Implementing a Dynamometer System on Electric Motors for Unmanned Systems

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ABSTRACT

Electric motors are becoming increasingly popular for the propulsion and control of unmanned systems. In order to optimize power generation and energy use for unmanned systems, it is important to understand the dynamics of electric motors and the corresponding powertrain. This paper provides an early, preliminary study on an electric motor used for unmanned aerial systems (UAS'). An electric motor dynamometer is used for collecting data on the motor, and trends are discussed. Future work will look at implementing mathematical models in an unmanned ground system built for experimentation.

Keywords: Electric motor, unmanned systems, dynamometer.

1. A BRIEF INTRODUCTION

This paper addresses the use of dynamometers for studying and characterizing electric motors used for unmanned systems. Preliminary data and early results are provided. A dynamometer or 'dyno' is a device that measures the force, torque, or power of a system. Power that is produced by an engine, motor, or some kind of rotating device may be calculated by measuring torque and RPM. The two main types of dynamometers are engine dynos or chassis dynos. An engine dyno is a device that is directly coupled to an engine. A chassis dyno is a device that can measure power and torque delivered by the power train directly from the drive wheel. The type of dyno studied in this paper is an electric dyno, which studies electrically powered motors and has no exhaust associated with the system. A computer and control cabinet is used to regulate the driver motor that is coupled to the motor being tested. Based on the input and output signal generated, the motor can be characterized and performance optimized. This is important for mission planning purposes.

Dynamometers are widely found in literature ranging from automobile theory to aerospace applications [1, 2]. With the advent of electric vehicles, the use of electric motors and electric dynos has increased significantly [3, 4]. A number of researchers have developed custom dynos for a wide-variety of test purposes and configurations [5, 6, 7]. Signal-based methodologies have been developed and applied on engines for the purposes of fault detection and diagnosis [8]. These methods are only possible by using dynos to simulate driving conditions. In this paper, a fault diagnostic system was developed, and was successful in detecting a number of commonly occurring and known defects, such as: defective lash adjuster, cam phaser, and chain tensioner [8]. These are faults commonly attributed to gasoline-powered engines. Engine defects were identified using the proposed method with a relatively high success rate (97%) [8]. Although applied to gasoline-engines, this same technique may be applied to electrically powered engines.

This paper is organized as follows. Electric motors and dynamometers are briefly discussed in Section 2, including the experimental setup used in this paper. Preliminary data collected from a 1 HP UAS motor is provided in Section 3. Conclusions and future work are discussed in the final section of the brief paper.

2. EXPERIMENTAL SETUP

The electric dynamometer used in the laboratory is able to test electric motors ranging from 0.01 HP to 10 HP. It may be able to test larger motors (40 HP) but with limited capabilities. The experimental setup is shown in the following series of figures.

Figure 1: Electric motor dynamometer setup as shown in the laboratory setting.

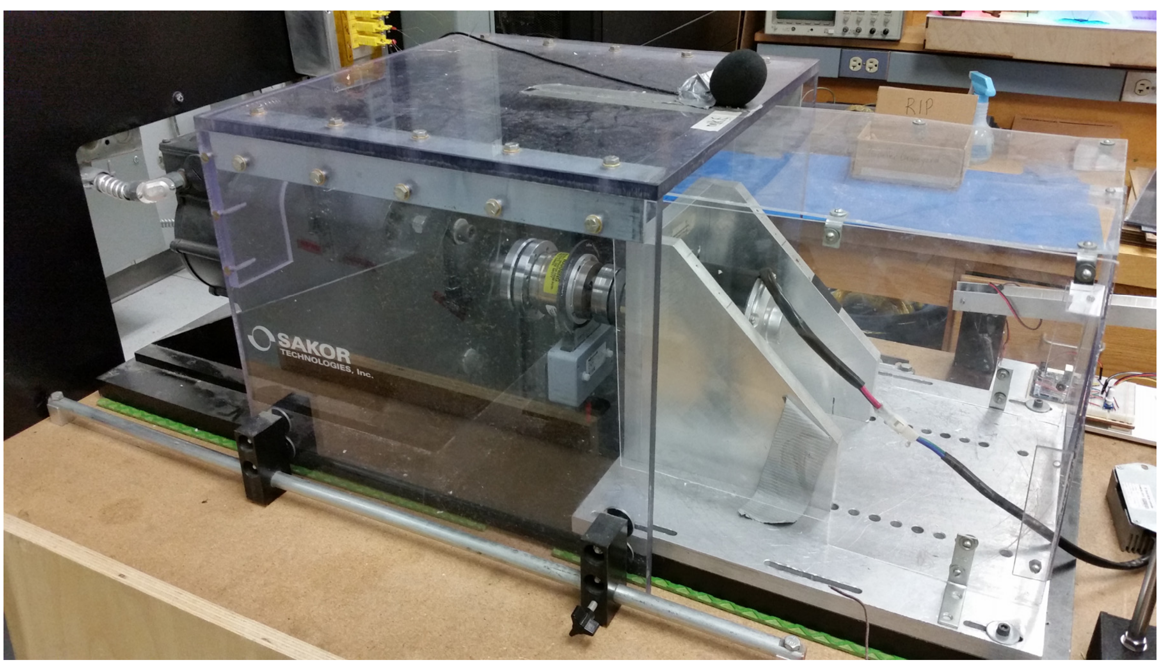

Figure 2: Sakor electric motor coupling system with Siemens drive motor and 1 HP UAS motor.

Figure 3: Computer and control cabinets, and electric distribution for dynamometer system.

3. PRELIMINARY DATA AND RESULTS

In this section, preliminary data and results obtained from the dynamometer are shared. An electric motor used by an unmanned aerial system (UAS) was studied. The motor was rated for 1 HP and could be used by many other medium-sized UAS'. A number of results (figures) were obtained, including: current vs torque, efficiency vs RPM and power, RPM vs torque, power vs RPM, torque vs throttle, RPM vs time, and amperage vs RPM.

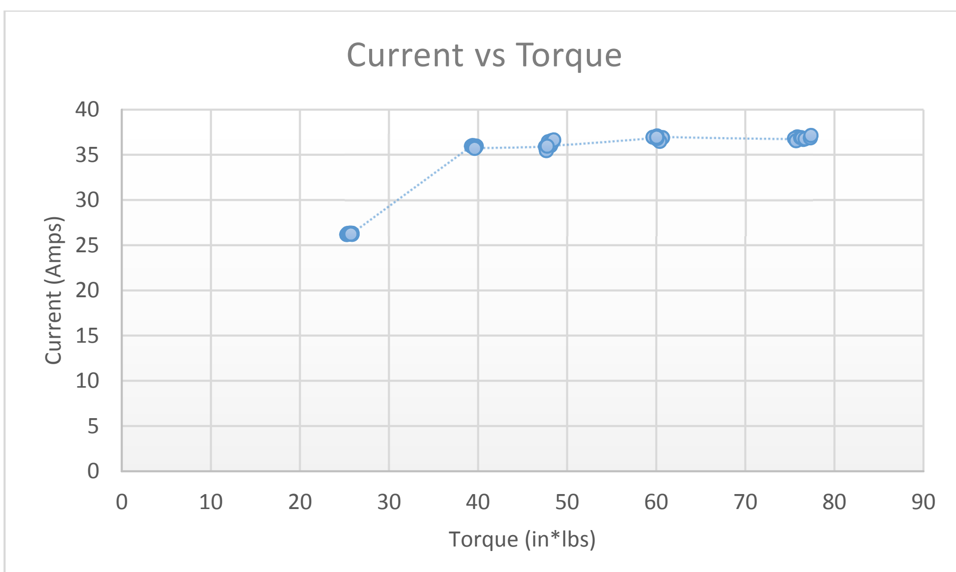

Figure 4: Current vs torque data curve obtained from running dynamometer on 1 HP UAS motor.

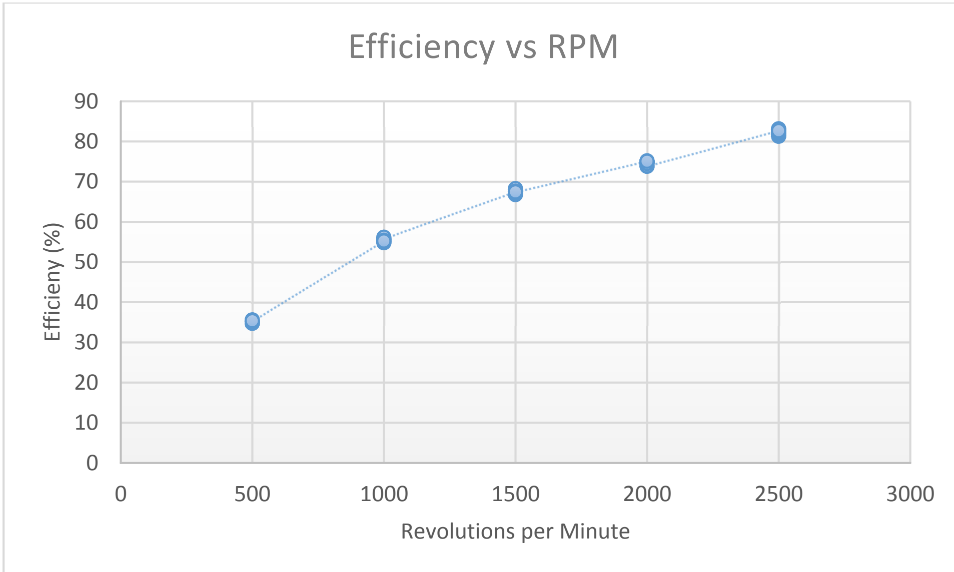

Figure 5: Efficiency vs RPM data curve obtained from running dynamometer on 1 HP UAS motor.

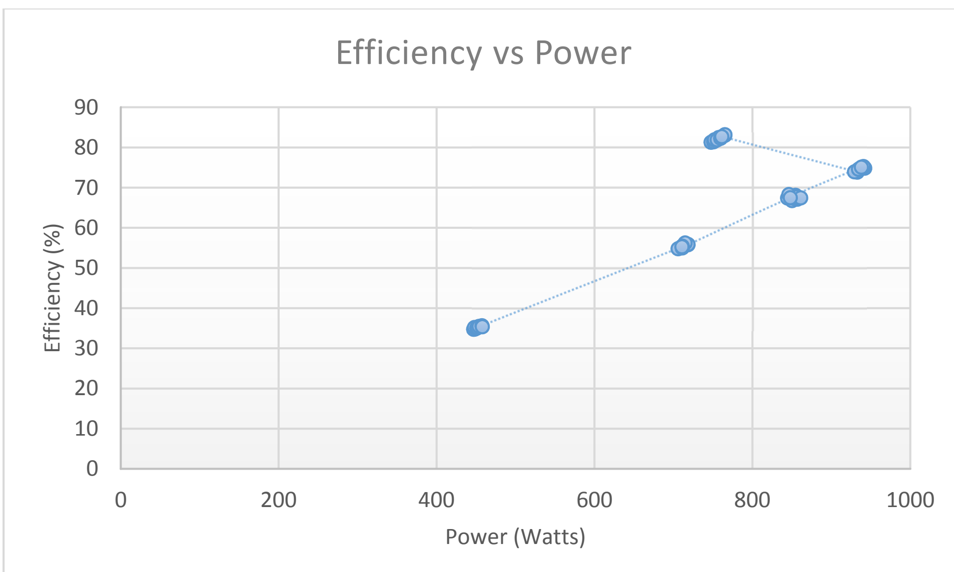

Figure 6: Efficiency vs power data curve obtained from running dynamometer on 1 HP UAS motor. Note that the overlapping data is caused by ramping the system up and down.

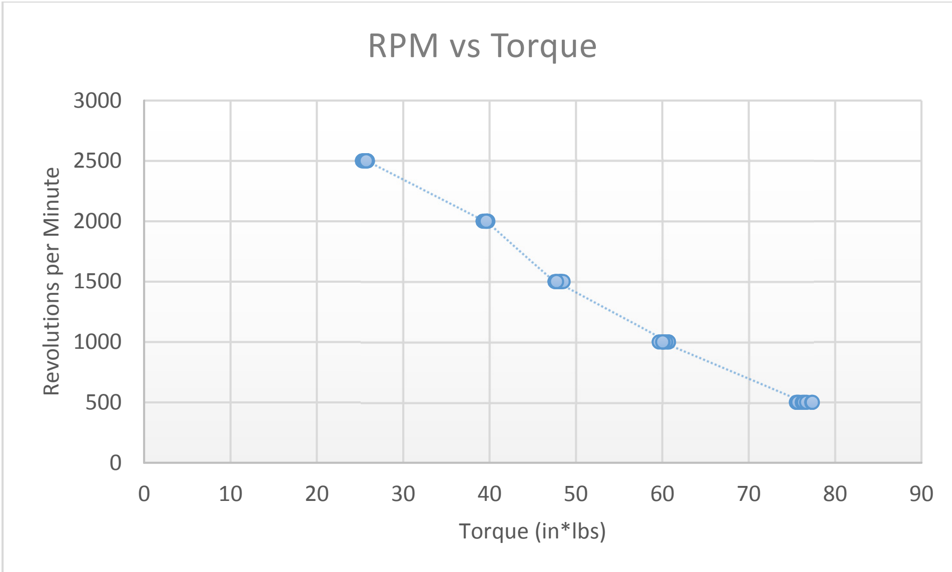

Figure 7: RPM vs torque data curve obtained from running dynamometer on 1 HP UAS motor.

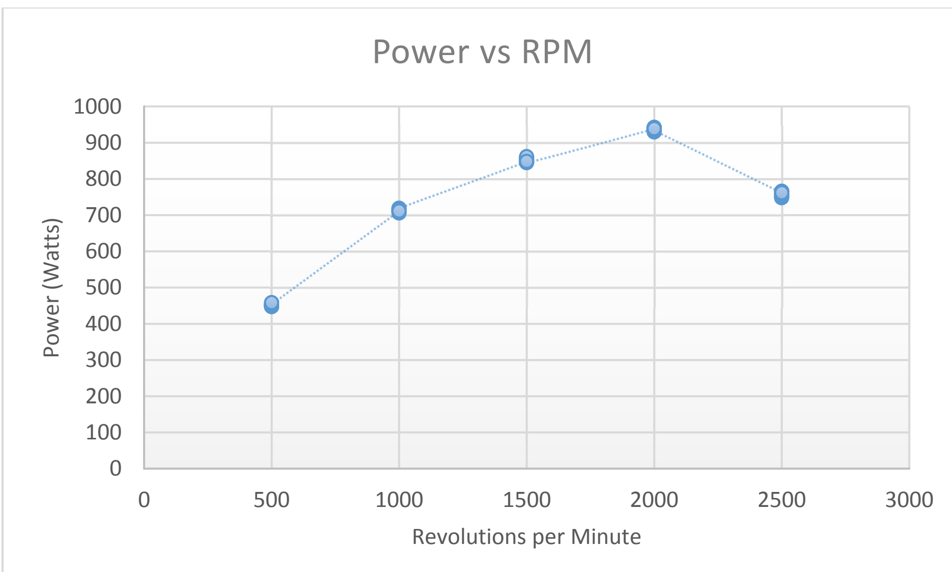

Figure 8: Power vs RPM data curve obtained from running dynamometer on 1 HP UAS motor.

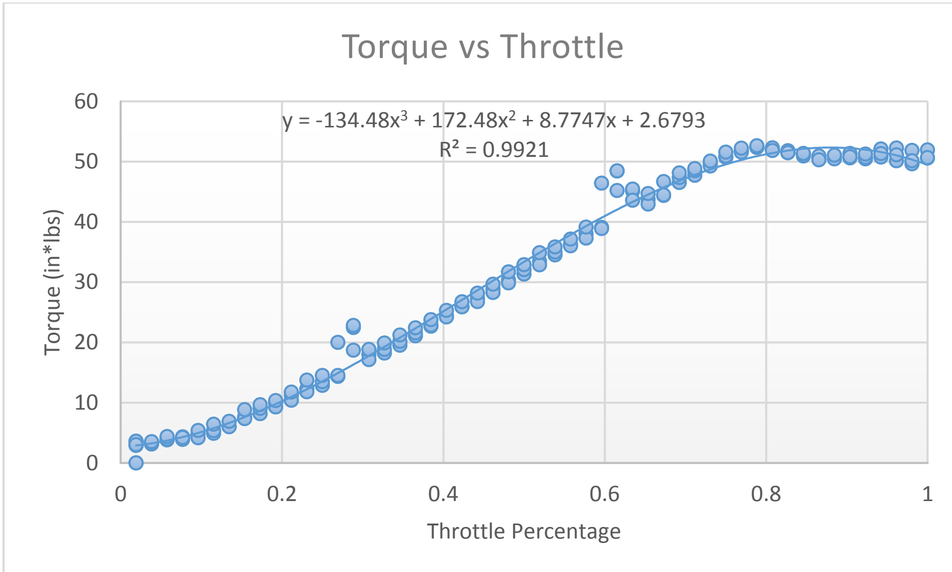

Figure 9: Torque vs throttle data obtained from running dynamometer on 1 HP UAS motor.

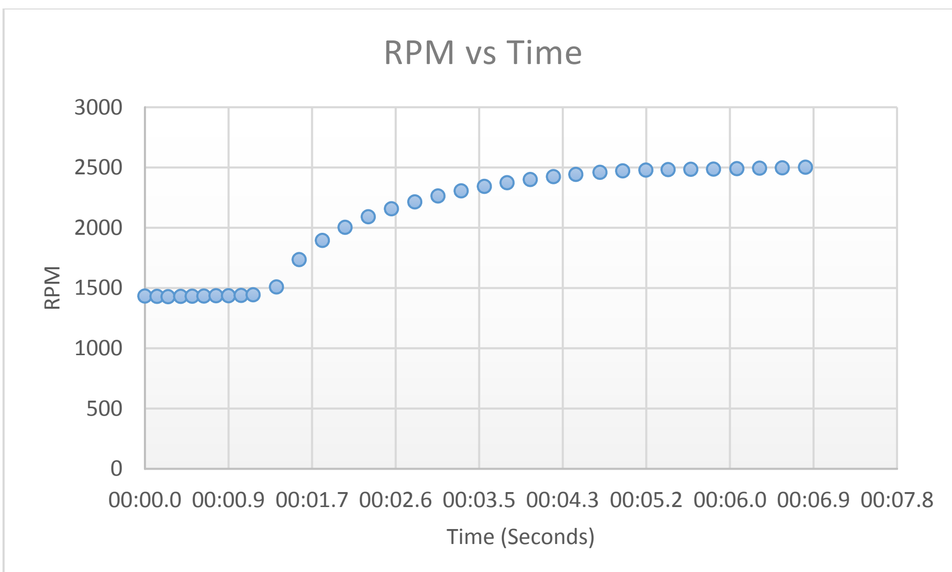

Figure 10: RPM vs time data obtained from running dynamometer on 1 HP UAS motor.

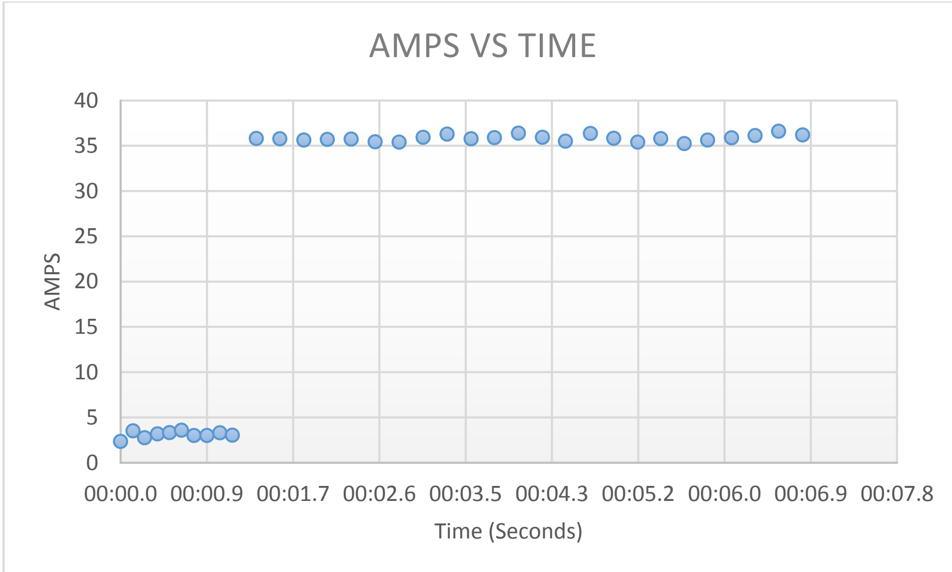

Figure 11: Amperage vs time data obtained from running dynamometer on 1 HP UAS motor.

4. CONCLUSIONS AND FUTURE WORK

This paper introduced early and preliminary results that were obtained by studying an electric motor commonly used by unmanned aerial systems on a dynamometer. Electric motors are becoming increasingly popular for the propulsion and control of unmanned systems. In order to optimize power generation and energy use for unmanned systems, it is important to understand the dynamics of electric motors and the corresponding powertrain. An electric motor dynamometer is used for collecting data on the motor. Future work will look at detailed discussion of trends and implementing mathematical models in an unmanned ground system built for experimentation.

5. REFERENCES

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