Design, Fabrication and Experimental Analysis of Brake Liner Test Rig

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Abstract—The objective of this project is to Fabricate, develop, and test a Brake Liner Test Rig aimed at evaluating the performance and durability of brake liners under various operational conditions. Brake liners are critical components in braking systems, directly impacting vehicle safety and performance. The test rig simulates real-world conditions to assess frictional behavior, wear characteristics, thermal stability, and overall reliability of brake liners used in automotive applications. The test rig is engineered to replicate the mechanical and thermal loads experienced by brake liners during braking events. During the testing phase, multiple brake liner materials are subjected to a series of controlled experiments. The performance metrics collected include coefficient of friction, wear rate, temperature rise, and deformation. The results are analyzed to determine the correlation between material composition, manufacturing processes, and performance under stress. This project contributes to the automotive industry by providing a reliable method to evaluate brake liners' performance before mass production. The insights gained from this research can inform future innovations in brake system design and material science.

Index Terms—Brake liner, thermal stability, automotive safety, data acquisition.

I. INTRODUCTION

The development of a Brake Liner Test Rig is essential for evaluating the performance and durability of brake linings under various operation conditions. This project aims to design and construct a test rig that simulates real-world braking scenarios, providing reliable and repeatable testing methods for brake liners used in automotive applications.

A Brake Liner Test Rig is a specialized apparatus used for evaluating the performance and characteristics of brake linings, which are critical components in braking systems. These rigs simulate real-world braking conditions to assess factors such as friction coefficient, wear rate, thermal stability, and noise generation of the brake liners. The primary objectives of using a brake liner test rig include ensuring safety, enhancing performance, and complying with regulatory standards.

The test rig typically consists of components like a rotating drum or disc to mimic the brake's operation, sensors to measure temperature, pressure, and friction, and data acquisition systems to record and analyze the results. By replicating various driving conditions, these rigs help manufacturers and researchers optimize brake materials and designs, ensuring reliable and effective braking performance in actual vehicles.

II. SCOPES AND OBJECTIVES

A brake liner test rig is a specialized piece of equipment used to evaluate the performance, durability, and safety of brake liners. These test rigs are essential in the automotive and transportation industries to ensure that brake systems meet safety standards and perform reliably under various conditions.The aim of this research work is to develop and carry out performance evaluation of brake pad test Rig. The objectives are:

1. To design a brake pad test rig

2. To fabricate a brake pad test rig.

3. To carry out Testing on brake pad test rig.

- Performance testing like (friction coefficient measurement, Wear and tear analysis, Thermal performance.)

- Safety testing which includes (Fade testing, Recovery testing, Vibration and noise testing.)
- Durability and Reliability Testing (Long-Term Endurance Testing, Cyclic Testing, Environmental Testing.)
- Material and Chemical Analysis.
- Compliance and Standards Verification (Quality Control, Regulatory Compliance.)
- Research and Development.

III. Design Considerations:

- Safety: Guards and enclosures to contain debris and heat.
- Emergency stop buttons and overload protection.
- Proper ventilation for heat and dust.
- Rigidity and Vibration Control:
- Sturdy frame to minimize vibrations that could affect measurements.
- Cooling systems (air or liquid) to control disc temperature.
- Insulation to protect sensitive components from heat.
- Data Acquisition and Control:
- High-speed DAQ system for real-time data collection.
- Design according to industry standards (e.g., SAE J2522, ISO 6312) for comparability.

The final design in AutoCAD is a detailed 2D and 3D model of the complete brake liner test rig assembly, including all necessary components and subassemblies. The design is accurately represent the dimensions, materials, and specifications required for the test rig to function as intended.
The main components of the brake liner test rig design in AutoCAD would typically include:
• Base structure: A sturdy base plate or frame that serves as the foundation for the test rig, providing stability and support for the other components.
• Brake component mounting: Fixtures, clamps, or brackets designed to securely hold the brake liners and the disc or drum they will be tested against. The mounting components should allow for easy installation and removal of the brake components.
• Loading mechanism: A system designed to apply the desired force or pressure to the brake liners during testing. This could be a hydraulic or pneumatic cylinder, a lever system, or a weight-based system, depending on the specific testing requirements.
• Instrumentation: Sensors and measuring devices integrated into the design, such as load cells, displacement sensors, or temperature probes, to collect data during testing.
• Safety features: Guards, enclosures, or emergency stop buttons included in the design to ensure safe operation of the test rig.
• Assembly and subassembly views: The design should include exploded views or sectional views to illustrate the assembly process and internal components of the test rig.
• Dimensions and annotations: Clear dimensions, notes, and labels should be included throughout the design to ensure accurate manufacturing and assembly.

❖ **Design of a Brake Liner Test Rig**

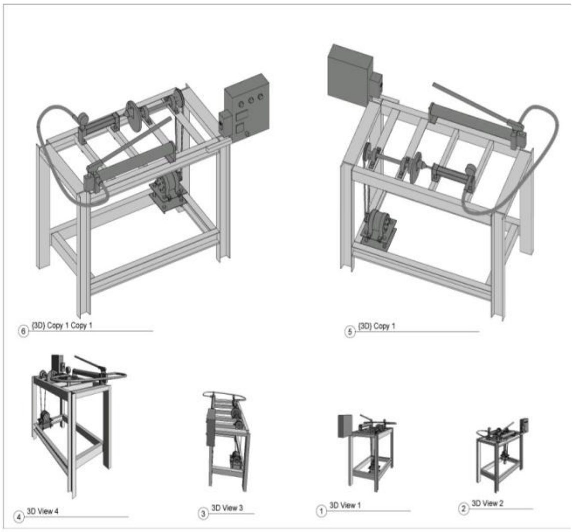

Fig: 3D design final output.

IV. FABRICATION PROCESS:

S.NO.	ITEMS	MATERIALS	SPECIFICATIONS in mm
1	Channel 1	Mildsteel	900x75x40
2	Channel 2	Mildsteel	750x75x40
3	Channel 3	Mildsteel	300x75x40
4	Shaft	Mildsteel	300x18
5	Disc	Carbonsteel	
6	AngleBarx2	Mildsteel	300x50x50
7	Squarepipex 2	Mildsteel	300x25x50
8	Nuts&Bolts	Stainlesssteel	
9	AllenBolts	Stainlesssteel	M6x20M8x20

Table 1: Material selection for brake liner test rig

S.NO.	ITEMS	MODELS	SPECIFICATIONS
1.	Electrical Arc welding machine	Maxm.Chtg/ Nma 400,400,380 Volts	
2.	Lathe	4jawchuck	
3.	Angular grindingmachine		125mmGrindingDisc
4.	Cuttingmachine	3800rpm 2200w	350mmCuttingblade
5.	Radialdrillingmachine	1440rpm .3phase .2hp .415v 1.5kw	
6.	Vernier caliper and measuring devices		Digitalverniercaliper

Table 2. Equipment used for Fabrication

S.NO.	ITEMS	DESCRIPTION
1.	D.C.Motor	4pol-24volts/1hp1450-1500rpm
2.	D.C.toA.C.Convertor	40Amps/24volts
3.	Speedcontroller	40Amps
4.	RPMIndicator	5000rpm(max)
5.	BeltPulley	4inch
6.	HydraulicPump	700bar
7.	PneumaticBrakecylinder	10bar
8.	Pressuregauge	21bar(max)
9.	TemperatureProbe	J-Type
10.	Temperatureindicator	1000C

Table 3. Technical specifications for analysis

Measuring/marking:

Measuring mild steel bars typically involves using a measuring tape or a ruler to determine the length, width, and thickness of the bar. Length is straightforward, while width and thickness are measured at various points along the bar to ensure consistency. It's important to use precise measuring tools and techniques for accurate results, especially in construction and engineering projects where mild steel bars are commonly used.

Fig: Measuring of mild steel

4.1 Cutting of mild steel bars

Cutting mild steel bars with a power cutter tool is a common practice in metalworking. Make sure to wear appropriate safety gear, such as goggles and gloves, and follow proper techniques for handling the tool. Ensure the steel bar is securely clamped down before cutting to prevent it from moving during the process. Be aware of sparks and hot metal fragments generated during cutting, and work in a well-ventilated area to avoid inhaling fumes.

Fig: Cutting of mild steel

4.2 Grinding:

Grinding mild steel bars with a tool typically involves using an abrasive grinding wheel or belt or finish.Grinding mild steel bars typically involves using a grinding wheel to shape and smooth the surface of metal. It's often done to achieve a specific finish,

Fig: Grinding of mild Steel

4.3 Drilling

Drilling machines are in differ types like, Handheld drilling machine, bench drill, radial arm drill, magnetic drill, pillar drills etc. But here for operation we have used radial arm drilling machine of given specimen.are commonly used for drilling holes in mild steel because they offer versatility and precision.

Fig (a) Specimen before drilling

Fig. (b) Performing drilling operation

4.4 Welding

Generally Welding mild steel, a common type of low carbon steel, is a fundamental process in fabrication and construction due to its versatility and weld ability. Welding of steel need special precautions according to differ welding processes. There are many processes of welding like, Gas Metal Arc Welding, Gas Tungsten Arc Welding, Shielded Metal Arc Welding, Flux-Cored Arc Welding, Submerged Arc Welding and electric arc welding. But here we are using electric arc welding as per availability and requirement of specimens.

V. METHODOLOGY

Final Assemble of Components:

After completion of welding part and surface finishing of frame work. The assembling of different components is done. In this no. of various components such as speed controller, dc motor, belt pulley, hydraulic pump, brake cylinder, temp probe, temp indicator, dc to ac converter, speed rpm indicator for acquiring required Performance and final result by doing testing part. The components which are assembled are as follows.

a. Frame b.Shaft c. Disc d. Hydraulic pump
e. Pneumatic brake cylinder f..D.C. to A.C. convertor g. Speed controller h.D.C. motor i. RPM indicator j. Belt pulley k..Pressure gauge l. Temperature probe
m..Temperature indicator

a.Frame: Frames play a crucial role in various fields by providing support, structure, and organization.The design and material choice for a frame depend on its specific application and requirements, balancing factors like strength, weight, durability, and cost. we have used mild steel channels for the frame of the test rig.

Fig: Frame of test rig- h*l*b - 900mm*750*300mm.

d. Hydraulic Pump:
A hydraulic pump is a mechanical device used to convert mechanical energy into hydraulic energy, typically in the form of fluid flow.The pressure and force of used hydraulic pump here is upto 700 bar.

Fig: Hydraulic pump

e. Pneumatic brake cylinder
In a brake liner test rig, a brake cylinder may refer to a component used to apply pressure to the brake lining being tested.Here we are using brake cylinder of 10 bar. because, of If the brake cylinder in the test rig has a pressure rating of 10 bar, it means that it can handle a maximum pressure of 10 bar without experiencing damage or failure.

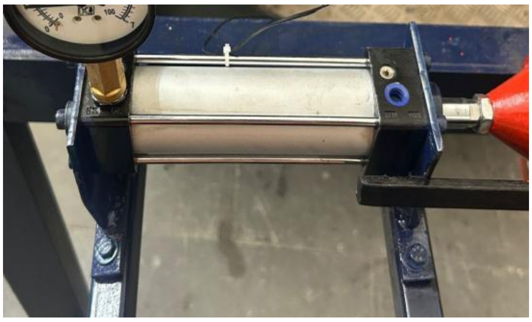

Fig: Pneumatic brake cylinder

g. Speed Controller:
A speed controller in a brake liner test rig serves to regulate the rotational speed of the test specimen or the load being tested. This control is essential for simulating various operating conditions and

evaluating the performance of the brake lining material under different speeds.

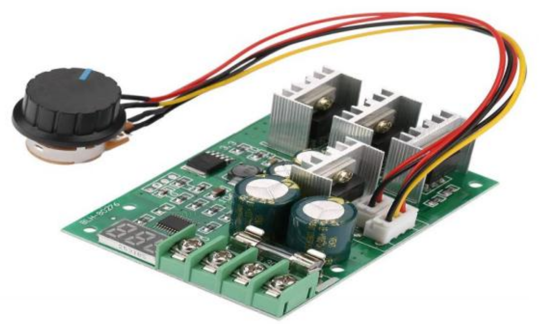

Fig: Speed Controller

h. Control panel

In a brake liner test rig, the control panel serves as the central interface for operating and controlling the various functions and parameters of the testing equipment. Control panel includes:

1. Temperature controller, 2. RPM indicator, 3. Speed Controller.

VI. RESULTS AND DISCUSSION

Design: The final design in AutoCAD is a detailed 2D and 3D model of the complete brake liner test rig assembly, including all necessary components and subassemblies. The design is accurately represent the dimensions, materials, and specifications required for the test rig to function as intended.

The main components of the brake liner test rig design in AutoCAD would typically include:

a. Base structure, b. Brake component mountings c. loading mechanism, d. instrumentation.

The final AutoCAD design is well-organized, with different components and subassemblies separated into appropriate layers or blocks for ease of viewing and modification.

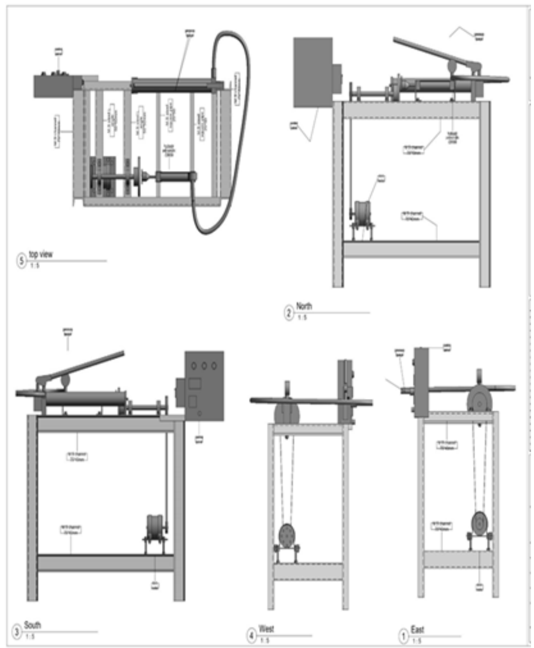

Fig: Final Design output of Brake line test rig

Fabrication:

In this process of completing of fabricating of brake liner test rig successfully fabricated as per given design of model and per given dimensions of acquired raw materials. During the process of fabrication specially mentioned about required dimensions have not succeeded and material dimensions is in the their limits only. Proper markings and measuring is done under guidance of guides. The frame work is been completed as per initially given design. And, after that the different components which have been used are properly placed according to previous model. The specifications of different components are taken according the working of test rig and according to final performing different tests on it. After completion of assembling and fabricating part. The working of test rig is done and no vibration sounds are not been observed. The test rig is performing well readings like temp reading and rpm reading at given speed has been successfully without any error we required proper readings.

Fig: Fabrication of Brake line test rig

Experimental Analysis of brake liner test Rig:

Wear Resistance:

The wear resistance tests revealed significant differences among the materials. Ceramic composites exhibited the lowest wear rates, followed by semi-metallic and organic liners. This indicates that ceramic composites are more durable and suitable for applications requiring high longevity.

Sl. No	Material Type	Wear Rate (g/km)
1	Ceramic 0.002	
2	Semi-metallic	0.005
3	Organic 0.01	

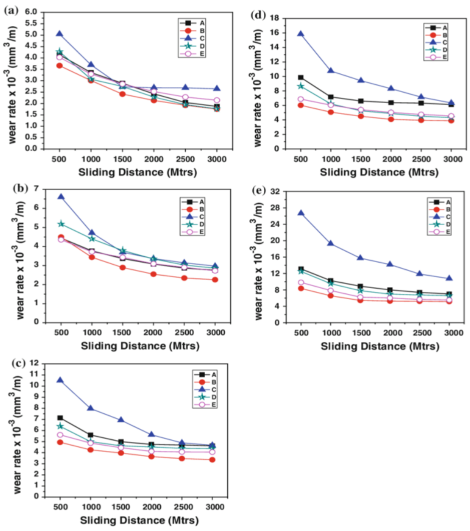

Fig: Wear Rate Comparison

Frictional performance:

Frictional performance tests showed that semi-metallic liners provided the best balance of initial friction and consistency over time. Organic liners had good initial friction but showed a decrease in performance with wear, while ceramic composites maintained consistent friction levels..Materials friction tests are as follows:

Sl. No	**Material Type**	**Initial Friction Coefficient**	**Friction Coefficient after Wear**
1	Ceramic	0.42	0.42
2	Semi-metallic	0.4	0.4
3	Organic	0.45	0.35

Thermal Stability:

Thermal stability assessments indicated that ceramic composites performed exceptionally well under high temperatures, maintaining their structural integrity and frictional properties. Semi-metallic liners showed moderate thermal stability, while organic liners were prone to degradation under thermal stress. Thermal stability tests for bike brake liners are essential to evaluate how well the brake liners perform under high-temperature conditions typically encountered during prolonged braking. These tests assess the brake liner's ability to maintain structural integrity, frictional performance, and wear resistance when subjected to elevated temperatures.

Sl. No	**Material Type**	**Structural Integrity (at 300°C)**	**Performance Degradation**
1	Ceramic	Maintained	None
2	Semi-metallic	Minor degradation	Moderate
3	Organic	Significant degradation	High

VII. CONCLUSIONS:

1. The brake liner test rig has been designed to meet all the specified requirements for testing the performance and durability of brake liners under various conditions. The final design consists of a robust and rigid base structure made of steel plates and square tubes, providing a stable foundation for the entire assembly.

2. The brake component mounting system incorporates high-strength clamps and adjustable fixtures to securely hold the brake liners and the disc or drum they will be tested against. This modular design allows for easy installation and removal of different brake components, enabling efficient testing of various brake configurations.

3. Integrated into the design are various instrumentation components, including load cells, displacement sensors, and temperature probes. These sensors are strategically positioned to measure and record critical data during the testing process, such as applied force, brake liner wear, and temperature changes.

4. Safety features have been incorporated throughout the design, including an enclosed guard surrounding the testing area, emergency stop buttons, and proper labeling of potential hazards. These measures ensure the safe operation of the test rig and protect the users from potential risks.

5. The design includes detailed exploded and sectional views, clearly illustrating the assembly process and internal components of the test rig. These views will facilitate the manufacturing, assembly, and maintenance processes.

6. Comprehensive dimensions and annotations have been provided throughout the design, ensuring accurate interpretation and implementation of the specifications. The design adheres to relevant industry standards and regulations for brake testing equipment, ensuring compliance and reliable performance.

7. The final AutoCAD design has been meticulously organized, with different components and subassemblies separated into appropriate layers and blocks for ease of viewing and modification. This organization will simplify future design updates or alterations as needed.

8. Overall, the brake liner test rig design meets the specified requirements and incorporates features that promote safety, accuracy, and efficiency during testing operations. The detailed design documentation provided in AutoCAD will enable the successful manufacturing and assembly of the test rig, enabling comprehensive evaluation and quality assurance of brake liner products.

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