Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, May : 2023

Dynamometers: The Measurement of Torque, Speed, and Power

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Abstract

An engine, motor, or other rotating machinery's power and torque can be measured with a dynamometer. It functions by applying pressure to the machine being tested, either by slowing down its spin with a brake or by absorbing the power output with an electrical generator. The force exerted by the dynamometer is measured, and the resulting figures are used to determine the power and torque being generated. In order to evaluate and improve the performance of engines and other equipment, dynamometers are used in a range of industries, including the automotive, aerospace, maritime, and manufacturing ones. They are crucial instruments for research, development, and quality control, assisting technicians and engineers in making sure that their products adhere to the necessary performance criteria.

Introduction

A dynamometer is a device used to measure force, torque, or power. It is commonly used in the automotive and aerospace industries, as well as in research and testing laboratories, to measure the output of engines, motors, and other machinery.

There are several types of dynamometers, each designed to measure different types of forces or torque. For example, an engine dynamometer is used to measure the horsepower and torque output of an engine, while a brake dynamometer is used to measure the braking force of a vehicle or machine.

Dynamometers can be classified into two main categories: absorption dynamometers and transmission dynamometers. Absorption dynamometers absorb the power produced by the machine being tested, while transmission

dynamometers measure the power as it is transmitted through a system.

Dynamometers are essential tools for engineers and researchers who need to measure the performance and efficiency of machines and engines. They are also used in the development and testing of new technologies, such as electric motors and hybrid vehicles.

Literature Review

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.

3.1 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.

Methodology

Select an appropriate electrical dynamometer based on the requirements of the research project, such as the desired torque range, power capacity, and measurement accuracy.

Install and set up the electrical dynamometer according to the manufacturer's guidelines, ensuring proper electrical connections and system integration.

Instrumentation and Data Acquisition:

Connect necessary sensors, such as torque transducers, rotational speed sensors, and temperature sensors, to the electrical dynamometer and the machinery being tested.

Set up a data acquisition system to capture and record measurements from the dynamometer and other relevant sensors. This may involve using specialized software or hardware for data acquisition and analysis.

Calibration:

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Calibrate the electrical dynamometer to ensure accurate and reliable measurements. This typically involves applying known loads or torque values to the dynamometer and comparing the measured values with the expected values.

Adjust the dynamometer's calibration if necessary to achieve accurate results throughout the research study.

Test Design and Execution:

Design experimental protocols and test scenarios that address the specific objectives of the research. This may involve varying parameters such as load levels, rotational speeds, or operating conditions.

Execute the planned tests while collecting data from the electrical dynamometer and other connected sensors.

Repeat the tests as needed to ensure repeatability and gather sufficient data for analysis.

Data Analysis:

Process and analyze the collected data using appropriate statistical or analytical techniques. This may include calculating torque, power, efficiency, or other performance parameters based on the recorded measurements.

Compare and interpret the results to draw meaningful conclusions and insights related to the research objectives.

Conduct any necessary data visualization or graphical representation to support the findings.

OVERALL SYSTEM ARCHITECTURE

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.

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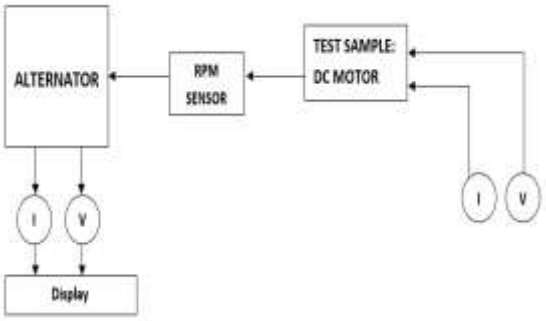

System Circuit Diagram

Discussion and Conclusion:

Discuss the research findings in the context of the original research objectives and relevant literature.

Address any limitations or uncertainties in the methodology or data.

Draw conclusions based on the results and their implications for the research field.

Identify potential areas for further research or improvement based on the obtained findings.

Conclusion

- A dynamometer is a measuring device used to determine the torque, force, speed, and power required to operate the machine or motor drive.
- For the best readings from a dynamometer, it is important to calibrate and test it regularly.
- Though the use of dynamometers may seem to be restricted to motors, engines, and other mechanical devices, in reality, they have found use in a wide variety of fields as a means for measuring power and force.
- The basic types of dynamometers are absorption, or passive, and universal. The absorption type is used for driving purposes, while the universal type is for absorption and driving.
- A dynamometer has a data acquisition system that includes a commander and workstation.

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