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# Performance Analysis of BLDC Motor under Moist Conditions

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***Abstract:*** *A brushless DC motor is famous for excellent efficiency and its high rpm capacity. Since the shielding of BLDC depending upon the manufacturer, normal BLDC motors are best applicable for using in dry weather conditions. But even for the properly shielded BLDC, the correct performance analysis is unknown when the stream of air is humid. This research focuses on analyzing the change in performance of a BLDC motor due to the presence of moisture during its powered operation.*
***Keywords:*** *Thrust calculator, BLDC, Quadcopter*

## I. Introduction

Drones are more formally known as unmanned aerial vehicles (UAV). A drone also called a Quadcopter, is a multirotor that is lifted and propelled by four rotors. Quadcopter is a device with an intense mixture of electronics, mechanical and mainly on the principle of aviation. UAVs have most often been associated with the military but they are also used for search and rescue, surveillance, traffic monitoring, weather monitoring and firefighting, among other things. Many times the application requires all-weather operation, but the avionics' equipment onboard are unsafe at moist conditions.

The research is about the effect of moisture on performance of motors. Normally there will be a change in the thrust produced by the motors due to the water reaching inside the rotor changing viscosity. But the exact reason and rate of degradation of performance of BLDC is still unclear. Garuda Aerospace has designed and developed a setup, for testing the performance.

## II. Experimental Setup

The setup is fully insulated by protective plastic films to avoid short circuit. An L beam thrust calculator setup is made as shown in figure 1. The output of thrust calculator is thrust in grams. A BLDC motor is connected at one end with the necessary powering circuit. A transmitter-receiver setup is used to change instantaneous power fed.

**Figure 1**: Thrust calculator

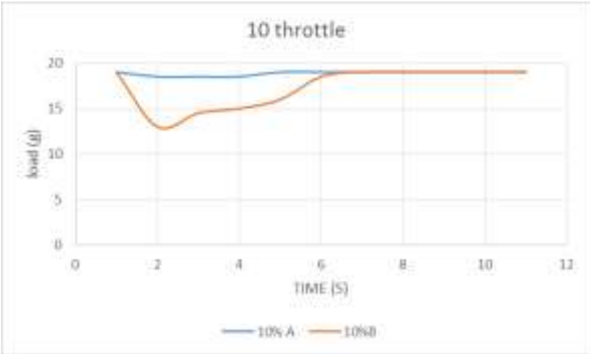
The experiment was carried out with different throttle ranges from 10-60% and for each throttle point two different quantities of water 5 grams of 2 seconds duration and 10 grams of 4 seconds duration has been sprayed. Each experiment was repeated at three different angle of attack corresponding to the propeller, +45, +90, -45 degrees respectively, to reduce the effect of angle on propeller.

## III. Observation and Inference

Table 1 is the average of 3 trails from 3 different angles. A graph was plotted between Load (Thrust in gm.) and Time(s). A and B represents each quantity of water sprayed.

| 10% throttle | | |
|---|---|---|
| Repetation | 10% A | 10%B |
| 1 | 19 | 19 |
| 2 | 18.5 | 13 |
| 3 | 18.5 | 14.5 |
| 4 | 18.5 | 15 |
| 5 | 19 | 16 |
| 6 | 19 | 18.5 |
| 7 | 19 | 19 |
| 8 | 19 | 19 |
| 9 | 19 | 19 |
| 10 | 19 | 19 |
| 11 | 19 | 19 |

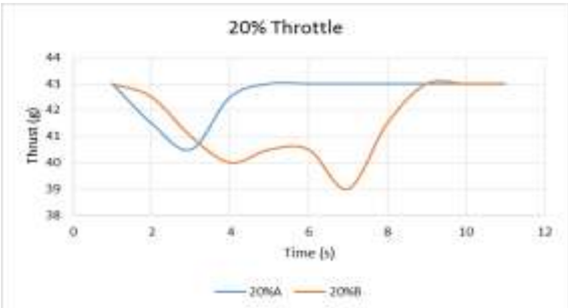
**Table 1**: 10%A-spraying time 2sec



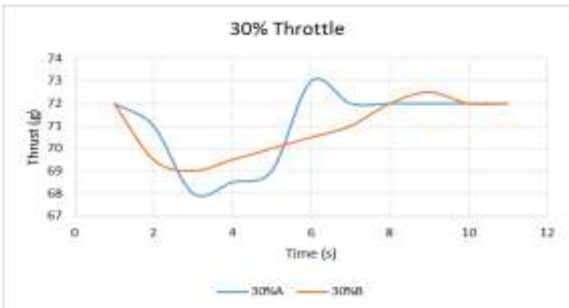

**Graph 1**: 10% throttle, Blue: 5 gms, Red : 10 gms

At 10% throttle, in ideal condition 19gm thrust is generated. When water is sprayed, thrust is slightly decreased which depends on the repetition of spraying and eventually the speed comes back to initial value once spraying is stopped.

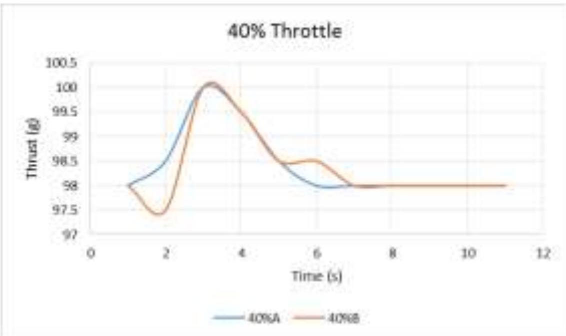
In 1st test when 5grams of water sprayed over the motor, the change in thrust was reduced slightly and is represents as blue line in above graph. While in 2nd test 10 grams of water is sprayed over the motor, but now the thrust is reduced by 5 gms which is almost 20% of the entire thrust generated. Same experiment was repeated for each 10 % increase in throttle value upto 60 % level. For each value of throttle, the alike the first experiment 5 and 10 gms of water was sprayed, graph was plotted representing the variation in thrust hence generated.



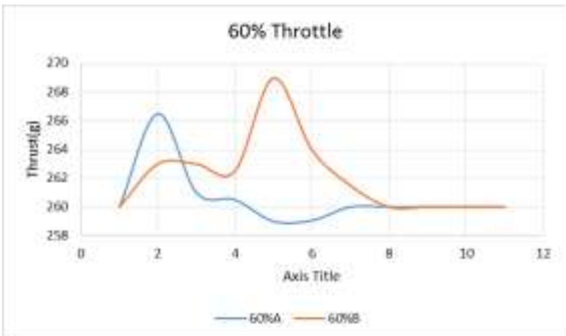

**Graph 2**: 10% throttle, Blue: 5 gms, Red : 10 gms




**Graph 3**: 10% throttle, Blue: 5 gms, Red : 10 gms




**Graph 4**: 10% throttle, Blue: 5 gms, Red : 10 gms




**Graph 5**: 10% throttle, Blue: 5 gms, Red : 10 gms

In graph 4, at 40 % throttle motor generates 98gms in ideal condition and when 10 gms of water is sprayed on to the rotating propeller, thrust generated by the motor is increased to a value which is comparable with 5 gms value unlike the previous situations. This might be because of the increase in mass flow of free stream of air due to the presence of water molecules. Slight variations are also noticed which might be due to the variation in drag imparted by the high density water molecules. While in graph 5, throttle is increased to 60 %, 260 gms was measured in ideal conditions. Again when the mass is at 10 gms, at one particular point, the thrust generated is increased surprisingly more than ideal value.

## IV. Conclusion

When fluid which is fed in to the propeller is moisturized in a controller manner, at lower RPM the thrust generated is reduced noticeably. This is due to the increase in viscosity of fluid passing through the propeller faces. This increased viscosity induces drag, reducing the RPM and hence the performance of BLDC.

When the RPM is increased after a particular level which is sufficient to push the whole air-water mixture backwards, thrust increases gradually and even exceeds the dry-condition value. This increase in thrust is due to the increase in mass flow rate of fluid passing the propeller. The motor also has slight variations in thrust generated due to the sudden variations in viscosity of fluid the motor is pushing backwards. But this is a minute deviation compared to the first one.

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