IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

FRONT AXLE TEST RIG

[1]Tejas Jagtap, [2]Om Nagapure, [3]Siddhant Patil, [4]Dr. Ravindra Edlabadkar

[1]Student, [2]Student, [3]Student, [4]Professor
[1]Department of Mechanical Engineering,
[1]Pune Vidyarthi Griha's College of Engineering and Technology, Pune, India

Abstract: This paper presents the development of a front axle test rig for evaluating the performance of the front axle of the tractor. The test rig employs pneumatic actuators, electric brakes, and data acquisition systems to simulate real-world driving conditions, including road irregularities and cornering manoeuvres. The design considers load capacity, actuation speed, and control accuracy for accurate and repeatable results. Validation is conducted by comparing data with real vehicle measurements. The front axle test rig offers valuable insights for research and development, enabling engineers to assess component performance, optimize designs, and enhance vehicle dynamics. This research contributes to the understanding of front axle behaviour and facilitates the development of improved suspension systems for enhanced vehicle performance and safety. We have recorded results for torque division during forward drive and reverse drive. We also recorded results when one of the two wheels were stopped using brakes. The developed test rig enables engineers to assess the performance of suspension components, evaluate their impact on vehicle dynamics and optimize design parameters.

Index Terms - Front axle, Torque division and conversion, Differential, Electric brakes, Proxy Sensors.

I. INTRODUCTION

The suspension system plays a crucial role in the overall performance, comfort, and safety of a vehicle. The front axle, as an integral part of the suspension, is subjected to various dynamic forces and conditions during vehicle operation. To ensure optimal suspension design and performance, it is essential to accurately evaluate and understand the behaviour of the front axle under different driving scenarios.

This research paper focuses on the development of a front axle test rig, designed to replicate real-world conditions and facilitate comprehensive evaluation of suspension performance. The test rig incorporates hydraulic actuators, load cells, and data acquisition systems to simulate road irregularities, cornering manoeuvres, and other dynamic inputs experienced by the front axle.

The primary objective of this project is to design a versatile and reliable test rig capable of providing accurate measurements and data for suspension analysis. The developed test rig enables engineers to assess the performance of suspension components, evaluate their impact on vehicle dynamics, and optimize design parameters. By enhancing the understanding of front axle behaviour and its interaction with the suspension system, this research contributes to the development of improved suspension designs, ultimately leading to enhanced vehicle performance, comfort, and safety

II. LITERATURE SURVEY

The front axle of a tractor is a crucial component responsible for supporting the weight of the front end and facilitating steering. It is designed to withstand heavy loads, provide stability, and allow for smooth manoeuvrability in various terrains and agricultural tasks. A differential gear box is a mechanical device that allows the wheels of a vehicle to rotate at different speeds, enabling smooth turns while maintaining traction. It distributes power evenly between the wheels, enhancing stability and manoeuvrability, particularly in vehicles with multiple driven wheels.

2.1. Differential Gearbox

Differential torque division refers to the way in which torque is distributed between the wheels on an axle, allowing for smooth and efficient turning. The differential is a component that allows the outer wheel to rotate faster than the inner wheel when going around a turn, compensating for the difference in distance travelled by each wheel. This helps to prevent tire scrubbing and improve overall vehicle handling. Gear ratio, on the other hand, refers to the relationship between the number of teeth on two gears in a transmission or axle. A higher gear ratio means that the engine must turn more times to rotate the wheels once, providing more torque and better acceleration at low speeds.

2.2. Acceleration test of Tractor's Front Axle

Engineers need to understand the usage environment, whereby the final product must endure to fulfil customer satisfaction. The response in an ALT is directly related to the lifetime of the product. Typically, ALT data is right censored because the test is terminated before all units fail. Examination of the gears after the third test. Each time the test failed, some improvements such as adjustment of shim values and level or position of the gears need to be made. None of the gears involve showed any damaged in the third test after 250 hours. Thus, it can be concluded the front axle assembly B10 life of 4,000 hours with 90 percent confidence level is guaranteed. The result obtained from this test was useful in predicting the reliability of the front axle assembly. ALT programs should be designed and conducted by teams including knowledgeable individuals about the product and its use environments, the physical/mechanical aspects of failure mode, and the statistical aspects of the design and analysis of reliability testing.

2.3. Need to Measure Torque

Measuring the mechanical torque of rotating shafts is essential when designing, commissioning, and troubleshooting all kinds of machines. Knowing the true mechanical torque of a shaft, propeller or other rotating member is the only way to know that it is meeting its specifications. In some applications it is critical to know what the torque is at all times, to guard against potentially dangerous excess torque that could lead to system damage or failure. Torque measurements are an important part of predictive maintenance. There are two kinds of torque: rotary torque and reaction torque: • Rotary torque aka rotational or dynamic torque • Reaction torque aka stationary or static torque

2.4. Material Selection

Material selection is an important problem attracting theoretical and practical interest. Nowadays, a lot of materials and alloys are designed. In most alloys some properties are good and in compliance with the requirements, but some of them are not acceptable. Generally, for material selection methods it is necessary to have unique synergy of theoretical knowledge and practical experiences data. Scientists used and developed some selection methods due to all of these.

1.Identify product design requirements
2. Identify product element design requirements
3. Identify potential materials
4. Evaluate materials
5.Determine whether any of the materials meet the selection criteria
6.Select materials.

Apart from all of the above technical factors, there are also the economic factors to be considered. Many of the decisions to be made in the design and manufacture of a product will be influenced by the costs involved. Therefore, the total cost of the product must be considered as early as possible. Other economic considerations will be based on the quantity required in terms of the production volume, the production rate and the economic batch size. This aspect of the process planning activity will be considered further.

III. PROPOSED SYSTEM

This proposed system provides a smart solution to measure the torque division in a front axle test rig of the tractor. The new tractors come with a differential gear box in the front axle. So, it is necessary to test the working of the Front axle. The Test rig has the ability to check the meshing of the gears in the differential. The Device includes various electronic sensors to measure the values of the torque and other factors.

1. *Electromagnetic brakes:*

Electromagnetic brakes are a type of braking system that uses electromagnetic force to slow down or stop a moving object. They work by creating a magnetic field that opposes the motion of the object, converting its kinetic energy into heat. Electromagnetic brakes are commonly used in industrial machinery, trains, and vehicles. They are known for their precise and rapid response time, high torque capacity, and their ability to provide consistent braking force.

Figure 1 Electromagnetic brakes

2. *Pneumatic clamping system:*

A pneumatic clamping system is a type of clamping system that uses compressed air to hold and secure objects in place. It is commonly used in manufacturing, machining, and welding operations. Pneumatic clamping systems consist of a pneumatic cylinder, which is connected to an air compressor and a control valve. When the control valve is activated, compressed air is directed into the cylinder, causing a piston to move and apply clamping force to the object being held.

Figure 2 Pneumatic Clamps

3. *Differential torque division and gear ratio:*

Differential torque division refers to the way in which torque is distributed between the wheels on an axle, allowing for smooth and efficient turning. The differential is a component that allows the outer wheel to rotate faster than the inner wheel when going around a turn, compensating for the difference in distance travelled by each wheel. This helps to prevent tire scrubbing and improve overall vehicle handling. Gear ratio, on the other hand, refers to the relationship between the number of teeth on two gears in a transmission or axle. A higher gear ratio means that the engine must turn more times to rotate the wheels once, providing more torque and better acceleration at low speeds.

4. *Induction motor and VFD:*

An induction motor is a type of AC electric motor that operates by using electromagnetic induction to generate rotational motion. Induction motors are widely used in industrial and commercial applications due to their reliability, low maintenance requirements, and high efficiency. A variable frequency drive (VFD) is an electronic device that can be used to control the speed of an induction motor by varying the frequency and voltage of the electrical power supplied to it. The use of a VFD to vary the speed of an induction motor has several advantages, including improved energy efficiency, reduced wear and tear on the motor, and increased control over the motor's speed and torque.

Figure 3 Induction Motor

VI. METHODOLOGY:

A front axle test rig is of equipment to test the performance and durability of a Tractor's front axle components. This includes various mechanical components such as the steering system, suspension and braking system. In this front axle test rig the scope of study are testing motor, testing unit with suitable fixed stand & fixtures, Clamping system. Clockwise rotation of front axle up to 750 rpm with gradual increase of rpm by help of VFD and siemens make Motor of 15HP Capacity (maximum 1440 rpm) Mounted on Frame-sliding mechanism with lead screw allows forward/reverse movement. The front axle is mounted on the specific fixtures by the means of dowel pins. The front axle is clamped using pneumatic clamping mechanism to avoid any unwanted damages and vibrations. Cylinder type clampers are used on the two sides of the frame. This will help for companies to check the front axle test rig at the time of manufacturing. Overall, the front axle test rig is a valuable tool for ensuring the safety and reliability of Tractors in the field.

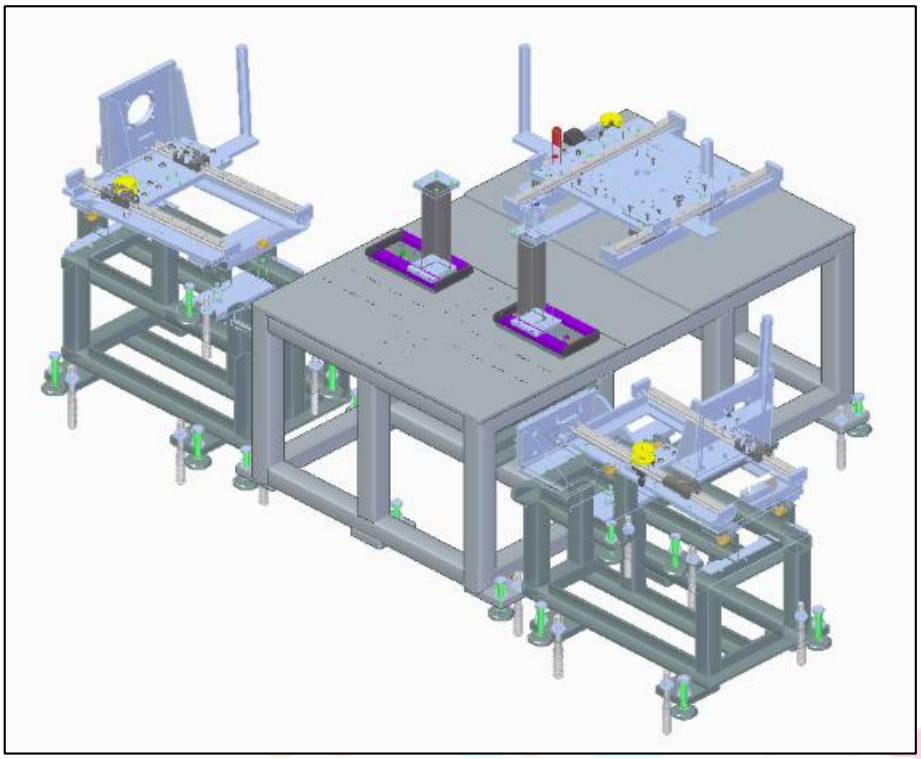

Figure 4 Final CAD Model Of the Test Rig

VII. RESULT:

The unit includes a suitable fixed stand and fixture for holding the front axle model securely in place during testing. The testing motor is capable of rotating the front axle in both clockwise and anticlockwise directions at variable speeds.
The motor is controlled by a VFD that allows for variations in speed. To collect oil during testing, the unit includes a provision for collecting oil and a suitable pump to feed the collected oil into a filtration system with a level sensor mechanism. The unit also includes necessary safety guards to ensure safe operation.

The clamping mechanism is pneumatically operated and includes four cylinder-type clampers on the two sides of the frame. The motor mounting frame features a sliding mechanism with a lead screw, allowing for easy forward and reverse movement. The motor itself is an induction motor with a maximum speed of 1440 rpm and a capacity of 15 HP, made by Siemens.

Overall, the font axle test rig unit project has resulted in a high-quality testing unit that is capable of accurately testing the front axle of a vehicle under a variety of conditions.

VIII. CONCLUSION

Main aim of our project is to evaluate the performance of the front axle of the tractor.The design considers load capacity, actuation speed, and control accuracy for accurate and repeatable results. The test rig incorporates hydraulic actuators, load cells and data acquisition systems to simulate road irregularities. The developed test rig enables engineers to assess the performance of suspension components, evaluate their impact on vehicle dynamics and optimize design parameters.

IX. ACKNOWLEDGEMENT

The project team is thankful to the guide, faculty evaluators, lab assistants in the department of Mechanical for the technical and infrastructural support. We sincerely wish to thank Module Industries staff for their guidance and support.
Our thanks and appreciation also go to all those who have guided and helped me in successful completion of this project in developing the project.

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