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Experimental Studies on MAV Propeller Performance and flow field Characteristics

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A propeller is a fan that conveys control by altering rotational movement into push. Innovative work on propellers is a progressing procedure. Everything began with the wright sibling's trip in 1903. The turned air foil state of propellers came into utilization from the wright sibling's first flight. The equivalent is currently utilized for micro light vehicles and unmanned flying vehicles. This paper focuses on light weight flying machine's propellers. Numerous advancements have been made and new speculations have been demonstrated right. The majority of this has been turned out to be conceivable by the test methods. Static stream think about is done in the open condition, where the propeller is kept running in standard environmental conditions. In this paper, principle fixation is on working up a static exploratory setup that can figure and study propeller attributes. The outcome acquired from this setup is approved utilizing hypothetical computations.

***Keywords*:** Propeller, Miniature aerial vehicle (MAV).

1. Introduction

Over the years there have been momentous research and development in the field of propeller design and studying the flow fields associated with it. The thrust is important for a propeller to produce high static thrust which in turn used to accelerate the aircraft during take-off. In the current scenario the aircraft industries test nearly 4,000 propellers to choose the best amongst them. Propellers along with their importance hold various other significant characteristics. One of which is the number of blades on the propeller which deals with a lot of variables. A two-bladed prop is the most efficient one and hence been widely used. The basic idea being more the propeller blades, greater the thrust generated. But a two bladed prop is the most efficient one. Constant pitch propeller whose blade angle is fixed with respect to hub is suitable for low speed air plane. The propellers have a magnificent role not only in the aviation field but various others. The prop-driven cars are a great example. This research addresses a combined work of experimental and theoretical study that gives a wider conclusion on the selection of best propellers and depth study of flow field characteristics around the propeller. The analytical study is done using the 'Blade Element Theory' to determine the thrust and torque of the propeller. Maximizing the thrust while minimizing the torque to turn a propeller has emerged as one of the most important aspects of a good propeller design. The product of thrust developed and airspeed of the aircraft gives the propulsive power. The ratio of propulsive power to the brake power gives the propulsive efficiency. Propeller wing interaction will affect the lift distribution over the wing due to high velocity. The propeller tip vortex deforms at the wing leading edge in span wise direction which was followed by the leading edge due to viscous effect. During rotation of the propeller free stream velocity and velocity components are considered. The aerodynamic effect is strong when the velocity and angle variation are in phase. In the propeller wake the unsteady tangential velocity highlight the strong unsteady effect. Larger thrust force produced during the down moving part of the blade rotation lower thrust force produced during upward motion on opposite direction. These maximum and minimum forces are shifted from azimuth angle. The axial flow cases total thrust as a sum of the blade thrust component. For each blade there is always an equal and opposite lift force component being generated by diametrically opposed blade. For two diametrically opposed blade net positive lateral forces are produce for a larger portion of the propeller revolution. Apart from changing potential field around the stator, the motion of stator and rotor will influence the performance of rotor. The propulsive performance during one blade passage passing period is evaluated by thrust co-efficient of rotor and stator. The potential influence and wake effects play a major role. The total efficiency is mainly depends on stator performance. The selection of air foil also plays a vital role. In propeller design aspect, we should try to keep the Mach number below 0.85 to avoid shockwave. The experimental results determined by carrying out the experiment in two variant, portable set-ups to measure the propeller characteristics such as thrust. This same process will be carried out for different a propeller which satisfies the core objective of this paper that is it provides efficient database to propeller researchers for a wide range of propellers. This database derived will be efficiently used in the field of propeller selection for Miniature Aerial Vehicle (MAV).

2. Experimental setup

An experimental setup has been built to find out the static thrust produced by a propeller in different RPM. Keeping in mind the diameter of the propeller chosen, the frame is designed. The height of the frame is 120 cm, width is 60 cm and length is 25 cm. It is built using steel rod of thickness 1 1/2 inches. The setup takes the shape of a truncated prism. The diameter of the propeller is taken into consideration, so to reduce the risk of tip flow disturbances. The setup is built to be a strong one to withstand the load produced by the propeller rotation. The setup is designed in such a way that the airflow direction is towards the ground and the thrust direction is upward.

The components are chosen taking into account the power required to conduct the experiment at different RPM, it is shown in table 1.

Table 1 Experimental setup specifications

Component	**Description**
Brushless Motor	Avionic C2830/12 KV1000 brushless motor
ESC	Wolf pack 30 Amp ESC SKU: RZ04410
Transmitter / Receiver	FlySkyFS-T6 2.4ghz Digital Proportional 6 Channel Transmitter and Receiver
Propeller	13x8 (inches), Two Bladed Propeller
Tachometer	Portable Digital Laser Tachometer Non-contact Rotate Speed Detector LCD Tachometer(RPM Meter Range 2.5-99999 RPM)

The weighing scale is the base of the setup. Since the weighing scale's value is taken as the thrust value, the frame is mounted on top of our weighing scale and the value is tared. The frame is 6.4 kg approx. On the top of the frame the motor is mounted upside down. The propeller is screwed to the motor. The rotation of the motor is anti-clockwise. The motor is connected to the Electronic Speed Controller. The ESC is connected to the Receiver and the Power Controller. The Power Controller is connected Switched Mode Power Supply (SMPS). The Power Controller controls the flow of current to the motor and saves the motor from burning out. The receiver obtains the signals from the transmitter and delivers it to the motor. Experimental setup details are shown in the following figures 1-3

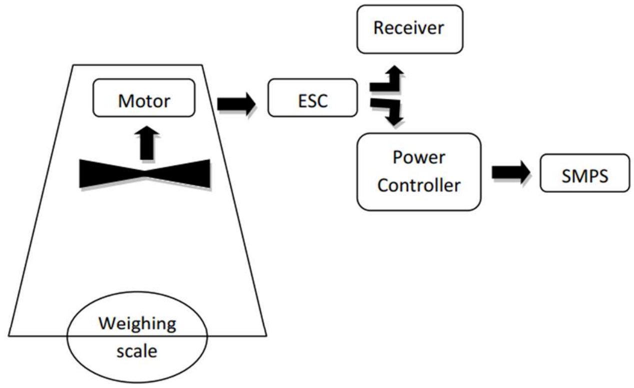

Fig 1.Flow of Experiment Setup

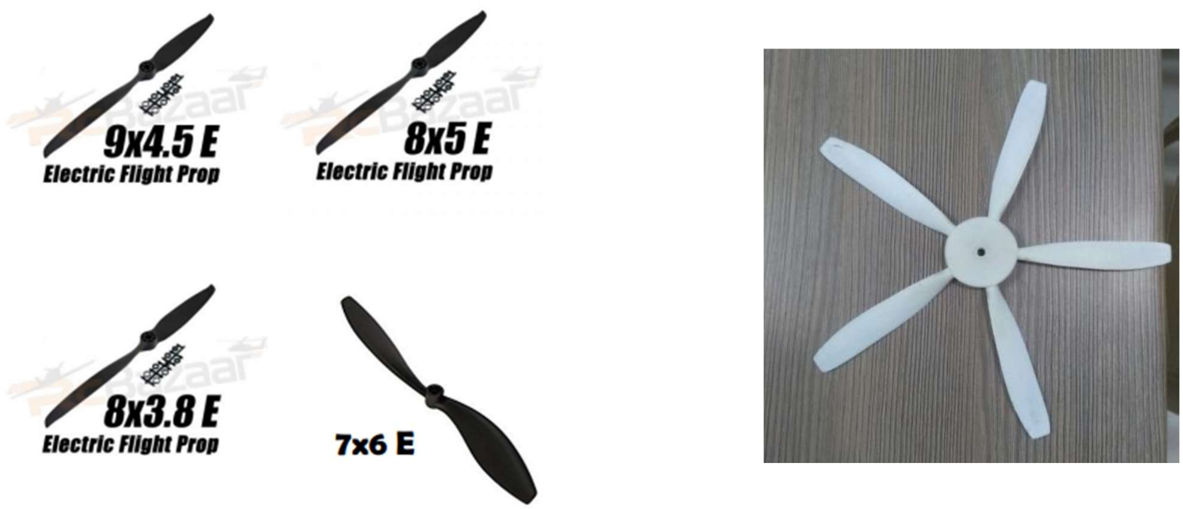

Fig 2.various configuration of propellers

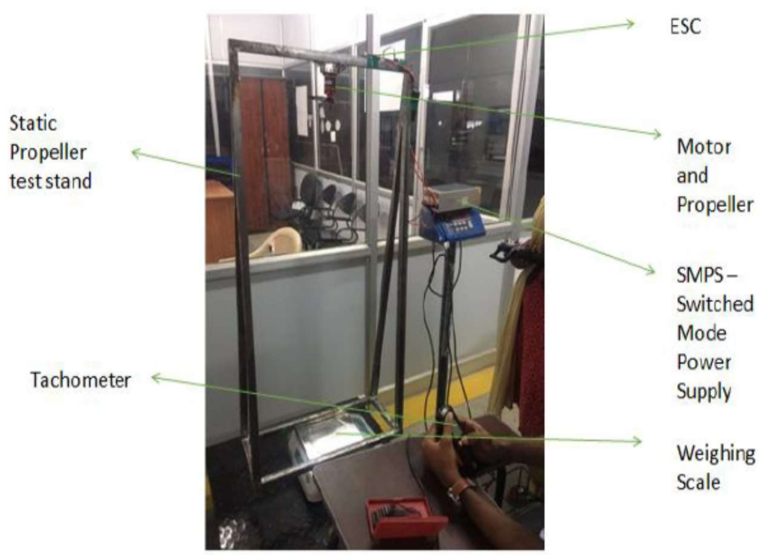

Fig 3.Experimental Setup

3. Results and discussion

Different RPM were chosen for the test. Experiment was conducted for different specifications of propellers. The thrust value which is equivalent to the weighing scale value is noted down and compared with the theoretical results. This comparison is shown in the following figures 4-9.

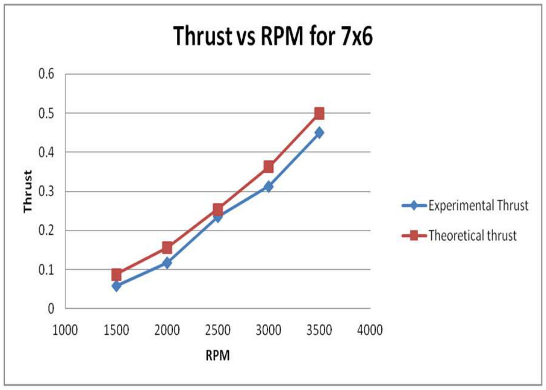

Fig 4: Graph - Thrust vs RPM for 7x6

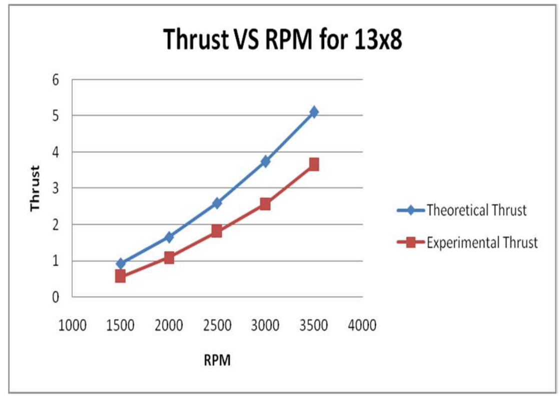

Fig 5: Graph - Thrust vs RPM for 13x8

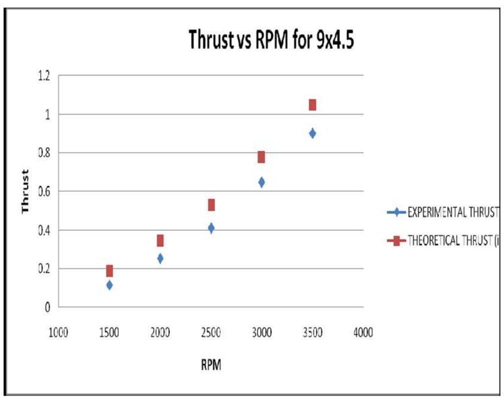

Fig 6. Graph - Thrust vs RPM for 9x4.5

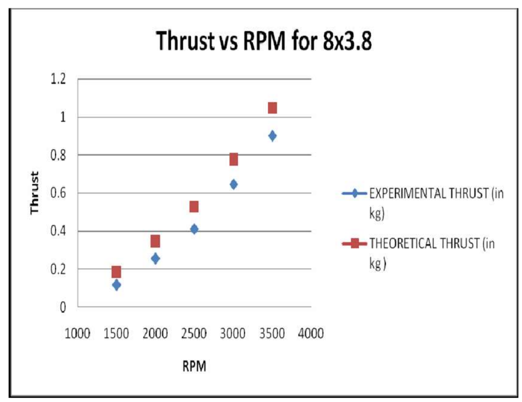

Fig 7. Graph - Thrust vs RPM for 8x3.8

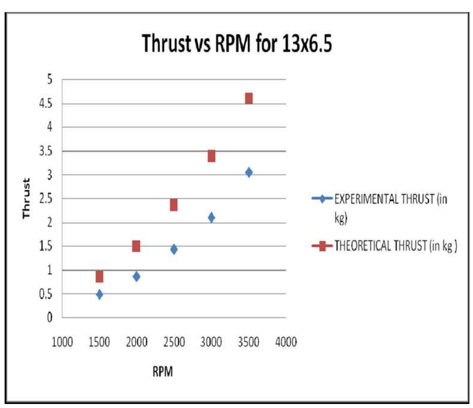

Fig 8. Graph - Thrust vs RPM for 13x6.5

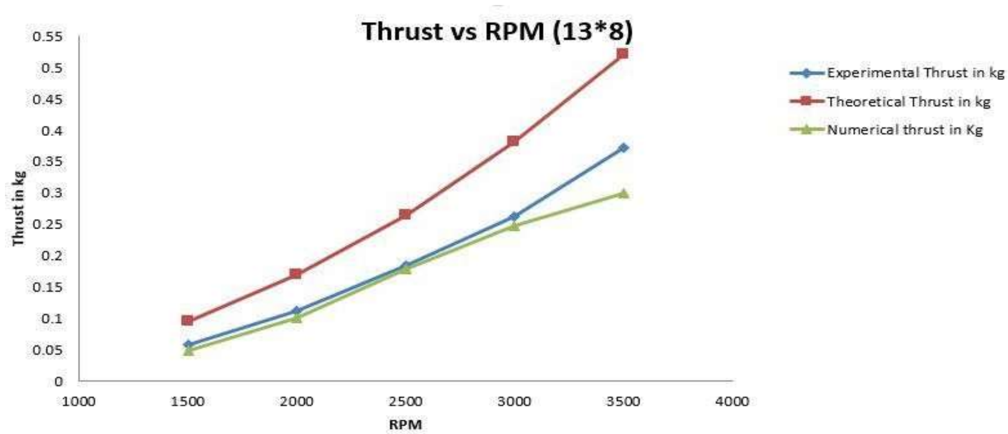

Fig 9. Thrust vs RPM for Experimental, Theoretical and Numerical thrust

4. Conclusion

After plotting the results it is evident that for propellers with greater diameters, that the variation of experimental thrust from the theoretical thrust is greater for higher RPM. For smaller diameter propellers the variation in the thrust is a bit lower comparatively. The main reason for the variation is because for higher diameters the flow is being disturbed. This is due to the frame size that was chosen in the start. Another major issue that was faced is the vibrations at higher propeller speeds. Due to the vibration that was caused by the airflow the frame started vibrating. This led to the oscillations in the weight displayed in the scale. This is the reason for the graph to vary slowly with increasing RPM for bigger diameter propellers (13x8 and 13x6.5). By using these experimental data base is planned to develop in future which will help the MAV researchers to choose an apt propeller for their applications.

References

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