	0.216	0.00418	0.003757	2.077532	0.030424	75.66	99.38	0	11.04	160	0.729	49.9	43.49
0.69	0.22	0.003484	0.003305	2.162844	0.025616	72.75	99.49	0	11.21	160	0.641	41.6	38.25
0.7	0.223	0.002786	0.002839	2.261804	0.02108	68.68	99.6	0	11.37	160	0.551	33.3	32.87
0.71	0.226	0.002089	0.002365	2.379619	0.016824	62.73	99.71	0	11.53	160	0.459	25	27.37
0.72	0.229	0.001387	0.001875	2.527757	0.012792	53.27	99.81	0	11.69	160	0.364	16.6	21.7
0.73	0.232	0.000689	0.001377	2.726089	0.009013	36.53	99.91	0	11.86	160	0.267	8.2	15.94
0.74	0.236	-1.9E-05	0.000861	3.035694	0.005409	0	99.99	0	12.02	160	0.167	-0.2	9.96
0.75	0.239	-0.00073	0.000333	3.720056	0.002011	0	99.99	0	12.18	160	0.065	-8.7	3.86
0.76	0.242	-0.00143	-0.0002	4.162078	-0.00118	0.12	55.87	0	12.34	160	-0.039	-17.1	-2.35

Table 85: Multi Analysis at 16 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	3	0.658	0.02287	28.78	26294	0.025	0.00439	0.00531	0	0	0.1	0.2	0.00288	0.00073	0.0084	0.0025
0.1	3	0.659	0.02289	28.79	83794	0.028	0.015	0.04231	0.57631	0.32019	1.5	3	0.00288	0.00066	0.0084	0.00229
0.15	3	0.659	0.02289	28.79	141375	0.032	0.02586	0.03209	0.50437	0.42455	1.7	3.3	0.00283	0.00059	0.00837	0.00208
0.2	3	0.659	0.02289	28.79	186043	0.038	0.03442	0.02403	0.43856	0.49214	1.7	3.3	0.00274	0.00052	0.0083	0.00187
0.25	3	0.659	0.02288	28.79	217731	0.044	0.04059	0.01821	0.38366	0.53597	1.6	3.1	0.00262	0.00045	0.00816	0.00167
0.3	3	0.659	0.02289	28.79	239657	0.051	0.04498	0.01409	0.33919	0.56528	1.5	2.8	0.00248	0.00039	0.00796	0.00147
0.35	3	0.659	0.02289	28.79	254757	0.057	0.0481	0.01115	0.30319	0.58539	1.4	2.6	0.00232	0.00033	0.0077	0.00127
0.4	3	0.659	0.02289	28.79	265074	0.064	0.05038	0.00901	0.27384	0.5997	1.3	2.4	0.00214	0.00028	0.00737	0.00109
0.45	3	0.659	0.02289	28.79	271898	0.071	0.05208	0.00741	0.24964	0.61018	1.2	2.2	0.00196	0.00023	0.00697	0.00092
0.5	3	0.659	0.02289	28.79	275984	0.079	0.05336	0.0062	0.22945	0.61807	1.1	2	0.00178	0.00018	0.00651	0.00075
0.55	3	0.659	0.02289	28.79	277714	0.086	0.05436	0.00527	0.21241	0.62415	1	1.9	0.00158	0.00014	0.00599	0.0006
0.6	3	0.659	0.02289	28.79	277181	0.093	0.05515	0.00453	0.19785	0.62892	0.9	1.8	0.00139	0.00011	0.00542	0.00047
0.65	3	0.659	0.02289	28.79	274233	0.1	0.05578	0.00393	0.18531	0.63273	0.9	1.7	0.00119	0.00008	0.00479	0.00035
0.7	3	0.659	0.02289	28.79	268460	0.107	0.0563	0.00345	0.17439	0.63583	0.8	1.6	0.00099	0.00006	0.00412	0.00025
0.75	3	0.659	0.02289	28.79	259147	0.115	0.05672	0.00306	0.16481	0.63839	0.8	1.5	0.0008	0.00004	0.00341	0.00016
0.8	3	0.659	0.02289	28.79	245134	0.122	0.05707	0.00273	0.15634	0.64052	0.8	1.4	0.00061	0.00002	0.00268	0.00009
0.85	3	0.659	0.02289	28.79	224522	0.13	0.05737	0.00245	0.14881	0.64231	0.7	1.4	0.00043	0.00001	0.00193	0.00004
0.9	3	0.659	0.02289	28.79	193837	0.137	0.05762	0.00221	0.14207	0.64383	0.7	1.3	0.00026	0	0.00121	0.00001
0.95	3	0.659	0.02289	28.79	144839	0.144	0.05787	0.00201	0.13602	0.64525	0.7	1.2	0.00012	0	0.00055	0
1	3	0.659	0.0229	28.79	7614	0.152	0.05812	0.00181	0.12996	0.64667	0.6	1.2	0.00001	0	0.00003	0

Table 86: Input values at 140 rpm

Diameter D	6.09 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	140 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
square tip			
Propeller			
v/(nD)	0.563	v/(ΩR)	0.179
Efficiency η	83.19%	loading	low
Thrust T	199.99 N	Ct	0.0219
Power P	1.92 kW	Cp	0.0148
β at 75%R	17.3°	Pitch H	4.46 m

Table 87: Propeller Geometry at 140 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	0.0142	78.3	0.758	152.25	43.3	4617.6	interpolated
0.1	0.0432	65.3	0.683	304.5	131.5	4161.1	interpolated
0.15	0.0671	54.8	0.668	456.75	204.3	4066.4	interpolated
0.2	0.0798	46.6	0.665	609	243.1	4047.9	interpolated
0.25	0.0839	40.3	0.666	761.25	255.4	4058.1	interpolated
0.3	0.0829	35.4	0.67	913.5	252.3	4082	Clark Y, Re=500'000
0.35	0.0793	31.6	0.675	1065.75	241.6	4113.6	Clark Y, Re=500'000
0.4	0.0747	28.5	0.681	1218	227.5	4150	interpolated
0.45	0.0698	25.9	0.688	1370.25	212.5	4189.5	interpolated
0.5	0.0648	23.9	0.695	1522.5	197.4	4231.1	interpolated
0.55	0.06	22.1	0.702	1674.75	182.7	4274.4	interpolated
0.6	0.0553	20.6	0.709	1827	168.4	4318.8	interpolated
0.65	0.0508	19.3	0.717	1979.25	154.6	4364.1	Clark Y, Re=500'000
0.7	0.0463	18.2	0.724	2131.5	140.9	4410.1	Clark Y, Re=500'000
0.75	0.0417	17.3	0.732	2283.75	127	4456.6	interpolated
0.8	0.037	16.4	0.74	2436	112.6	4503.7	interpolated
0.85	0.0318	15.6	0.747	2588.25	96.8	4551	interpolated
0.9	0.0259	15	0.755	2740.5	78.7	4598.7	interpolated
0.95	0.0182	14.3	0.763	2892.75	55.5	4646.7	interpolated
1	0.0096	13.8	0.771	3045	29.1	4694.9	Clark Y, Re=500'000

Table 88: Single Analysis at 140 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.032967	0.017053	0	999999	0.01	0	36.00 !	0	140	2.216	301.5	151.14
0.05	0.016	0.034978	0.017334	0.112509	353.1311	10.09	28.23	68.00 !	0.71	140	2.252	319.8	153.63
0.1	0.032	0.034684	0.017122	0.225574	43.60072	20.26	48.14	57.00 !	1.42	140	2.225	317.2	151.75
0.15	0.048	0.034324	0.017046	0.338664	12.86109	30.2	62.03	52	2.13	140	2.215	313.9	151.07
0.2	0.064	0.033796	0.017003	0.451777	5.412299	39.75	71.75	47	2.84	140	2.209	309	150.7
0.25	0.08	0.033252	0.016967	0.564964	2.765139	49	78.57	36	3.55	140	2.205	304.1	150.37
0.3	0.095	0.032572	0.017	0.677694	1.603303	57.48	83.46	26	4.26	140	2.209	297.8	150.67
0.35	0.111	0.031739	0.017077	0.789929	1.014231	65.05	87.04	15	4.97	140	2.219	290.2	151.35
0.4	0.127	0.03072	0.017158	0.901917	0.682696	71.62	89.72	0	5.68	140	2.229	280.9	152.07
0.45	0.143	0.029391	0.017195	1.014221	0.480509	76.92	91.8	0	6.39	140	2.234	268.8	152.4
0.5	0.159	0.026756	0.016626	1.134519	0.338704	80.46	93.66	0	7.1	140	2.16	244.7	147.36
0.55	0.175	0.0229	0.015225	1.270142	0.233026	82.73	95.31	0	7.82	140	1.978	209.4	134.94
0.6	0.191	0.018906	0.013469	1.419979	0.158794	84.22	96.63	0	8.53	140	1.75	172.9	119.38
0.65	0.207	0.014835	0.011376	1.591174	0.105482	84.77	97.67	0	9.24	140	1.478	135.7	100.82
0.7	0.223	0.01069	0.008931	1.798522	0.066307	83.78	98.51	0	9.95	140	1.16	97.8	79.16
0.71	0.226	0.009853	0.0084	1.846747	0.059761	83.29	98.66	0	10.09	140	1.091	90.1	74.44
0.72	0.229	0.009014	0.007854	1.898096	0.053581	82.64	98.8	0	10.23	140	1.02	82.4	69.61
0.73	0.232	0.008172	0.007293	1.953201	0.047737	81.8	98.94	0	10.37	140	0.948	74.7	64.63
0.74	0.236	0.007326	0.006716	2.012825	0.042206	80.72	99.07	0	10.52	140	0.873	67	59.53
0.75	0.239	0.006475	0.006123	2.078109	0.036959	79.31	99.19	0	10.66	140	0.796	59.2	54.27
0.76	0.242	0.005623	0.005516	2.150254	0.031998	77.47	99.32	0	10.8	140	0.717	51.4	48.89
0.77	0.245	0.00477	0.004895	2.231193	0.027305	75.03	99.43	0	10.94	140	0.636	43.6	43.39
0.78	0.248	0.003915	0.00426	2.323926	0.022857	71.7	99.54	0	11.08	140	0.553	35.8	37.75
0.79	0.251	0.003059	0.003609	2.433006	0.018641	66.95	99.65	0	11.23	140	0.469	28	31.99
0.8	0.255	0.002196	0.002941	2.566735	0.014629	59.74	99.75	0	11.37	140	0.382	20.1	26.07
0.81	0.258	0.001328	0.002255	2.740599	0.010806	47.71	99.85	0	11.51	140	0.293	12.1	19.99
0.82	0.261	0.000456	0.001553	2.989555	0.00717	24.1	99.95	0	11.65	140	0.202	4.2	13.76
0.83	0.264	-0.00041	0.000844	3.418332	0.003759	0	99.99	0	11.79	140	0.11	-3.7	7.48
0.84	0.267	-0.00127	0.000119	5.117696	0.000512	0	99.99	0	11.94	140	0.015	-11.6	1.06
0.85	0.271	-0.00216	-0.00064	3.703528	-0.00264	0.26	55.25	0	12.08	140	-0.083	-19.7	-5.64

Table 89: Multi Analysis at 140 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	3	0.658	0.02287	28.78	24697	0.024	0.00353	0.00437	0	0	0.1	0.1	0.00431	0.00111	0.01133	0.00344
0.1	3	0.659	0.02289	28.79	82388	0.027	0.01279	0.04754	0.59409	0.28604	1.5	3	0.00431	0.00101	0.01133	0.00316
0.15	3	0.659	0.02289	28.79	145734	0.031	0.02318	0.03777	0.53176	0.38959	1.8	3.5	0.00424	0.0009	0.0113	0.00287
0.2	3	0.659	0.02289	28.79	199244	0.035	0.03214	0.02937	0.47094	0.46125	1.8	3.5	0.00412	0.0008	0.01121	0.00259
0.25	3	0.659	0.02289	28.79	239765	0.04	0.03906	0.02289	0.41749	0.51014	1.8	3.4	0.00396	0.0007	0.01104	0.00232
0.3	3	0.659	0.02288	28.79	269118	0.046	0.04419	0.01806	0.37245	0.54385	1.7	3.2	0.00375	0.0006	0.0108	0.00205
0.35	3	0.659	0.02288	28.79	289962	0.052	0.04799	0.01449	0.33502	0.56768	1.5	3	0.00352	0.00052	0.01046	0.00179
0.4	3	0.659	0.02289	28.79	304485	0.057	0.05084	0.01182	0.30391	0.58494	1.4	2.7	0.00327	0.00044	0.01003	0.00153
0.45	3	0.659	0.02289	28.79	314208	0.063	0.05299	0.0098	0.27788	0.59777	1.3	2.5	0.003	0.00036	0.00951	0.0013
0.5	3	0.659	0.02289	28.79	320091	0.07	0.05466	0.00824	0.25593	0.60752	1.2	2.4	0.00272	0.00029	0.00891	0.00107
0.55	3	0.659	0.02289	28.79	322662	0.076	0.05596	0.00702	0.23723	0.61508	1.2	2.2	0.00243	0.00023	0.00823	0.00087
0.6	3	0.659	0.02289	28.79	322113	0.082	0.057	0.00605	0.22116	0.62106	1.1	2.1	0.00214	0.00018	0.00746	0.00068
0.65	3	0.659	0.02289	28.79	318338	0.088	0.05783	0.00527	0.20724	0.62586	1	2	0.00184	0.00013	0.00664	0.00052
0.7	3	0.659	0.02289	28.79	310944	0.095	0.05852	0.00463	0.19507	0.62978	1	1.9	0.00155	0.00009	0.00575	0.00037
0.75	3	0.659	0.02289	28.79	299196	0.101	0.05908	0.0041	0.18435	0.63301	0.9	1.8	0.00126	0.00006	0.00481	0.00025
0.8	3	0.659	0.02289	28.79	281878	0.107	0.05956	0.00366	0.17486	0.63571	0.9	1.7	0.00097	0.00004	0.00384	0.00016
0.85	3	0.659	0.02289	28.79	256965	0.114	0.05996	0.00329	0.16639	0.63799	0.8	1.6	0.00071	0.00002	0.00287	0.00008
0.9	3	0.659	0.02289	28.79	220700	0.12	0.0603	0.00297	0.15879	0.63993	0.8	1.5	0.00046	0.00001	0.00192	0.00004
0.95	3	0.659	0.02289	28.79	164014	0.127	0.06059	0.0027	0.15195	0.64159	0.8	1.5	0.00025	0	0.00107	0.00001
1	3	0.659	0.02289	28.79	90344	0.133	0.06088	0.00243	0.1451	0.64326	0.7	1.4	0.00009	0	0.00039	0

Table 90: Input values at 120 rpm

Diameter D	6.09 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation	120 [1/min]		
Velocity v	8 [m/s]		
Number of Blades	2 [-]		
square tip			
Propeller			
v/(nD)	0.657	v/(ΩR)	0.209
Efficiency η	83.89%	loading	low
Thrust T	199.99 N	Ct	0.0298
Power P	1.91 kW	Cp	0.0233
β at 75%R	19.6°	Pitch H	5.1 m

Table 91: Propeller Geometry at 120 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil	
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]		
0	Spinner	-	-	-	-	-	-	
0.05	0.0134	80.4	0.927	152.25	40.8	5644.8	interpolated	
0.1	0.0435	68.9	0.813	304.5	132.4	4953.2	interpolated	
0.15	0.0727	59.1	0.788	456.75	221.4	4798	interpolated	
0.2	0.0923	51.2	0.78	609	281	4751.8	interpolated	
0.25	0.1019	44.8	0.779	761.25	310.4	4746.1	interpolated	
0.3	0.1045	39.7	0.782	913.5	318.3	4759.7	Clark Y, Re=500'000	
0.35	0.1028	35.5	0.786	1065.75	313.2	4784.1	Clark Y, Re=500'000	
0.4	0.0988	32.2	0.791	1218	300.8	4815.2	interpolated	
0.45	0.0935	29.4	0.796	1370.25	284.8	4850.6	interpolated	
0.5	0.0877	27.1	0.803	1522.5	267.1	4889	interpolated	
0.55	0.0817	25.1	0.809	1674.75	248.8	4929.6	interpolated	
0.6	0.0756	23.4	0.816	1827	230.3	4971.8	interpolated	
0.65	0.0696	22	0.824	1979.25	211.8	5015.2	Clark Y, Re=500'000	
0.7	0.0634	20.7	0.831	2131.5	193.1	5059.7	Clark Y, Re=500'000	
0.75	0.0571	19.6	0.838	2283.75	173.8	5104.9	interpolated	
0.8	0.0505	18.6	0.846	2436	153.7	5150.7	interpolated	
0.85	0.0433	17.7	0.853	2588.25	131.8	5197	interpolated	
0.9	0.0351	16.9	0.861	2740.5	106.7	5243.8	interpolated	
0.95	0.0246	16.2	0.869	2892.75	75	5290.9	interpolated	
1	0.0128	15.6	0.877	3045	38.9	5338.4	Clark Y, Re=500'000	

Table92: Single Analysis at 120 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.045184	0.027398	0	999999	0.01	0	47.00 !	0	120	2.242	303.5	178.4
0.05	0.016	0.047591	0.028472	0.101879	580.0273	8.36	24.74	89.00 !	0.61	120	2.33	319.7	185.4
0.1	0.032	0.040994	0.02309	0.212479	58.79803	17.75	45.4	78.00 !	1.22	120	1.889	275.4	150.35
0.15	0.048	0.046788	0.027796	0.307111	20.97237	25.25	56.65	68.00 !	1.83	120	2.274	314.3	180.99
0.2	0.064	0.046328	0.027458	0.410482	8.740312	33.74	66.55	57	2.44	120	2.247	311.2	178.8
0.25	0.08	0.04576	0.027245	0.513906	4.44018	41.99	73.84	47	3.04	120	2.229	307.4	177.4
0.3	0.095	0.045167	0.027226	0.616771	2.567818	49.77	79.24	42	3.65	120	2.228	303.4	177.28
0.35	0.111	0.044463	0.027229	0.719553	1.617192	57.15	83.3	31	4.26	120	2.228	298.7	177.3
0.4	0.127	0.043599	0.027305	0.821887	1.086424	63.87	86.41	21	4.87	120	2.234	292.9	177.8
0.45	0.143	0.042538	0.027393	0.924025	0.765504	69.88	88.84	0	5.48	120	2.241	285.8	178.37
0.5	0.159	0.04113	0.027415	1.026535	0.558485	75.01	90.79	0	6.09	120	2.243	276.3	178.51
0.55	0.175	0.039232	0.027277	1.130324	0.417495	79.1	92.41	0	6.7	120	2.232	263.6	177.62
0.6	0.191	0.035368	0.025944	1.245501	0.305859	81.79	93.99	0	7.31	120	2.123	237.6	168.93
0.65	0.207	0.030447	0.023651	1.374501	0.219302	83.68	95.41	0	7.92	120	1.935	204.5	154
0.7	0.223	0.025429	0.020947	1.516611	0.155513	84.98	96.58	0	8.53	120	1.714	170.8	136.4
0.75	0.239	0.02032	0.017819	1.678367	0.107554	85.53	97.54	0	9.14	120	1.458	136.5	116.03
0.8	0.255	0.015127	0.014254	1.871984	0.070894	84.9	98.35	0	9.74	120	1.166	101.6	92.82
0.81	0.258	0.014079	0.013488	1.91644	0.06463	84.55	98.49	0	9.87	120	1.104	94.6	87.83
0.82	0.261	0.013027	0.012704	1.963488	0.058671	84.09	98.63	0	9.99	120	1.039	87.5	82.72
0.83	0.264	0.011972	0.011901	2.013546	0.053002	83.5	98.76	0	10.11	120	0.974	80.4	77.49
0.84	0.267	0.010914	0.01108	2.067143	0.047604	82.74	98.89	0	10.23	120	0.907	73.3	72.15
0.85	0.271	0.009854	0.010241	2.124947	0.042466	81.78	99.02	0	10.35	120	0.838	66.2	66.69
0.86	0.274	0.00879	0.009384	2.18788	0.037568	80.56	99.14	0	10.47	120	0.768	59	61.1
0.87	0.277	0.007718	0.008503	2.257369	0.032883	78.96	99.26	0	10.6	120	0.696	51.8	55.37
0.88	0.28	0.006642	0.007603	2.334994	0.02841	76.87	99.37	0	10.72	120	0.622	44.6	49.51
0.89	0.283	0.005564	0.006686	2.423045	0.02415	74.07	99.49	0	10.84	120	0.547	37.4	43.53
0.9	0.286	0.004486	0.005751	2.525219	0.020088	70.2	99.59	0	10.96	120	0.471	30.1	37.45
0.91	0.29	0.003407	0.004799	2.647371	0.016216	64.6	99.7	0	11.08	120	0.393	22.9	31.25
0.92	0.293	0.002324	0.003827	2.800313	0.012517	55.86	99.8	0	11.21	120	0.313	15.6	24.92
0.93	0.296	0.001231	0.00283	3.006926	0.00896	40.45	99.89	0	11.33	120	0.232	8.3	18.43
0.94	0.299	0.000148	0.001826	3.317672	0.005598	7.64	99.99	0	11.45	120	0.149	1	11.89
0.95	0.302	-0.00095	0.000786	3.968272	0.002336	0	99.99	0	11.57	120	0.064	-6.4	5.12
0.96	0.306	-0.00206	-0.00027	4.957358	-0.00078	0.08	54.48	0	11.69	120	-0.022	-13.8	-1.77

Table 93: Multi Analysis at 120 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	3	0.658	0.02287	28.78	23058	0.024	0.00275	0.00351	0	0	0	0.1	0.00672	0.00175	0.01541	0.0047
0.1	3	0.659	0.02289	28.79	80269	0.026	0.01055	0.05416	0.61076	0.24846	1.5	2.9	0.00672	0.00159	0.01541	0.00431
0.15	3	0.659	0.02289	28.79	149018	0.029	0.02019	0.04517	0.5597	0.34841	1.8	3.6	0.00663	0.00142	0.01537	0.00393
0.2	3	0.659	0.02289	28.79	212624	0.032	0.02931	0.03666	0.50602	0.42248	2	3.8	0.00647	0.00126	0.01527	0.00355
0.25	3	0.659	0.02288	28.79	264582	0.037	0.03692	0.02954	0.45591	0.47604	2	3.8	0.00623	0.0011	0.01507	0.00317
0.3	3	0.659	0.02288	28.79	304453	0.041	0.04293	0.02391	0.41165	0.51469	1.9	3.6	0.00592	0.00096	0.01475	0.0028
0.35	3	0.659	0.02288	28.79	333982	0.046	0.04759	0.01954	0.37356	0.54294	1.8	3.4	0.00557	0.00082	0.01431	0.00244
0.4	3	0.659	0.02288	28.79	355197	0.051	0.05123	0.01617	0.34109	0.56405	1.7	3.2	0.00518	0.00069	0.01374	0.0021
0.45	3	0.659	0.02289	28.79	369756	0.056	0.05405	0.01355	0.31333	0.57996	1.6	3	0.00475	0.00057	0.01304	0.00177
0.5	3	0.659	0.02288	28.79	378831	0.061	0.05622	0.01148	0.28951	0.59212	1.5	2.8	0.00431	0.00046	0.01222	0.00147
0.55	3	0.659	0.02288	28.79	383144	0.066	0.05798	0.00984	0.269	0.60175	1.4	2.7	0.00385	0.00036	0.01128	0.00119
0.6	3	0.659	0.02288	28.79	383030	0.071	0.0594	0.00852	0.25121	0.60942	1.3	2.5	0.00338	0.00028	0.01023	0.00093
0.65	3	0.659	0.02289	28.79	378483	0.077	0.06056	0.00745	0.23567	0.61563	1.3	2.4	0.00291	0.00021	0.00909	0.0007
0.7	3	0.659	0.02289	28.79	369155	0.082	0.06151	0.00656	0.22201	0.62071	1.2	2.2	0.00244	0.00015	0.00786	0.00051
0.75	3	0.659	0.02289	28.79	354310	0.087	0.06231	0.00583	0.20992	0.62493	1.1	2.1	0.00198	0.0001	0.00656	0.00034
0.8	3	0.659	0.02289	28.79	332667	0.093	0.06297	0.00521	0.19915	0.62847	1.1	2	0.00153	0.00006	0.00523	0.00021
0.85	3	0.659	0.02289	28.79	302027	0.098	0.06354	0.00468	0.18952	0.63146	1	1.9	0.0011	0.00003	0.0039	0.00011
0.9	3	0.659	0.02289	28.79	258214	0.104	0.06402	0.00424	0.18085	0.63401	1	1.9	0.00072	0.00001	0.00261	0.00005
0.95	3	0.659	0.02289	28.79	190954	0.109	0.06444	0.00385	0.17301	0.63621	0.9	1.8	0.00038	0	0.00144	0.00001
1	3	0.659	0.02289	28.79	104038	0.115	0.06485	0.00346	0.16518	0.63841	0.9	1.7	0.00014	0	0.00052	0

Table 94: Input values at 100 rpm

Diameter D	6.09 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation	100 [1/min]		
Velocity v	8 [m/s]		
Number of Blades	2 [-]		
square tip			
Propeller			
v/(nD)	0.788	v/(ΩR)	0.251
Efficiency η	84.33%	loading	low
Thrust T	200 N	Ct	0.0429
Power P	1.9 kW	Cp	0.0401
β at 75%R	22.8°	Pitch H	6.03 m

Table 95: Propeller Geometry at 100rpm

r/R	c/R	β	H/D	r	c	H	Airfoil	
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]		
0	Spinner	-	-	-	-	-	-	
0.05	0.0126	82.5	1.195	152.25	38.3	7275.4	interpolated	
0.1	0.0432	72.7	1.007	304.5	131.6	6134.5	interpolated	
0.15	0.0778	63.9	0.964	456.75	236.8	5870.4	interpolated	
0.2	0.1059	56.5	0.948	609	322.5	5775.3	interpolated	
0.25	0.1242	50.2	0.943	761.25	378.2	5741.8	interpolated	
0.3	0.1336	45	0.942	913.5	406.7	5737.6	Clark Y, Re=500'000	
0.35	0.1363	40.6	0.944	1065.75	415	5749.5	Clark Y, Re=500'000	
0.4	0.1346	37	0.948	1218	409.9	5771.4	interpolated	
0.45	0.1301	34	0.952	1370.25	396.2	5799.7	interpolated	
0.5	0.1239	31.4	0.958	1522.5	377.3	5832.6	interpolated	
0.55	0.1167	29.1	0.964	1674.75	355.3	5868.6	interpolated	
0.6	0.1088	27.2	0.97	1827	331.4	5907.1	interpolated	
0.65	0.1006	25.6	0.977	1979.25	306.2	5947.4	Clark Y, Re=500'000	
0.7	0.0919	24.1	0.983	2131.5	279.9	5989.1	Clark Y, Re=500'000	
0.75	0.0829	22.8	0.99	2283.75	252.3	6032	interpolated	
0.8	0.0732	21.7	0.998	2436	223	6075.8	interpolated	
0.85	0.0627	20.6	1.005	2588.25	191	6120.3	interpolated	
0.9	0.0507	19.7	1.012	2740.5	154.3	6165.5	interpolated	
0.95	0.0355	18.9	1.02	2892.75	108.1	6211.2	interpolated	
1	0.0183	18.1	1.027	3045	55.7	6257.4	Clark Y, Re=500'000	

Table 96: Single Analysis at 100rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.064933	0.047855	0	999999	0	0	57.00 !	0	100	2.266	302.9	216.4
0.05	0.016	0.068507	0.050498	0.090848	1028.745	6.78	21.06	100.00 !	0.51	100	2.391	319.6	228.35
0.1	0.032	0.067975	0.050278	0.181855	128.0317	13.52	37.55	100.00 !	1.02	100	2.381	317.1	227.35
0.15	0.048	0.067351	0.049769	0.273338	37.55114	20.3	50.37	94.00 !	1.52	100	2.357	314.2	225.05
0.2	0.064	0.066563	0.049198	0.365292	15.66032	27.06	60.29	89	2.03	100	2.33	310.5	222.47
0.25	0.08	0.065923	0.04843	0.458054	7.892894	34.03	67.91	78	2.54	100	2.293	307.6	219
0.3	0.095	0.065267	0.047834	0.551028	4.51145	40.93	73.8	63	3.04	100	2.265	304.5	216.3
0.35	0.111	0.064645	0.047483	0.643814	2.820173	47.65	78.36	52	3.55	100	2.248	301.6	214.71
0.4	0.127	0.063983	0.04747	0.735827	1.888779	53.91	81.94	47	4.06	100	2.248	298.5	214.65
0.45	0.143	0.063256	0.047485	0.827755	1.326954	59.95	84.77	36	4.57	100	2.249	295.1	214.72
0.5	0.159	0.062372	0.047581	0.919356	0.969308	65.54	87.06	15	5.07	100	2.253	291	215.16
0.55	0.175	0.061186	0.047716	1.010716	0.730329	70.53	88.94	0	5.58	100	2.26	285.5	215.77
0.6	0.191	0.0595	0.047681	1.102764	0.56212	74.87	90.54	0	6.09	100	2.258	277.6	215.61
0.65	0.207	0.057452	0.04753	1.195417	0.440726	78.57	91.89	0	6.6	100	2.251	268	214.93
0.7	0.223	0.053785	0.046327	1.293993	0.343935	81.27	93.19	0	7.1	100	2.194	250.9	209.48
0.75	0.239	0.047707	0.043027	1.40706	0.259716	83.16	94.53	0	7.61	100	2.037	222.6	194.56
0.8	0.255	0.041358	0.03909	1.529947	0.194419	84.64	95.68	0	8.12	100	1.851	192.9	176.76
0.85	0.271	0.034899	0.034623	1.665508	0.143563	85.68	96.66	0	8.63	100	1.639	162.8	156.56
0.9	0.286	0.028336	0.029611	1.819498	0.103435	86.13	97.51	0	9.14	100	1.402	132.2	133.9
0.95	0.302	0.021671	0.02404	2.002336	0.071401	85.64	98.24	0	9.64	100	1.138	101.1	108.71
0.96	0.306	0.020325	0.022857	2.043938	0.065788	85.37	98.38	0	9.74	100	1.082	94.8	103.36
0.97	0.309	0.018977	0.021652	2.087721	0.060412	85.02	98.51	0	9.85	100	1.025	88.5	97.91
0.98	0.312	0.017625	0.020424	2.134021	0.055258	84.57	98.63	0	9.95	100	0.967	82.2	92.35
0.99	0.315	0.016269	0.019173	2.183228	0.050317	84.01	98.76	0	10.05	100	0.908	75.9	86.7
1	0.318	0.014908	0.017897	2.235852	0.045575	83.3	98.88	0	10.15	100	0.847	69.6	80.93
1.01	0.321	0.013544	0.016599	2.292472	0.041026	82.41	99	0	10.25	100	0.786	63.2	75.06
1.02	0.325	0.012175	0.015276	2.353943	0.036657	81.29	99.11	0	10.35	100	0.723	56.8	69.08
1.03	0.328	0.010804	0.013931	2.42124	0.032466	79.88	99.22	0	10.45	100	0.66	50.4	63
1.04	0.331	0.009429	0.012563	2.495835	0.02844	78.06	99.33	0	10.56	100	0.595	44	56.81
1.05	0.334	0.008039	0.011158	2.580326	0.024544	75.65	99.44	0	10.66	100	0.528	37.5	50.45
1.06	0.337	0.006653	0.009738	2.676795	0.02082	72.42	99.54	0	10.76	100	0.461	31	44.03
1.07	0.341	0.005266	0.008295	2.79009	0.017243	67.92	99.64	0	10.86	100	0.393	24.6	37.51
1.08	0.344	0.003865	0.006818	2.928856	0.013782	61.22	99.74	0	10.96	100	0.323	18	30.83
1.09	0.347	0.002457	0.005312	3.107261	0.010445	50.41	99.84	0	11.06	100	0.252	11.5	24.02
1.1	0.35	0.001057	0.003795	3.353908	0.007261	30.65	99.93	0	11.17	100	0.18	4.9	17.16
1.11	0.353	-0.00035	0.002252	3.75661	0.004194	0	99.99	0	11.27	100	0.107	-1.6	10.18
1.12	0.357	-0.00177	0.00067	4.830773	0.001214	0	99.99	0	11.37	100	0.032	-8.2	3.03
1.13	0.36	-0.00317	-0.00091	4.584233	-0.00161	0.16	53.25	0	11.47	100	-0.043	-14.8	-4.12

Table 97: Multi Analysis at 100rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	3	0.658	0.02287	28.78	21430	0.024	0.00205	0.00274	0	0	0	0.1	0.01139	0.00302	0.02219	0.00682
0.1	3	0.659	0.02289	28.79	77498	0.025	0.00836	0.06321	0.6259	0.20747	1.4	2.8	0.01139	0.00273	0.02219	0.00626
0.15	3	0.659	0.02289	28.79	150868	0.027	0.01691	0.0553	0.58707	0.30002	1.9	3.7	0.01127	0.00245	0.02215	0.00571
0.2	3	0.659	0.02288	28.79	225440	0.03	0.02583	0.04702	0.54294	0.37374	2.1	4.1	0.01103	0.00218	0.02203	0.00516
0.25	3	0.659	0.02288	28.79	291825	0.033	0.03399	0.03946	0.49886	0.43075	2.2	4.2	0.01067	0.00191	0.02178	0.00461
0.3	3	0.659	0.02288	28.79	346541	0.037	0.04095	0.03301	0.45761	0.47428	2.2	4.2	0.01019	0.00166	0.02137	0.00408
0.35	3	0.659	0.02288	28.78	389447	0.04	0.04667	0.02768	0.42036	0.50748	2.1	4	0.00961	0.00142	0.02077	0.00356
0.4	3	0.659	0.02288	28.79	421737	0.044	0.05135	0.02338	0.38745	0.53314	2	3.9	0.00896	0.00119	0.01998	0.00306
0.45	3	0.659	0.02288	28.79	444857	0.048	0.05511	0.01989	0.35848	0.55304	1.9	3.7	0.00825	0.00099	0.019	0.00259
0.5	3	0.659	0.02288	28.79	460056	0.052	0.05816	0.01707	0.33309	0.56873	1.8	3.5	0.00749	0.0008	0.01782	0.00214
0.55	3	0.659	0.02288	28.79	468228	0.057	0.0606	0.01476	0.31076	0.58115	1.7	3.3	0.00669	0.00063	0.01647	0.00173
0.6	3	0.659	0.02288	28.79	469894	0.061	0.06264	0.01288	0.29113	0.59127	1.7	3.1	0.00588	0.00048	0.01494	0.00136
0.65	3	0.659	0.02288	28.79	465188	0.065	0.06433	0.01132	0.27379	0.59955	1.6	3	0.00505	0.00036	0.01327	0.00102
0.7	3	0.659	0.02288	28.79	453852	0.07	0.06574	0.01003	0.25838	0.60639	1.5	2.8	0.00423	0.00025	0.01147	0.00074
0.75	3	0.659	0.02289	28.79	435160	0.074	0.06692	0.00893	0.24464	0.6121	1.4	2.7	0.00342	0.00017	0.00957	0.0005
0.8	3	0.659	0.02289	28.79	407742	0.078	0.06793	0.00801	0.23232	0.61692	1.4	2.6	0.00264	0.0001	0.00762	0.00031
0.85	3	0.659	0.02288	28.79	369130	0.083	0.06874	0.00722	0.2212	0.62091	1.3	2.5	0.0019	0.00005	0.00566	0.00017
0.9	3	0.659	0.02288	28.79	314492	0.087	0.06948	0.00654	0.21118	0.62443	1.3	2.4	0.00123	0.00002	0.00378	0.00007
0.95	3	0.659	0.02289	28.79	231671	0.092	0.07012	0.00595	0.20207	0.62746	1.2	2.3	0.00066	0.00001	0.00208	0.00002
1	3	0.659	0.02289	28.79	125229	0.097	0.07076	0.00537	0.19297	0.63049	1.1	2.1	0.00023	0	0.00075	0

Table 98: Input at 80 rpm

Diameter D	6.09 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	80 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
square tip			
Propeller			
v/(nD)	0.985	v/(ΩR)	0.314
Efficiency η	84.21%	loading	low
Thrust T	200 N	Ct	0.067
Power P	1.9 kW	Cp	0.0784
β at 75%R	27.5°	Pitch H	7.47 m

Table 99: Propeller Geometry at 80 pm

r/R	c/R	β	H/D	r	c	H	Airfoil	
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]		
0	Spinner	-	-	-	-	-	-	
0.05	0.0118	84.7	1.687	152.25	35.9	10273.6	interpolated	
0.1	0.0425	76.7	1.329	304.5	129.5	8091.9	interpolated	
0.15	0.082	69.3	1.248	456.75	249.6	7599.9	interpolated	
0.2	0.1201	62.7	1.216	609	365.7	7405.7	interpolated	
0.25	0.1508	56.8	1.201	761.25	459.1	7316.7	interpolated	
0.3	0.1721	51.7	1.195	913.5	523.9	7277.1	Clark Y, Re=500'000	
0.35	0.1844	47.3	1.193	1065.75	561.6	7264.5	Clark Y, Re=500'000	
0.4	0.1895	43.5	1.193	1218	577	7268.3	interpolated	
0.45	0.189	40.2	1.196	1370.25	575.6	7282.8	interpolated	
0.5	0.1846	37.4	1.199	1522.5	562	7304.7	interpolated	
0.55	0.1772	34.9	1.204	1674.75	539.5	7332	interpolated	
0.6	0.1677	32.7	1.209	1827	510.7	7363.1	interpolated	
0.65	0.1567	30.7	1.215	1979.25	477.1	7397.3	Clark Y, Re=500'000	
0.7	0.1444	29	1.221	2131.5	439.7	7433.8	Clark Y, Re=500'000	
0.75	0.1309	27.5	1.227	2283.75	398.6	7472.2	interpolated	
0.8	0.1161	26.1	1.234	2436	353.6	7512	interpolated	
0.85	0.0997	24.9	1.24	2588.25	303.5	7553.1	interpolated	
0.9	0.0806	23.8	1.247	2740.5	245.5	7595.3	interpolated	
0.95	0.0565	22.8	1.254	2892.75	172	7638.2	interpolated	
1	0.0291	21.9	1.261	3045	88.6	7682	Clark Y, Re=500'000	

Table 100: Single Analysis at 80 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.099501	0.094746	0	999999	0	0	78.00 !	0	80	2.297	297.1	274.2
0.1	0.032	0.104359	0.099358	0.158694	253.012	10.5	31.56	100.00 !	0.81	80	2.409	311.6	287.54
0.2	0.064	0.103277	0.098111	0.31819	31.22961	21.05	52.59	100.00 !	1.62	80	2.379	308.4	283.93
0.3	0.095	0.077375	0.06668	0.51561	6.288894	34.81	71.07	100	2.44	80	1.617	231	192.97
0.4	0.127	0.099139	0.093769	0.642168	3.730933	42.29	75.78	78	3.25	80	2.273	296	271.37
0.5	0.159	0.097815	0.092859	0.804277	1.891702	52.67	81.84	57	4.06	80	2.251	292.1	268.73
0.6	0.191	0.096766	0.093148	0.964532	1.098143	62.33	85.95	31	4.87	80	2.258	288.9	269.57
0.7	0.223	0.094792	0.093908	1.123459	0.697189	70.66	88.92	0	5.68	80	2.277	283	271.77
0.8	0.255	0.090372	0.093563	1.2849	0.465343	77.27	91.26	0	6.5	80	2.268	269.8	270.77
0.9	0.286	0.080933	0.08911	1.459678	0.311272	81.74	93.35	0	7.31	80	2.16	241.7	257.89
1	0.318	0.064525	0.076304	1.672978	0.194307	84.56	95.4	0	8.12	80	1.85	192.7	220.83
1.1	0.35	0.047601	0.060742	1.926168	0.116213	86.2	97.01	0	8.93	80	1.473	142.1	175.79
1.2	0.382	0.030176	0.042297	2.259013	0.062332	85.61	98.32	0	9.74	80	1.025	90.1	122.41
1.22	0.388	0.026632	0.038253	2.343296	0.053644	84.94	98.55	0	9.91	80	0.927	79.5	110.7
1.24	0.395	0.023068	0.034086	2.437288	0.045525	83.92	98.77	0	10.07	80	0.826	68.9	98.64
1.26	0.401	0.019486	0.029799	2.544079	0.037934	82.39	98.98	0	10.23	80	0.722	58.2	86.24
1.28	0.407	0.015886	0.025391	2.668542	0.030831	80.08	99.19	0	10.39	80	0.616	47.4	73.48
1.3	0.414	0.012267	0.02086	2.818892	0.024179	76.45	99.38	0	10.56	80	0.506	36.6	60.37
1.32	0.42	0.008629	0.016205	3.010546	0.017942	70.29	99.58	0	10.72	80	0.393	25.8	46.9
1.34	0.427	0.004935	0.011373	3.280404	0.012037	58.15	99.76	0	10.88	80	0.276	14.7	32.91
1.36	0.433	0.001251	0.006452	3.729063	0.006532	26.36	99.94	0	11.04	80	0.156	3.7	18.67
1.38	0.439	-0.0025	0.001342	5.180086	0.0013	0	99.99	0	11.21	80	0.033	-7.5	3.88
1.4	0.446	-0.00622	-0.00384	4.259642	-0.00356	0.36	51.3	0	11.37	80	-0.093	-18.6	-11.1

Table 101: Multi Analysis at 80 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	3	0.658	0.02287	28.78	19917	0.024	0.00144	0.00207	0	0	0	0	0.02183	0.00592	0.03471	0.01081
0.1	3	0.659	0.02289	28.79	74380	0.025	0.00629	0.07714	0.63897	0.16312	1.4	2.8	0.02183	0.00538	0.03471	0.00994
0.15	3	0.659	0.02289	28.79	151302	0.026	0.01345	0.07059	0.61252	0.2438	1.9	3.8	0.02165	0.00483	0.03466	0.00907
0.2	3	0.659	0.02288	28.79	237050	0.028	0.02171	0.06304	0.58015	0.3129	2.3	4.4	0.02128	0.0043	0.03451	0.00821
0.25	3	0.659	0.02288	28.79	320854	0.03	0.03003	0.05541	0.54513	0.37029	2.5	4.8	0.02069	0.00378	0.03419	0.00735
0.3	3	0.659	0.02288	28.78	396119	0.032	0.03783	0.0483	0.51006	0.41714	2.5	4.9	0.01987	0.00329	0.03364	0.00651
0.35	3	0.658	0.02287	28.78	459774	0.035	0.04476	0.04195	0.47645	0.45501	2.6	4.9	0.01886	0.00282	0.03281	0.00569
0.4	3	0.658	0.02287	28.78	511007	0.038	0.05078	0.03645	0.44518	0.48563	2.5	4.8	0.01767	0.00237	0.03167	0.0049
0.45	3	0.658	0.02287	28.78	550158	0.041	0.05589	0.03175	0.41649	0.51037	2.5	4.7	0.01633	0.00197	0.03021	0.00415
0.5	3	0.658	0.02288	28.78	578001	0.044	0.06028	0.02779	0.39053	0.53061	2.4	4.5	0.01488	0.00159	0.02843	0.00344
0.55	3	0.658	0.02288	28.78	595307	0.047	0.06395	0.02442	0.36704	0.54714	2.3	4.3	0.01333	0.00126	0.02634	0.00278
0.6	3	0.658	0.02288	28.78	602647	0.051	0.06706	0.02158	0.34588	0.5608	2.2	4.2	0.01173	0.00097	0.02395	0.00218
0.65	3	0.658	0.02287	28.78	600256	0.054	0.06964	0.01916	0.32675	0.57209	2.1	4	0.0101	0.00072	0.0213	0.00165
0.7	3	0.658	0.02288	28.78	587956	0.057	0.07189	0.01711	0.30953	0.58165	2	3.8	0.00846	0.0005	0.01843	0.00118
0.75	3	0.659	0.02288	28.78	565003	0.061	0.07381	0.01536	0.29396	0.58973	2	3.7	0.00684	0.00033	0.01539	0.0008
0.8	3	0.659	0.02288	28.79	529847	0.064	0.07547	0.01386	0.27984	0.59663	1.9	3.5	0.00528	0.0002	0.01226	0.00049
0.85	3	0.659	0.02288	28.79	479536	0.068	0.07691	0.01255	0.26699	0.60255	1.8	3.4	0.0038	0.00011	0.00911	0.00027
0.9	3	0.659	0.02288	28.79	408077	0.071	0.0781	0.01142	0.25525	0.60755	1.7	3.2	0.00246	0.00004	0.00608	0.00011
0.95	3	0.659	0.02288	28.79	300057	0.075	0.07919	0.01043	0.24453	0.61199	1.7	3.1	0.00131	0.00001	0.00334	0.00003
1	3	0.659	0.02288	28.79	161944	0.078	0.08028	0.00944	0.23382	0.61643	1.6	3	0.00046	0	0.00121	0

Table 102: Input at 60 rpm

Diameter D	6.09 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	60 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	1.314	v/(ΩR)	0.418
Efficiency η	82.72%	loading	low
Thrust T	199.99 N	Ct	0.1191
Power P	1.93 kW	Cp	0.1891
β at 75%R	35°	Pitch H	10.04 m

Table 103: Propeller Geometry at 60 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]	
0	Spinner	-	-	-	-	-	-
0.05	0.0112	86.9	2.906	152.25	34.1	17697.3	interpolated
0.1	0.0421	80.9	1.972	304.5	128.1	12007.4	interpolated
0.15	0.086	75.2	1.789	456.75	262	10892.8	interpolated
0.2	0.1352	69.9	1.715	609	411.5	10442	interpolated
0.25	0.1825	64.9	1.677	761.25	555.6	10213.4	interpolated
0.3	0.2232	60.4	1.656	913.5	679.6	10086	Clark Y, Re=500'000
0.35	0.2549	56.2	1.644	1065.75	776.1	10013.2	Clark Y, Re=500'000
0.4	0.2769	52.5	1.638	1218	843.2	9973.1	interpolated
0.45	0.2898	49.1	1.635	1370.25	882.6	9954.2	interpolated
0.5	0.2947	46.1	1.634	1522.5	897.4	9949.8	interpolated
0.55	0.2928	43.4	1.635	1674.75	891.4	9955.8	interpolated
0.6	0.2851	41	1.637	1827	868.1	9969.5	interpolated
0.65	0.2727	38.8	1.64	1979.25	830.3	9989	Clark Y, Re=500'000
0.7	0.2562	36.8	1.644	2131.5	780	10013	Clark Y, Re=500'000
0.75	0.2359	35	1.649	2283.75	718.4	10040.6	interpolated
0.8	0.212	33.3	1.654	2436	645.4	10071.2	interpolated
0.85	0.1838	31.9	1.659	2588.25	559.6	10104.1	interpolated
0.9	0.1499	30.5	1.665	2740.5	456.4	10139	interpolated
0.95	0.1057	29.2	1.671	2892.75	321.7	10175.5	interpolated
1	0.0053	28.1	1.677	3045	16.1	10213.4	Clark Y, Re=500'000

Table 104: Single Analysis at 60 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.168787	0.22361	0	999999	0	0	100.00 !	0	60	2.287	283.5	364.01
0.1	0.032	0.169925	0.230796	0.134077	587.7161	7.36	25.56	100.00 !	0.61	60	2.361	285.4	375.71
0.2	0.064	0.171164	0.229726	0.268403	73.12399	14.9	43.96	100.00 !	1.22	60	2.35	287.5	373.97
0.3	0.095	0.171265	0.227515	0.403385	21.45782	22.58	57.22	100	1.83	60	2.327	287.6	370.37
0.4	0.127	0.170121	0.224347	0.539357	8.926486	30.33	66.86	100	2.44	60	2.295	285.7	365.21
0.5	0.159	0.168055	0.221448	0.675952	4.511298	37.94	73.93	100	3.04	60	2.265	282.3	360.49
0.6	0.191	0.165421	0.218419	0.81338	2.574995	45.44	79.14	89	3.65	60	2.234	277.8	355.56
0.7	0.223	0.164383	0.217294	0.949923	1.613219	52.95	82.89	68	4.26	60	2.223	276.1	353.73
0.8	0.255	0.164975	0.219079	1.083852	1.089608	60.24	85.59	42	4.87	60	2.241	277.1	356.63
0.9	0.286	0.165451	0.222802	1.215231	0.778272	66.83	87.66	0	5.48	60	2.279	277.9	362.69
1	0.318	0.162076	0.224456	1.34826	0.571573	72.21	89.47	0	6.09	60	2.296	272.2	365.39
1.1	0.35	0.156179	0.223941	1.483768	0.428446	76.72	91.04	0	6.7	60	2.291	262.3	364.55
1.2	0.382	0.143029	0.214712	1.632338	0.316411	79.94	92.63	0	7.31	60	2.196	240.2	349.52
1.3	0.414	0.121986	0.192413	1.807576	0.22302	82.42	94.28	0	7.92	60	1.968	204.9	313.22
1.4	0.446	0.10039	0.166615	2.003481	0.154622	84.35	95.68	0	8.53	60	1.704	168.6	271.23
1.5	0.477	0.078166	0.137113	2.231905	0.103453	85.51	96.89	0	9.14	60	1.402	131.3	223.2
1.6	0.509	0.055319	0.103792	2.517025	0.064527	85.28	97.96	0	9.74	60	1.062	92.9	168.96
1.62	0.516	0.050675	0.09666	2.585033	0.057895	84.93	98.15	0	9.87	60	0.989	85.1	157.35
1.64	0.522	0.046004	0.089367	2.658326	0.051592	84.42	98.35	0	9.99	60	0.914	77.3	145.48
1.66	0.528	0.041314	0.081925	2.737945	0.045607	83.71	98.54	0	10.11	60	0.838	69.4	133.36
1.68	0.535	0.036596	0.074318	2.825471	0.039912	82.73	98.72	0	10.23	60	0.76	61.5	120.98
1.7	0.541	0.031854	0.066552	2.92292	0.034495	81.37	98.9	0	10.35	60	0.681	53.5	108.34
1.72	0.547	0.027086	0.058624	3.033283	0.029338	79.47	99.08	0	10.47	60	0.6	45.5	95.43
1.74	0.554	0.022296	0.050538	3.161012	0.024429	76.76	99.25	0	10.6	60	0.517	37.4	82.27
1.76	0.56	0.017481	0.042288	3.313363	0.019752	72.75	99.42	0	10.72	60	0.433	29.4	68.84
1.78	0.567	0.012642	0.033876	3.503002	0.015296	66.43	99.58	0	10.84	60	0.346	21.2	55.15
1.8	0.573	0.007787	0.025316	3.754868	0.011054	55.37	99.75	0	10.96	60	0.259	13.1	41.21
1.82	0.579	0.002804	0.016402	4.140866	0.006928	31.11	99.91	0	11.08	60	0.168	4.7	26.7
1.84	0.586	-0.00214	0.007441	4.903324	0.003042	0	99.99	0	11.21	60	0.076	-3.6	12.11
1.86	0.592	-0.00712	-0.00172	6.640698	-0.00068	0.07	48.07	0	11.33	60	-0.018	-12	-2.81

Table 105: Multi Analysis at 60 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	3	0.658	0.02287	28.78	18823	0.024	0.00091	0.00152	0	0	0	0	0.05007	0.01385	0.05976	0.0187
0.1	3	0.659	0.02289	28.79	72064	0.024	0.0044	0.10333	0.64936	0.11534	1.4	2.8	0.05007	0.0126	0.05976	0.01721
0.15	3	0.659	0.02289	28.79	152162	0.025	0.00998	0.09837	0.63449	0.17927	2	4	0.04976	0.01136	0.0597	0.01572
0.2	3	0.659	0.02288	28.79	249262	0.026	0.01705	0.09208	0.61481	0.23774	2.5	4.9	0.0491	0.01013	0.05952	0.01423
0.25	3	0.659	0.02288	28.79	353522	0.027	0.02495	0.08505	0.59176	0.29	2.8	5.5	0.048	0.00893	0.05909	0.01275
0.3	3	0.658	0.02288	28.78	456623	0.029	0.03313	0.0778	0.56677	0.33592	3.1	6	0.04643	0.00777	0.05832	0.01129
0.35	3	0.658	0.02287	28.78	552409	0.031	0.04116	0.07067	0.54092	0.37571	3.3	6.2	0.04438	0.00666	0.05711	0.00987
0.4	3	0.658	0.02286	28.78	636851	0.032	0.04878	0.06395	0.51522	0.40996	3.3	6.4	0.04187	0.00561	0.05536	0.00848
0.45	3	0.658	0.02286	28.78	707597	0.034	0.05579	0.05772	0.49018	0.43925	3.4	6.4	0.03894	0.00464	0.05303	0.00716
0.5	3	0.658	0.02285	28.78	763472	0.037	0.06218	0.05208	0.4663	0.46433	3.4	6.3	0.03566	0.00375	0.05009	0.0059
0.55	3	0.658	0.02285	28.78	803953	0.039	0.06781	0.04699	0.44371	0.48574	3.3	6.2	0.03208	0.00295	0.04653	0.00474
0.6	3	0.658	0.02285	28.78	828847	0.041	0.07298	0.0425	0.42263	0.50421	3.3	6.1	0.02828	0.00224	0.04237	0.00368
0.65	3	0.657	0.02285	28.78	837871	0.043	0.07744	0.03849	0.40294	0.52004	3.2	5.9	0.02433	0.00163	0.03766	0.00274
0.7	3	0.657	0.02285	28.78	830497	0.046	0.0814	0.03495	0.38466	0.53372	3.1	5.7	0.02031	0.00112	0.03247	0.00193
0.75	3	0.658	0.02285	28.78	805593	0.048	0.0849	0.03182	0.3677	0.54559	3	5.6	0.01629	0.00072	0.02689	0.00126
0.8	3	0.658	0.02285	28.78	760982	0.051	0.08801	0.02905	0.352	0.55593	2.9	5.4	0.01237	0.00041	0.02107	0.00073
0.85	3	0.658	0.02285	28.78	692531	0.053	0.09078	0.0266	0.33744	0.56499	2.8	5.2	0.00864	0.00019	0.01518	0.00035
0.9	3	0.658	0.02286	28.78	591724	0.056	0.09324	0.02442	0.32395	0.57294	2.8	5.1	0.00522	0.00006	0.00947	0.00011
0.95	3	0.658	0.02286	28.78	436328	0.058	0.09543	0.02249	0.31143	0.57996	2.7	4.9	0.00229	0	0.00428	0.00001
1	3	0.658	0.02286	28.78	22790	0.061	0.09762	0.02055	0.2989	0.58697	2.6	4.7	0.00011	0	0.00022	0

Table 106: Input at 40 rpm

Diameter D	6.09 [m]		
Spinner Dia. Dsp	0.30 [m]		
Speed of Rotation n	40 [1/min]		
Velocity v	8 [m/s]		
Number of Blades B	2 [-]		
Propeller			
v/(nD)	1.97	v/(ΩR)	0.627
Efficiency η	76.19%	loading	low
Thrust T	199.99 N	Ct	0.2679
Power P	2.1 kW	Cp	0.6929
β at 75%R	48.5°	Pitch H	16.22 m

Table 107: Propeller Geometry at 40 rpm

r/R	c/R	β	H/D	r	c	H	Airfoil	
[-]	[-]	[°]	[-]	[mm]	[mm]	[mm]		
0	Spinner	-	-	-	-	-	-	
0.05	0.0117	89.3	12.031	152.25	35.5	73271.4	interpolated	
0.1	0.0451	85.5	4.024	304.5	137.2	24505.7	interpolated	
0.15	0.0964	81.9	3.304	456.75	293.6	20118.3	interpolated	
0.2	0.1606	78.3	3.038	609	489.1	18504.4	interpolated	
0.25	0.2321	74.9	2.904	761.25	706.6	17682.9	interpolated	
0.3	0.3051	71.5	2.824	913.5	929.2	17196.7	Clark Y, Re=500'000	
0.35	0.375	68.4	2.772	1065.75	1141.9	16883.5	Clark Y, Re=500'000	
0.4	0.4378	65.3	2.737	1218	1333	16671.2	interpolated	
0.45	0.4906	62.5	2.713	1370.25	1493.8	16522.9	interpolated	
0.5	0.5316	59.8	2.696	1522.5	1618.8	16417.7	interpolated	
0.55	0.5599	57.2	2.684	1674.75	1705	16343	interpolated	
0.6	0.5751	54.8	2.675	1827	1751.1	16290.6	interpolated	
0.65	0.577	52.6	2.669	1979.25	1757.1	16255	Clark Y, Re=500'000	
0.7	0.5659	50.5	2.665	2131.5	1723	16232.4	Clark Y, Re=500'000	
0.75	0.5415	48.5	2.663	2283.75	1648.8	16220	interpolated	
0.8	0.5033	46.7	2.663	2436	1532.6	16215.9	interpolated	
0.85	0.4498	44.9	2.663	2588.25	1369.5	16218.5	interpolated	
0.9	0.3767	43.3	2.664	2740.5	1147	16226.5	interpolated	
0.95	0.2719	41.8	2.667	2892.75	827.8	16239.3	interpolated	
1	0.0136	40.4	2.669	3045	41.4	16255.9	Clark Y, Re=500'000	

Table 108: Single Analysis at 40 rpm

v/(nD)	v/ΩR	Ct	Cp	Cs	Pc	η	η*	stalled	v	n	Power	Thrust	Torque
[-]	[-]	[-]	[-]	[-]	[-]	[%]	[%]	[%]	[m/s]	[1/min]	[kW]	[N]	[Nm]
0	0	0.301672	0.679226	0	999999	0	0	100.00 !	0	40	2.058	225.2	491.42
0.1	0.032	0.267962	0.633828	0.109548	1614.029	4.23	20.72	100.00 !	0.41	40	1.921	200	458.58
0.2	0.064	0.279516	0.651238	0.217912	207.2953	8.58	36.13	100.00 !	0.81	40	1.974	208.6	471.17
0.3	0.095	0.289562	0.664599	0.325544	62.68099	13.07	47.75	100.00 !	1.22	40	2.014	216.1	480.84
0.4	0.127	0.298867	0.674371	0.432793	26.83239	17.73	56.57	100	1.62	40	2.044	223.1	487.91
0.5	0.159	0.30608	0.679705	0.54014	13.84683	22.52	63.42	100	2.03	40	2.06	228.5	491.77
0.6	0.191	0.312211	0.681939	0.647742	8.039558	27.47	68.77	100	2.44	40	2.067	233.1	493.38
0.7	0.223	0.316364	0.683956	0.755253	5.07778	32.38	73.05	100	2.84	40	2.073	236.2	494.84
0.8	0.255	0.318909	0.687037	0.862371	3.417041	37.13	76.52	100	3.25	40	2.082	238.1	497.07
0.9	0.286	0.320122	0.691634	0.968874	2.415957	41.66	79.35	94	3.65	40	2.096	239	500.4
1	0.318	0.320056	0.698573	1.074379	1.778901	45.82	81.69	94	4.06	40	2.117	238.9	505.42
1.1	0.35	0.323947	0.70548	1.179494	1.34973	50.51	83.44	68	4.47	40	2.138	241.8	510.42
1.2	0.382	0.332556	0.721978	1.280786	1.063947	55.27	84.69	26	4.87	40	2.188	248.2	522.35
1.3	0.414	0.340527	0.7451	1.378797	0.863624	59.41	85.74	5	5.28	40	2.258	254.2	539.08
1.4	0.446	0.342242	0.761948	1.478233	0.707101	62.88	86.82	5	5.68	40	2.309	255.5	551.27
1.5	0.477	0.340348	0.773343	1.579126	0.583497	66.01	87.84	5	6.09	40	2.344	254.1	559.52
1.6	0.509	0.335972	0.781245	1.68098	0.485699	68.81	88.78	5	6.5	40	2.368	250.8	565.23
1.7	0.541	0.329102	0.786494	1.783651	0.407651	71.14	89.67	0	6.9	40	2.384	245.7	569.03
1.8	0.573	0.307574	0.757247	1.902939	0.330644	73.11	90.84	0	7.31	40	2.295	229.6	547.87
1.9	0.605	0.285086	0.722035	2.027878	0.268064	75.02	91.91	0	7.71	40	2.188	212.8	522.39
2	0.637	0.261238	0.681151	2.15964	0.216817	76.7	92.92	0	8.12	40	2.064	195	492.81
2.1	0.668	0.236824	0.635933	2.298989	0.174861	78.2	93.84	0	8.53	40	1.927	176.8	460.1
2.2	0.7	0.212317	0.587289	2.447103	0.140451	79.53	94.69	0	8.93	40	1.78	158.5	424.91
2.3	0.732	0.186703	0.533152	2.608301	0.111585	80.54	95.49	0	9.34	40	1.616	139.4	385.74
2.4	0.764	0.160328	0.474122	2.786335	0.087337	81.16	96.26	0	9.74	40	1.437	119.7	343.03
2.5	0.796	0.133649	0.41126	2.986185	0.067025	81.24	96.97	0	10.15	40	1.246	99.8	297.55
2.6	0.828	0.106221	0.343518	3.219462	0.04977	80.4	97.66	0	10.56	40	1.041	79.3	248.54
2.62	0.834	0.100656	0.329405	3.271563	0.046641	80.06	97.8	0	10.64	40	0.998	75.1	238.33
2.64	0.84	0.095045	0.315053	3.326038	0.043603	79.64	97.93	0	10.72	40	0.955	70.9	227.94
2.66	0.847	0.089408	0.300513	3.383054	0.040659	79.14	98.06	0	10.8	40	0.911	66.7	217.42
2.68	0.853	0.083742	0.285777	3.44294	0.037806	78.53	98.2	0	10.88	40	0.866	62.5	206.76
2.7	0.859	0.07805	0.270852	3.506045	0.035041	77.8	98.33	0	10.96	40	0.821	58.3	195.96
2.72	0.866	0.072331	0.255736	3.572814	0.032361	76.93	98.46	0	11.04	40	0.775	54	185.03
2.74	0.872	0.066578	0.240408	3.643854	0.02976	75.88	98.59	0	11.12	40	0.729	49.7	173.94
2.76	0.879	0.060797	0.224886	3.719774	0.027238	74.62	98.72	0	11.21	40	0.682	45.4	162.71
2.78	0.885	0.054981	0.20915	3.801486	0.024789	73.08	98.85	0	11.29	40	0.634	41	151.32
2.8	0.891	0.049138	0.193222	3.889975	0.022414	71.21	98.97	0	11.37	40	0.586	36.7	139.8
2.82	0.898	0.043262	0.177083	3.986702	0.020108	68.89	99.1	0	11.45	40	0.537	32.3	128.12
2.84	0.904	0.037375	0.160794	4.093212	0.017875	66.01	99.23	0	11.53	40	0.487	27.9	116.33
2.86	0.91	0.031457	0.144302	4.212226	0.015708	62.35	99.35	0	11.61	40	0.437	23.5	104.4
2.88	0.917	0.025499	0.127577	4.347484	0.0136	57.56	99.48	0	11.69	40	0.387	19	92.3
2.9	0.923	0.01953	0.110705	4.503649	0.011559	51.16	99.6	0	11.77	40	0.336	14.6	80.1
2.92	0.929	0.013527	0.093616	4.689353	0.009575	42.19	99.72	0	11.86	40	0.284	10.1	67.73
2.94	0.936	0.007506	0.076358	4.917862	0.007652	28.9	99.85	0	11.94	40	0.231	5.6	55.25
2.96	0.942	0.001365	0.058632	5.219931	0.005757	6.89	99.97	0	12.02	40	0.178	1	42.42
2.98	0.949	-0.00483	0.040635	5.655042	0.00391	0	99.99	0	12.1	40	0.123	-3.6	29.4
3	0.955	-0.01104	0.022449	6.410349	0.002117	0	99.99	0	12.18	40	0.068	-8.2	16.24
3.02	0.961	-0.01713	0.004518	8.892537	0.000418	0	99.99	0	12.26	40	0.014	-12.8	3.27
3.04	0.968	-0.02332	-0.01381	7.15829	-0.00125	0.13	40.89	0	12.34	40	-0.042	-17.4	-9.99

Table 109: Multi Analysis at 40 rpm

r/R	α	Cl	Cd	L/D	Re	Ma	a	a'	Cx	Cy	δ	δff	CQx	CMx	CQy	CMy
[-]	[°]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[°]	[°]	[-]	[-]	[-]	[-]
0	Spinner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.05	3	0.658	0.02287	28.78	19526	0.024	0.00044	0.00113	0	0	0	0	0.17462	0.05091	0.1343	0.04363
0.1	3	0.659	0.0229	28.79	75995	0.024	0.0027	0.17606	0.65665	0.06305	1.6	3.2	0.17462	0.04655	0.1343	0.04028
0.15	3	0.659	0.02289	28.79	164954	0.024	0.00666	0.1729	0.65106	0.1047	2.4	4.7	0.17388	0.0422	0.13423	0.03692
0.2	3	0.659	0.02289	28.79	280289	0.025	0.01213	0.16847	0.64317	0.14494	3	6	0.17228	0.03789	0.13397	0.03357
0.25	3	0.659	0.02288	28.79	414899	0.025	0.01885	0.163	0.6331	0.18334	3.6	7.1	0.16954	0.03365	0.13335	0.03024
0.3	3	0.658	0.02287	28.78	561274	0.026	0.02656	0.15673	0.62115	0.21959	4.2	8.1	0.16544	0.02952	0.13216	0.02693
0.35	3	0.658	0.02286	28.78	712019	0.027	0.03497	0.14987	0.60754	0.2534	4.6	8.9	0.15984	0.02552	0.13018	0.02368
0.4	3	0.657	0.02284	28.77	860267	0.028	0.04387	0.1427	0.5927	0.2847	5	9.5	0.15268	0.0217	0.1272	0.0205
0.45	3	0.656	0.02281	28.77	999914	0.029	0.05314	0.13551	0.57699	0.31346	5.3	10	0.14393	0.01811	0.123	0.01742
0.5	3	0.655	0.02278	28.76	1125470	0.03	0.06218	0.12797	0.56059	0.33961	5.5	10.3	0.13367	0.01476	0.11742	0.01449
0.55	3	0.654	0.02275	28.75	1232588	0.031	0.07148	0.12089	0.54407	0.36346	5.7	10.5	0.12202	0.01171	0.11036	0.01173
0.6	2.9	0.653	0.02271	28.74	1317013	0.032	0.0803	0.1138	0.52751	0.38506	5.8	10.6	0.10914	0.00899	0.10176	0.00919
0.65	2.9	0.652	0.02268	28.73	1375177	0.034	0.0889	0.10704	0.51121	0.40466	5.8	10.7	0.09526	0.0066	0.09162	0.00689
0.7	2.9	0.651	0.02265	28.72	1403340	0.035	0.09729	0.10067	0.49531	0.42245	5.8	10.7	0.08064	0.00459	0.08005	0.00489
0.75	3	0.658	0.02287	28.78	1396075	0.036	0.10261	0.09369	0.48548	0.44498	5.8	10.5	0.0656	0.00295	0.06722	0.00321
0.8	2.9	0.649	0.0226	28.71	1350290	0.038	0.11215	0.0887	0.46495	0.45318	5.8	10.5	0.05035	0.00169	0.05325	0.00188
0.85	3	0.658	0.02287	28.78	1253196	0.039	0.11612	0.08256	0.45678	0.47445	5.7	10.3	0.03566	0.0008	0.03892	0.00091
0.9	2.9	0.648	0.02257	28.7	1090968	0.041	0.12564	0.07832	0.43699	0.47871	5.7	10.2	0.02174	0.00025	0.02447	0.0003
0.95	3	0.658	0.02287	28.78	816574	0.042	0.12786	0.07286	0.43007	0.49878	5.6	10	0.00969	0.00001	0.01127	0.00001
1	3.1	0.669	0.02317	28.86	42336	0.044	0.13009	0.0674	0.42316	0.51884	5.4	9.7	0.00049	0	0.0006	0