



Design and Development of Leaf Spring Fatigue Testing Machine

¹Adwait Dhande, ²Yash Abhani, ³Vyankatesh Sakhare, ⁴Tejas Patil

¹Student, ²Student, ³Student, ⁴ Student

¹Mechanical Engineering,

¹P.E.S. Modern College of Engineering, Shivajinagar, Pune, India.

Abstract : In today's automobile industry, leaf springs are commonly used in heavy-duty vehicles. A leaf spring is a simple form of spring commonly used as a suspension in wheeled vehicles. Fatigue is responsible for 90% of the failures that occur in an industry. Fatigue testing equipment is used to determine the fatigue life or fatigue strength of a material. Mechanical Engineering students are having a hard time visualizing on how manufacturers determine the fatigue strength of a leaf spring. This is because the professors only teach the concepts and theories about leaf spring, and there is no actual representation on how the testing of leaf spring really works. So are tried to develop prototype leaf spring fatigue testing machine using pneumatic cylinder and microcontroller. With the help of this machine, we can measure fatigue life cycle of testing leaf spring..

Keywords- Arduino UNO, Pneumatic cylinder, Aeroflex Pneumatic valve, HC SR04

I. INTRODUCTION

A fatigue test helps determine a material's ability to withstand cyclic fatigue loading conditions. By design, a material is selected to meet or exceed service loads that are anticipated in fatigue testing applications. Cyclic fatigue tests produce repeated loading and unloading in tension, compression, bending, torsion or combinations of these stresses. Fatigue tests are commonly loaded in tension – tension, compression – compression and tension into compression and reverse.

The failure by fatigue fracture is the most common failure in automotive components such as crankshaft and spring on trucks. In addition to, leaf spring especially as automotive components often experience over load and vibration that occur due to the unevenness of the road. So, this work develops prototype leaf spring fatigue testing machine using pneumatic cylinder and microcontroller. With the help of this machine, we can measure fatigue life cycle of testing leafspring may measured.

II. OBJECTIVES

1. The aim of Present work is to design and fabrication of Fatigue Testing Machine which is capable of testing the fatigue life of leaf springs for Automobile application.
2. To design the fatigue tester and its components.
3. To predict the life span of the leaf spring easily.

III. Methodology

- Studying the conventional fatigue testing machine.
- Material Selection for Mechanism.
- Designing the mechanism for pneumatic base leaf spring fatigue testing machine.
- CAD diagram of leaf spring fatigue testing machine.
- Studying working of sensors and programming for pneumatic cylinder
- Fabrication of Leaf spring fatigue testing machine.

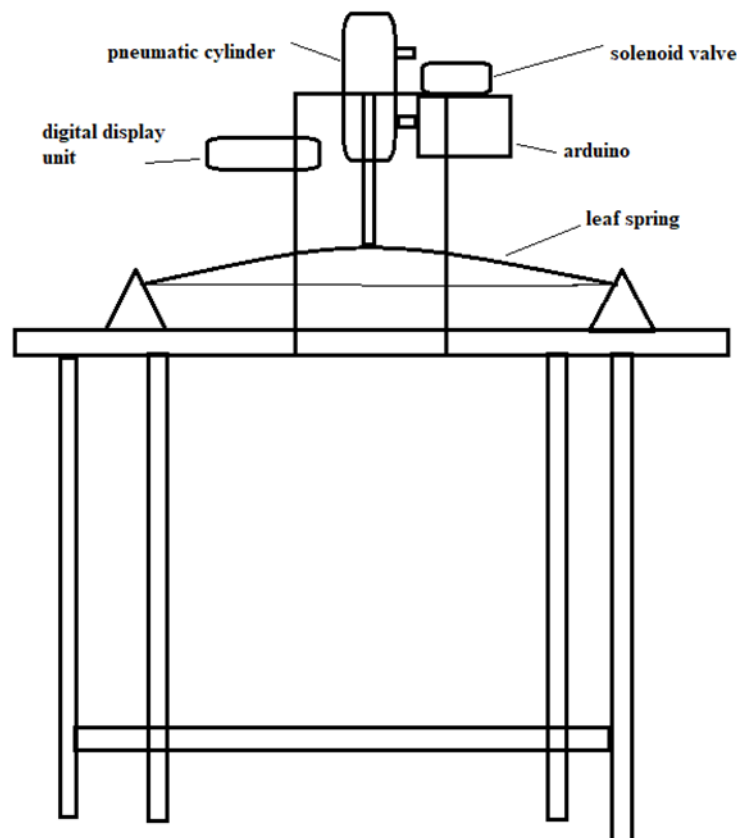


Fig. No. 1 Basic Diagram of Project

IV. Components

1. Arduino

Arduino is an open source hardware and software platform designed for creating and prototyping interactive electronic projects. It consists of a microcontroller board with various input and output pins that can be connected to sensors, actuators, and other components.

Arduino boards are programmable using the Arduino programming language, which is based on C/C++. It provides an easy to use and beginner-friendly way to develop project, allowing users to control and monitor a wide range of devices and systems.

2. Pneumatic Cylinder double acting 50mm*100mm

A pneumatic cylinder is a mechanical device that converts compressed air energy into a reciprocating linear motion. A double-acting cylinder uses compressed air to move a piston in and out, while a single-acting cylinder uses compressed air for one-way movement and a return spring for the other.

3. Aeroflex 1/4 inch 5/2 Single Solenoid Valve

Aeroflex 1/4 inch 5/2 Single Solenoid Valve, V4-08 is a premium quality product from Aeroflex. Moglix is a well-known ecommerce platform for qualitative range of Pneumatic Solenoid Valve. All Aeroflex 1/4 inch 5/2 Single Solenoid Valve, V4-08 are manufactured by using quality assured material and advanced techniques, which make them up to the standard in this highly challenging field.

4. Ultrasonic sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound. This is the HC-SR04 ultrasonic distance sensor. This economical sensor provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit

V. Drafted model

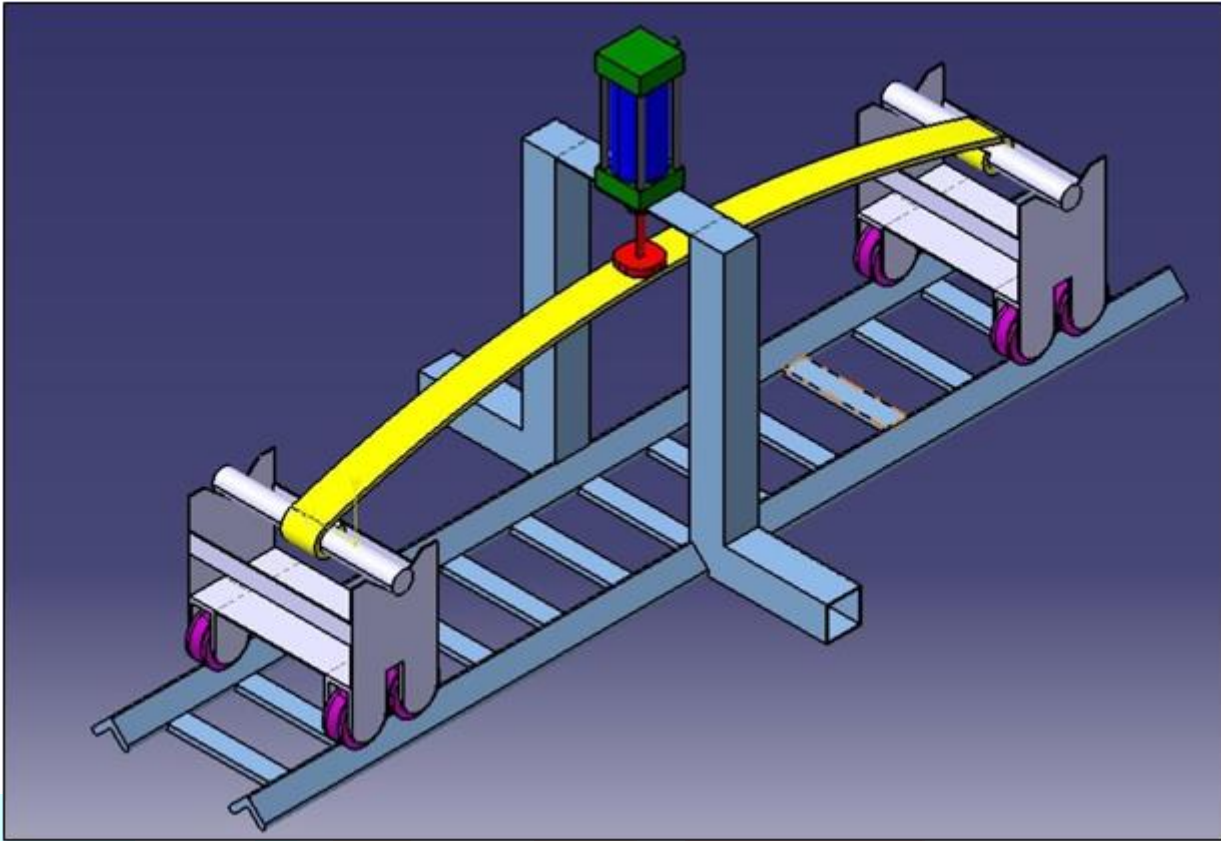


Fig. No. 2 Drafted Model

V. Programming for Arduino uno microcontroller

- The code for an Arduino in a pneumatic fatigue testing machine will depend on the specific requirements of the testing process and the components being used. However, here is a basic outline of the code structure that you can use as a starting point.
- The setup function is called once at the beginning of the program and is used to initialize any variables and settings that are needed for the testing process. For example, you can use this function to set the pin modes for the input and output pins, initialize the serial communication, and set the initial values for the variables.
- Link for Arduino uno code: <https://github.com/adwaitdhande/leafspringarduono>

The loop function is the main function that is called repeatedly during the testing process. It is used to read input values, control the output pins, and perform any calculations or logic needed for the testing process. Within the loop function, you will need to include the following steps:

- 1) Read input values: This includes reading data from the sensors, ultrasonic sensor, and other inputs that are used to monitor the testing process.
- 2) Control output pins: This includes setting the output pins to control the solenoids, valves, and other

components in the pneumatic system.

- 3) Perform calculations and logic: This includes calculating the displacement, velocity, and acceleration of the hydraulic cylinder, as well as any other calculations or logic needed to perform the testing process.
- 4) Send data to serial monitor: This includes sending the data to the serial monitor for real-time monitoring and analysis of the testing process.

VI. Development of Leaf spring Fatigue testing machine:

- **A) Manufacturing Process:** Pneumatic fatigue testing machine is a special equipment used to test the fatigue resistance and durability of materials by applying repeated loading and unloading cycles to materials. These machines are commonly used in the aerospace, automotive, and materials industries to determine the endurance limits of various components and materials under various conditions. The manufacturing process of pneumatic fatigue testing machine includes several major steps, including cutting, welding, finishing, and assembling.
- **B) Cutting:** The first step in manufacturing a pneumatic fatigue testing machine is to cut the raw materials into the required shapes and sizes. This is typically done by using abrasive metal chop saws cutters. The material used to make the testing machine is usually steel, as it is strong, durable, and able to withstand the high stress levels that the machine will be subjected to during operation. The steel is cut into various shapes and sizes, depending on the design specifications of the testing machine.
- **C) Welding:** When the material is cut, the parts are welded together to form the main structure of the testing machine. Welding is an important process in machine manufacturing because it determines the strength and durability of joints between various parts. The welding process used depends on the type of material used and the desired strength and durability of the joint. The most common welding types used in the manufacture of pneumatic fatigue testing machines include TIG welding.

VII. D) Finishing: After welding, the testing machine goes through a finishing process that smoothens rough edges, removes burrs and prepares surfaces for painting or coating. The finishing process includes grinding, sanding, polishing or other surface treatment. The goal is to create a smooth, uniform surface without any defects or defects that can affect the performance of the machine.

VIII. RESULT:

- We have successfully built a leaf spring fatigue testing machine.
- After each cycle of stroke by pneumatic cylinder, digital display unit was showing the correct count.
- The leaf spring was going through a cyclic load.
- With the help of SN curve we were able to find out number of cycles before crack initiation in the given pneumatic leaf spring fatigue testing machine is approximately 81,86,357

$$\log(N_f) = a - b \times \log(\sigma_a)$$

- The conventional fatigue testing machines are made for multiple components such as shaft and are also used for alternating load test which is why they use hydraulic cylinder, with the use of pneumatic cylinder the cost was decreased drastically and the true application of the machine was served without any compromise.

ACTUAL MODEL:

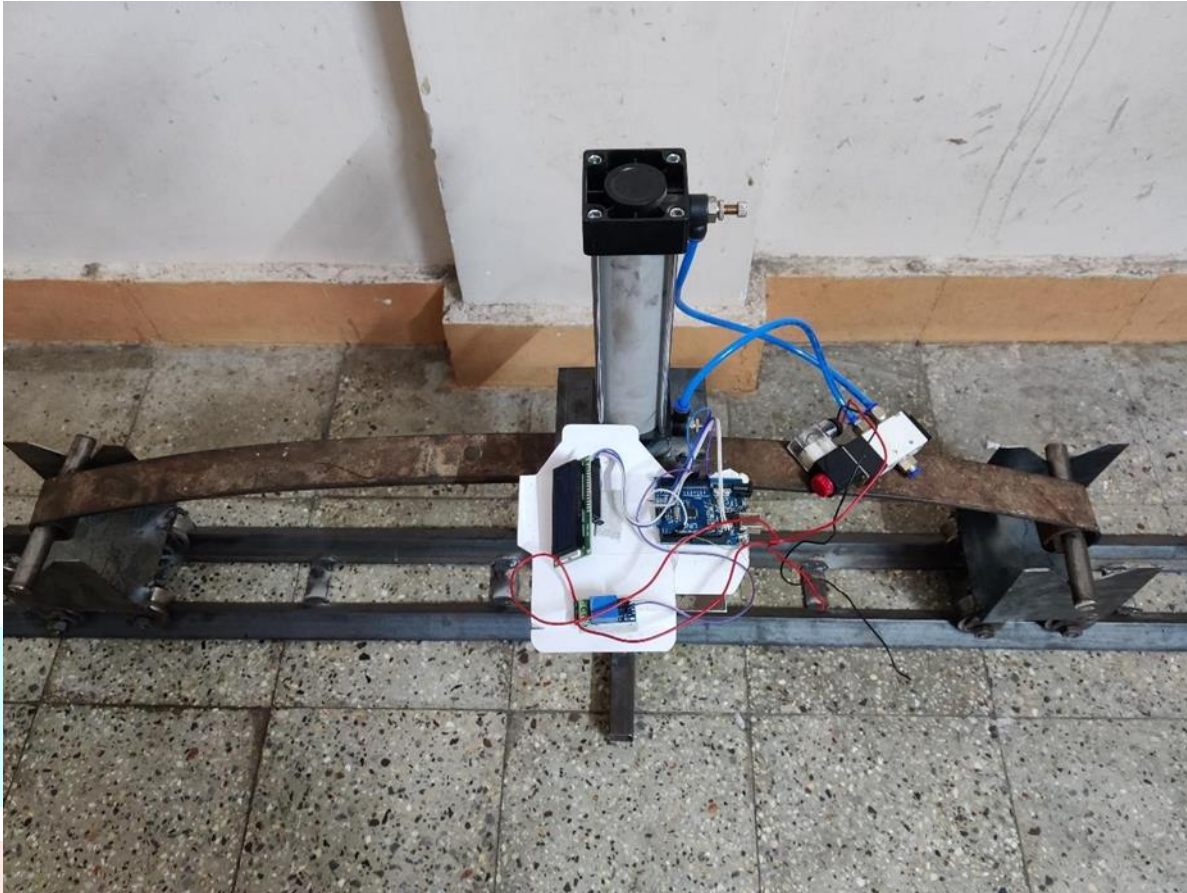


Fig. No. 3 Actual Prototype

IX. CONCLUSION:

In this research,

- 1) The machine applies cyclic loads to a test specimen and measures the resulting deformation and/or damage over time. By subjecting the material to repeated loading, the machine can simulate the stresses and strains that the material may encounter in real-world applications, allowing engineers and researchers to assess the material's performance and predict its lifespan.
- 2) Theoretical bending stress of hollow square pipe has been calculated and that value is greater than actual stress so design is safe.

Overall, the design of a pneumatic fatigue testing machine requires expertise in mechanical engineering, control systems, and data acquisition systems. It is important to ensure that the system is designed and tested to meet the requirements and specifications of the intended application

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