Dynamometer Setup for Motor Testing at Initial Research Stage: Studying Basic Parameters for Design and Development

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Abstract – *This paper describes about an experimental dynamometer setup for determining the characteristics of electric motor during the initial research phase. Industrial dynamometers give a huge range of output parameters, that may be initially not needed in the ideation phase, where iterations are carried. The repeated testing of electric motors on industrial dynamometers proves to be quite expensive. Thus, a cost-effective method to this problem has been developed in the form of an experimental setup which serves as a solution during the initial design phases. This setup helps in reducing the overall cost of testing by almost 60-70%. Thus, it will help to determine the efficiency of the motor and eventually help in improvising the motor in the predesign stage at a very low cost.*

Key Words: motor, alternator, current, voltage, power

1. INTRODUCTION

In the view of the futuristic demand of electric vehicles, motors will be a very crucial component in the automotive industry. They will be the replacement to engines. The first commercial internal combustion engine dates back to 1859 whereas the first motor developed is in 1828. But using motors in vehicles began in early 1900s. IC engine vehicles have been used for a very long time. Considering it, a lot o study and research on IC engine applications in various sectors has been done. Certain applications of motors have come into picture very recently. The study of motors has now become a topic of interest for the engineering sector. In the initial phases of designing or studying a motor, few basic parameters like rpm, torque, efficiency, load, etc. are required. Industrial dynamometers give a large number of output parameters like vibrations, thermal properties, etc. These are not required, but a user has to pay a hefty amount for getting the motor tested because due to all these details, industrial dynamometers are a bit expensive. So, to make the process economical, we have developed an experimental motor testing setup using an alternator. The motor has to be coupled to the alternator and then the test can be performed.

2. LITERATURE SURVEY

1) How to Test & Evaluate Motors in Your Application, Grosschop. Inc: Before testing or designing any motor, the application area of the motor should be thoroughly researched. This article offers insights into development of the testing apparatus by deciding and finalizing the various parameters and values involved. This helped in working towards the pragmatic development of the entire setup to be used.
2) Thesis-Design and Construction of Electric Motor Dynamometer and Grid Attached Storage Laboratory, submitted by Markus Lutz, Department of Mechanical Engineering: A proper study of electric motors, inverters, controllers, data acquisition, high voltage safety and other experimental setups must be done before selecting the components in the setup. Torque curves and efficiency of each component mainly affects the selection of the specifications so as to obtain a desired output. Along with this, the load balance characteristics also play a major role in the development of the setup.
3) Design and Implementation of a Small Electric Motor Dynamometer for Mechanical Engineering Undergraduate Laboratory- A thesis by Aaron Farley, University of Arkansas, Bachelor of Science in Mechanical Engineering, 2001: May 2012 -University of Arkansas: Comparative testing can be employed as a method to determine the accuracy of the newly developed setup of dynamometer. In this literature review, it is seen that 2 different testing setups have been used by the students to test the performance of electric motors. One is manually operated while the other is a computer assisted one. Thus, the testing setup has to be employed as per the end applications of the motor.
4) Maxon Motor Data and Operating Ranges: How to interpret the data of maxon motors? It is a PowerPoint presentation explaining briefly about the motor data and operating ranges of DC motors. It also gives an overview of characteristics like speed, torque, current by explaining their characteristics through graphs and values at different conditions and factors. Also, influence of heat on all the conditions has been stated for detailed knowledge of the concepts.
5) Design and Construction of a Dynamometer by Rachel E. Batzer, Massachusetts Institute of Technology, June 2011: Access to a dynamometer is a useful tool for any electrical system where the motors must be selected from various suppliers and fully characterized. Motor suppliers usually provide a torque, speed, efficiency curve, but it frequently does not have complete motor characterization and includes

motor controller losses in the total system loss. The dynamometer presented in this thesis is designed with the objective to test high efficiency motors and motor controllers in the power and speed range requires for competition in the World Solar Challenge, a transcontinental race for solar electric vehicles. The testing specifications of a solar electric vehicles are rare among motor testing needs because it requires high torque, low power, high efficiency, and the only a small operating range. This thesis explains the design and construction of the dynamometer.
6) Design of a Small Electric Motor Dynamometer by William A. Black Jr.: With the increased use of sub-fractional hp electric motors it has become necessary to further study the problems encountered in experimentally determining speed-torque characteristics of electric motors. An electronically controlled dynamometer was designed and built which would provide accurate loading, and accurate torque measurements of these small motors. A study of the dynamometer indicated that it can be used to accurately control the loading and to accurately determine the speed-torque characteristics of small electric motors if care is exercised in its construction and operation.

3. OVERALL SYSTEM ARCHITECTURE

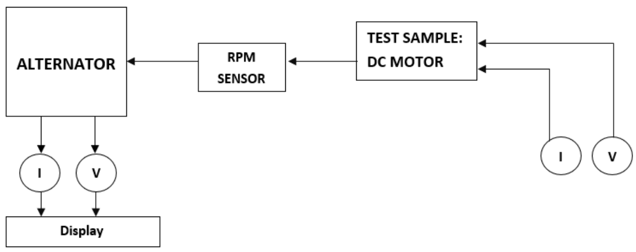

Fig. 1: System Circuit Diagram

The proposed setup for motor testing is based on the circuit diagram as shown above. When we give power supply to the motor, it will drive the alternator and the output will be the speed, load current and load voltage of the alternator. This will give the motor specifications.

3.1 Alternator

An automotive charging system has three major components: the battery, the voltage regulator and an alternator. The alternator works with the battery and generates power for the electrical components of a vehicle. An alternator gets its name from the term alternating current (AC). Alternators are usually placed near the front of the engine and are driven by the crankshaft. On similar lines, here the input will be given to the motor and the motor will drive the alternator that will give the output by which we can check the motor.

3.2 Motor

A DC test motor has been selected here of known parameters for evaluating the efficiency of the setup. The motor will drive the alternator for certain value of rpm and then we can obtain the torque with the help of the load current and voltage. The speed of the motor is varied by varying the value of input current and voltage to the motor.

3.3 DC Power Supply Unit

The DC power supply is used to regulate the voltage and current to the motor to take the different readings at different inputs to determine the characteristics of the unknown motor.

3.4 Current & Voltage Indicator

The output from the alternator is measured i.e. current and voltage are noted and they are used for the calculation of torque of the motor. The output is digital and can be noted directly.

3.5 RPM Sensor

The RPM sensor is used to measure the RPM of the motor to plot the graph and works on Hall Effect Principle. The output is digital and can be noted directly.

4. PROCEDURE

The setup consisted of an alternator of very low power so a wide range of motors can drive it. The alternator is of 12 V, 35 A delivering a power of 336 Watts (considering a power factor of 0.8). The motors above 336 Watts will be required to drive the alternator considering losses that take place. The motor and the alternator will be coupled using a coupling. The coupling will be such that at the motor end, there will be removable sockets of a set of sizes to fit for different motor shaft sizes. The losses in the coupling have to be as minimum as possible. The entire setup will be mounted on a table. The rpm sensor will give the value of the speed. Simultaneously, the current and voltage indicator will give the values of current and voltage output from the alternator, which will be used for the determination of torque.

The torque developed by an electric motor is given by the eq uation

$$T_{motor} = 9.6 \frac{U \, x \, I}{\eta \, x \, n}$$

where U is the voltage across the generator terminals in vo lts, I is the current in the field winding in amperes, n is the rotation rate in rpm, and η is the efficiency of the generato r. Thetorque is varied by adjusting the load resistance and the current in the generator's field winding.

5. TEST SETUP

The test setup was developed which consisted of the test motor, DC power supply, alternator and the current and voltage measurement sensors.

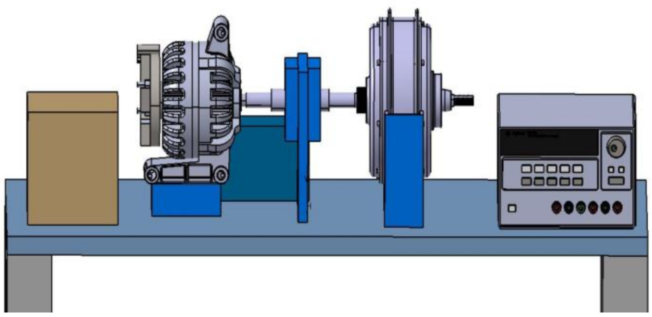

Fig.2: Rendered CAD Model of the experimental setup

The industrial dynamometer testing is very expensive for all types of electric motors, especially the small motors which have small arena of parameters to be tested. This experimental setup is capable of testing most of the parameters like speed, current, voltage, torque, power and give the result at a very economical cost. This helps in reducing the overall cost of testing by almost 60% to 70%.

6. RESULTS

The table gives the torque obtained at the set rpm values of the motor. The torque is calculated using the formula and rpm is recorded by the rpm sensor. The rpm and torque graph can be generated using these results that help to define their relationship in the test motor. The results obtained are tabulated below.

Table 1: Rpm and Torque Values

Rpm	Torque
1000	5.604324
2000	2.802162
3000	1.868108
4000	1.401081
5000	1.120865
6000	0.934054
7000	0.800618

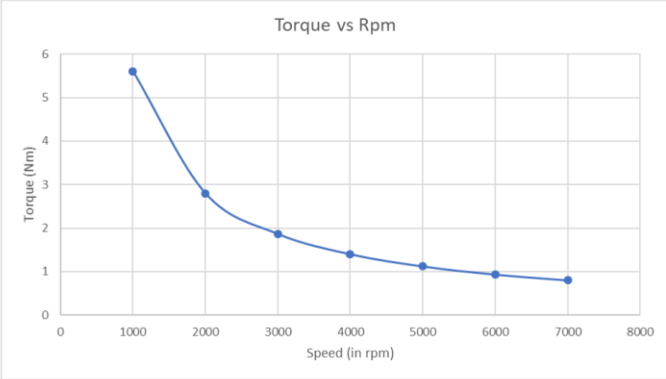

Fig 3: Graph of Torque vs RPM

7. CONCLUSION

With the automotive industry moving towards electric technology where electric motor plays an important role. This will lead to a significant increase in the research for new and efficient electric motors. This test setup has been designed for the initial testing of electric motor during the preliminary design phase in a cost-effective manner. The results obtained will help to determine the operating parameters of the motor which are critical in the early phase of motor development.

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