

# Development and Performance Analysis of a Rope Brake Dynamometer for Electric Vehicle Motor Testing

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**Abstract** – Now days electric vehicle sector is growing at rapid rate, hence it is necessary to develop efficient testing methods to assess the performance and reliability of electric vehicle motor. This research paper presents design, development and performance analysis of rope brake dynamometer for electric vehicle motor testing. Rope brake dynamometer provides cost effective solution for evaluating power, torque and efficiency. The paper covers all the aspects related to experimental setup, design considerations and performance evaluation of the rope brake dynamometer. The paper will also focus on other types of dynamometers which can be implemented for electric vehicle motor testing. It will also consider real world parameters that will eventually affect the motor performance.

**Key Words:** Electric Vehicle, Electric Motor, Testing, Dynamometer, Torque, Efficiency.

## 1. INTRODUCTION

Dynamometer is a device used to measure power and torque. Traditionally, dynamometers have been widely used for motor testing in various applications. However, the unique characteristics of electric vehicle motors, such as high torque output and regenerative braking capabilities, necessitate specialized dynamometers that can accurately simulate real-world driving conditions. The conventional dynamometers often struggle to replicate these conditions, leading to inaccurate test results and limited insights into the motor's performance. If you are responsible for the maintenance or testing of electric motors, a dynamometer is a valuable tool. It can help you to ensure that your motors are operating properly and that they are meeting the demands of their application. The primary objective of this research is to design a rope brake dynamometer system that can measure and analyze the power, torque, and efficiency of electric vehicle motors under various operating conditions. By utilizing a rope brake as the load absorption mechanism, this dynamometer can provide controlled and adjustable resistance, enabling accurate simulation of different driving scenarios. Furthermore, the rope brake dynamometer offers enhanced thermal management capabilities, critical for

handling the high power outputs generated by electric vehicle motors.

## 2. Types Of Dynamometers

### A. Absorption Type

1. Prony Brake Dynamometer

2. Rope Brake Dynamometer

3. Eddy Current Dynamometer

4. Hydraulic Dynamometer

### B. Transmission Type

#### Absorption type dynamometer:

The working principle of an absorption dynamometer involves the application of a load that resists the rotational motion of the motor. This load can be achieved through various mechanisms, such as hydraulic brakes, eddy current devices, or friction-based systems like the rope brake dynamometer. The choice of load absorption mechanism depends on factors such as the power capacity, torque range, cost-effectiveness, and specific testing requirements.

#### 1. Prony Brake Dynamometer:

The basic principle behind a Prony brake dynamometer involves applying a frictional load to the motor's rotating output shaft, thereby resisting its motion and converting the power into heat.



The brake assembly consists of two surfaces, typically made of materials with high frictional characteristics such as brake linings or friction pads. These surfaces are pressed against the rotating shaft, creating a frictional force that opposes the rotational motion. By measuring and controlling this frictional force, the power output of the motor can be accurately determined.

## 2. Rope Brake Dynamometer:

A rope brake dynamometer is a specific type of absorption dynamometer commonly used for measuring the power and torque output of an engine or motor. It is a simple and cost-effective device that applies a braking force to the rotating shaft of the engine or motor being tested. When the engine or motor is running, the brake band or rope is tightened around the drum, creating friction and resisting the rotation. The tension applied to the band or rope can be adjusted to control the braking force and load on the engine or motor. By measuring the force or torque applied to the band or rope, the power output and performance characteristics of the engine or motor can be determined. Rope brake dynamometers are commonly used in small-scale applications, such as testing small engines, agricultural machinery, and some industrial equipment. They offer a straightforward and affordable method for measuring power and torque but may have limitations in terms of accuracy and precision compared to more advanced dynamometer systems.



## 3. Eddy Current Dynamometer:

The fundamental principle behind an eddy current dynamometer involves the generation of eddy currents in a conducting disc or rotor, which is positioned in close proximity to a fixed magnetic field source. When the motor under test drives the rotor, the magnetic field induces eddy currents in the rotor material. These eddy currents create a resistive force, known as the eddy current drag, which opposes the motor's motion and provides a controlled load. By adjusting the magnetic field strength and controlling the rotor speed, the load on the motor can be accurately regulated.



## 4. Hydraulic Dynamometer:

A hydraulic dynamometer is a type of dynamometer that uses hydraulic fluid to create a resistive load for measuring power output and torque of an engine or motor. It provides a controlled and adjustable resistance to simulate various operating conditions and determine the performance characteristics of the system under test. Hydraulic dynamometers are commonly used in applications such as engine testing, performance evaluation, research and development, and quality control in industries such as automotive, marine, aerospace, and heavy machinery.



## Transmission Type Dynamometer:

Transmission dynamometers typically consist of a hydraulic or electric motor coupled to a load mechanism, which is connected to the transmission output shaft. The load mechanism can vary depending on the specific design and requirements, and may include hydraulic brake systems, torque multipliers, or variable resistance devices. By controlling the load on the transmission output, the dynamometer can accurately replicate different driving conditions, including acceleration, deceleration, and steady-state operation.

The advantages of using a transmission dynamometer for electric vehicle motor testing are significant. Firstly, it provides a holistic evaluation of the motor and transmission system's performance, enabling comprehensive analysis of power transmission efficiency,

energy consumption, and drivetrain losses. This information is critical for optimizing the motor and transmission designs to achieve higher efficiency and range in electric vehicles.

### 3. Selection criteria for dynamometer:

The selection of a dynamometer depends on various factors and criteria. Here are some key considerations when choosing a dynamometer:

**Power and Torque Capacity:** Determine the power and torque range of the engines or motors you will be testing. Select a dynamometer that can handle the maximum power and torque levels required for your application.

**Load Control and Simulation:** Consider the level of control and simulation capability needed for your testing. Different dynamometers offer varying degrees of load control, allowing you to simulate specific operating conditions, such as road or track conditions. Consider whether you need precise load control, transient response capabilities, or the ability to simulate specific load profiles.

**Measurement Accuracy and Precision:** Evaluate the measurement accuracy and precision requirements for your testing. Different dynamometers offer different levels of measurement accuracy. Consider the accuracy of torque, power, rotational speed, and other parameters that you need to measure. The dynamometer should provide reliable and precise measurements within your desired tolerances.

**Application Compatibility:** Consider the compatibility of the dynamometer with your specific application. Certain dynamometers may be better suited for specific types of engines or motors, such as internal combustion engines, electric motors, or specific industries like automotive, aerospace, or marine. Ensure that the dynamometer is suitable for your intended application and can handle the specific requirements and characteristics of your systems.

**Budget and Cost Considerations:** Evaluate the cost and budget constraints for the dynamometer system. Dynamometers can vary significantly in terms of cost, depending on their features, capacity, and capabilities. Consider the overall system cost, including any additional equipment or infrastructure required for installation and operation.

**Support and Service:** Assess the availability of technical support and service from the dynamometer manufacturer or supplier. It is essential to have reliable support for installation, calibration, maintenance, and troubleshooting to ensure the optimal performance and longevity of the dynamometer system.

**Future Expandability:** Consider the potential for future expansion or upgrading of the dynamometer system. If you

anticipate changes in your testing requirements or expect increased power or torque levels in the future, it is beneficial to choose a dynamometer that can be easily expanded or upgraded to accommodate such changes.

By considering these criteria, you can select a dynamometer that meets your specific testing needs, provides accurate and reliable measurements, and aligns with your budget and future requirements. It is often helpful to consult with dynamometer manufacturers or experts in the field to assess your specific requirements and obtain recommendations tailored to your application.

### 4. Necessity of Rope Brake Dynamometer.

The choice of a rope brake dynamometer for electric vehicle motor testing can be attributed to several reasons:

**Cost-effectiveness:** Rope brake dynamometers are generally more affordable compared to other types of dynamometers, making them a cost-effective option for testing and research purposes. This affordability is beneficial, especially for smaller-scale laboratories or research facilities with limited budgets.

**Flexibility and adjustability:** Rope brake dynamometers offer a high degree of flexibility and adjustability in terms of load control. The resistance can be easily adjusted by changing the tension on the rope, allowing for a wide range of load settings and the ability to simulate various driving conditions.

**Real-world simulation:** Rope brake dynamometers provide a relatively realistic simulation of the load experienced by the motor during actual driving conditions. By adjusting the brake tension, the dynamometer can mimic different driving scenarios, including acceleration, deceleration, and steady-state operation.

**Thermal management:** Electric vehicle motors can generate high power outputs, leading to significant heat generation. Rope brake dynamometers often incorporate effective thermal management systems to dissipate the heat generated during testing. This ensures that the dynamometer can handle the high power levels without overheating or affecting the accuracy of the test results.

**Ease of setup and maintenance:** Rope brake dynamometers are relatively simple in design and construction, making them easy to set up and maintain. They typically have fewer moving parts compared to other dynamometers, reducing the complexity of installation, operation, and maintenance.

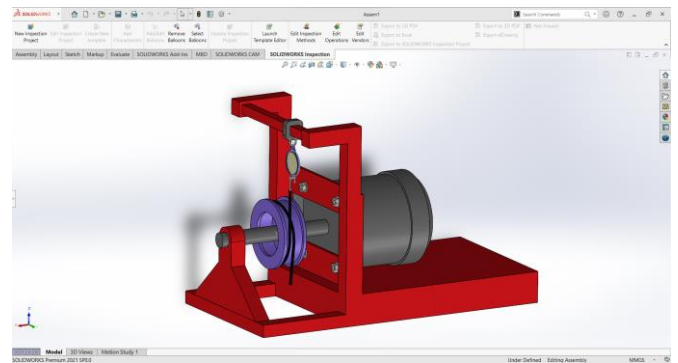
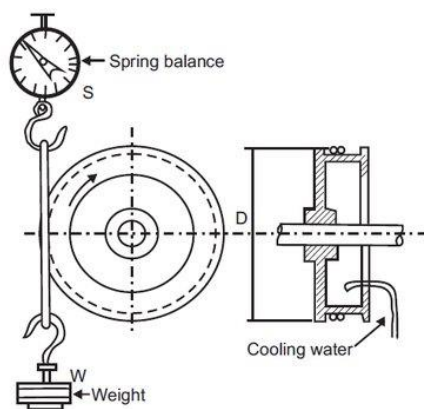
**Wide torque range:** Rope brake dynamometers can accommodate a wide range of torque outputs, making them suitable for testing electric vehicle motors with varying

power levels. By adjusting the rope tension, the dynamometer can be calibrated to handle different torque requirements, allowing for testing of motors with different performance capabilities.

**Accuracy and reliability:** When properly calibrated and maintained, rope brake dynamometers can provide accurate and reliable measurements of power, torque, and efficiency. The load absorption mechanism, which involves the friction between the rope and the brake drum, allows for precise control and measurement of the motor's output.

Overall, the selection of a rope brake dynamometer for electric vehicle motor testing offers a balance between cost-effectiveness, flexibility, and accuracy. It provides a practical and reliable solution for assessing the performance and efficiency of electric vehicle motors under various operating conditions, contributing to the development of more efficient and reliable electric vehicles.

### 5. Construction of Rope Brake Dynamometer.



To construct a rope brake dynamometer for electric vehicle (EV) motor testing, follow these steps:

- 1. Drum:** Create a sturdy drum with a smooth surface that can rotate freely. The drum should be able to handle the torque and speed of the EV motor being tested.
- 2. Mounting:** Securely mount the drum on a shaft or axle, ensuring it is supported by bearings for smooth rotation. The shaft should be connected to a suitable power transmission mechanism, such as a gearbox or coupling, to transfer the motor's torque to the drum.
- 3. Rope:** Choose a high-strength and heat-resistant rope that can withstand the forces exerted by the EV motor. Wrap the rope tightly around the drum, ensuring good contact and grip.
- 4. Tensioning System:** Design a mechanism to apply adjustable tension to the rope. This can be accomplished by connecting one end of the rope to a tensioning device, such as a spring-loaded arm or a hydraulic/pneumatic cylinder. The tensioning system should provide enough force to maintain a consistent grip on the drum during testing.
- 5. Force Measurement:** Install a suitable force measurement device or load cell to measure the resistance generated by the drum. This could be a strain gauge, a torque sensor, or any other accurate force measuring instrument capable of capturing the torque output of the EV motor.
- 6. Calibration:** Before conducting tests, calibrate the dynamometer using known torque values. This ensures accurate measurement and reliable results.
- 7. Safety Measures:** Implement safety features, such as guards or shields, to protect against accidents and injuries. Make sure the dynamometer is securely mounted to a stable structure or frame.

When conducting EV motor testing, connect the motor to the dynamometer using a suitable coupling or adapter. As the motor operates, it will exert a force on the rope, causing the drum to rotate. The resistance generated by the drum can be

measured by the force measurement device, providing information about the torque output of the EV motor.

## 6. Results Of Developed Rope Brake Dynamometer

After construction of rope brake dynamometer following observations were taken and subsequent calculations were performed.

W = Dead weight

S = Spring balance reading

T = Transmitted Torque

Sr. No.	W (in Kg)	W (in N)	S (in Kg)	S (in N)	T (in Nm)
1	25	245.25	7.7	75.53	6.541
2	25	245.25	7.3	71.61	6.685
3	25	245.25	8.0	78.48	6.420
4	25	245.25	7.1	69.65	6.760
5	25	245.25	6.9	67.68	6.830

Sr. No	Transmitted Torque(in Nm)	Brake Power (in watt)
1	6.541	231.09
2	6.685	236.18
3	6.420	226.81
4	6.760	238.83
5	6.830	241.30

1. From calculations we obtained motor power is 234.84 kW.
2. The accuracy was 93.94 %.

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