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Design & Manufacturing of Digital Magnet Angle Checking Gauge

Vishal Jadhav[1], Dr. A.S. Todkar[1], Dr. P.J. Patil[1]
[1]*Department of Mechanical Engineering, Tatyasaheb Kore Institute of Engineering & Technology (Autonomous), Warananagar, Maharashtra- 416113.*

Abstract: This paper presents the design and analysis of semi-automated digital angle measuring system for fuel injectors. The existing system is fully mechanical and has scope to plenty of errors in operations. The gauge measures the angle between high-pressure inlet and magnetic knob of fuel injector. This type of gauge is useful for Automobile industries, including manufacturing, engineering, and research, where accurate measurements of angles are essential. Design and CAE analysis have done to confirm its Strength, Performance and Stability.
Keywords: Digital angle measuring gauge, Fuel injectors, Design, Strength, and Durability.

I. INTRODUCTION

Angle gauges like sine bar are used for angle inspection. It is used for various purposes such as measuring V-pulley groove and V-belt, checking the precision of steel frames, and inspecting the angle of the tool bit blade shape. Materials vary depending on the gauge, but mainly carbon steel for machine structures and stainless steel are used. There are also block gauges that are fully hardened. The block gauge is suitable for performing precise angle inspections. One of the features of the block gauge is that it can measure the angle of planar objects. Angle gauges are also available for special angle inspections, such as the bevel gauge used to measure bevel angles. Some of them come with a storage case that is suitable for carrying, so you need to select one depending on the operating environment and application.

The purpose of designing and manufacturing a digital angle checking gauge which measures angle between high-pressure inlet and magnetic knob because of customer complaint from Mahindra & Mahindra regarding fitment of injector in engine. This type of gauge is useful for Automobile industries, including manufacturing, engineering and research, where accurate measurements of angles are essential. The digital angle checking gauge for the digital angle measuring will provide a reliable and precise solution for measuring angle checking. It will allow technicians and engineers to make necessary adjustments to optimize the performance of equipment and devices that rely on this component. The digital gauge will be designed to be easy to use and provide accurate readings of the angle between the maximum high-pressure inlet knob. It will be manufactured using high-quality materials to ensure its durability and longevity in various industrial settings.

A. Problem Statement

In Mass production of a sensitive product, it is must to check each parameter carefully. Hence, Special purpose gauging system has to be established to check the parameter which has impact on performance as well as fitment. One such important parameter is Angle of Magnet of Injector with respect to its High-Pressure Connector. It is not feasible to check the angle in Inspection lab for each sample as it consumes more time which will further hamper the production. Previous gauging system was purely mechanical and Parallax error occurred. So, a special gauging setup is to be designed which can be used on production line itself and will consume negligible time with high precision and ease to operate.

II. METHODOLOGY

The measurement of angles in manufacturing processes is a critical factor for ensuring precision and accuracy in the production of various components. Traditional methods of angle measurement often involve the use of manual protractors, which can be time-consuming and prone to human error. To address these issues, digital angle gauges have been developed, which offer greater accuracy and efficiency in angle measurement. In this study, we focus on the design and manufacturing of a digital magnet angle checking gauge, which utilizes Encoders and Digital Screen to provide highly accurate and reliable angle measurement. The main objective of this study is to evaluate the performance of the digital magnet angle checking gauge and compare it to traditional angle measurement methods, with the aim of identifying potential improvements in manufacturing processes.

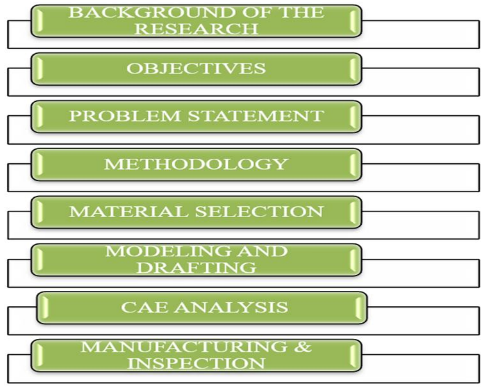

Figure 1: Methodology

III. DESIGN AND ANALYSIS

A. Design

When designing a digital angle checking gauge for measuring the angle between high-pressure inlet and magnetic knob, there are several key design considerations to consider. Some of these considerations include:

1) *Accuracy:* The gauge must be designed with high accuracy in mind to ensure that it provides accurate measurements. The accuracy of the gauge depends on various factors such as material selected, manufacturing process,
2) *Repeatability:* The gauge should be designed to provide consistent and repeatable measurements. Repeatability is essential for ensuring that the gauge can be used to detect small changes in the angle between maximum high pressure inlet knobs.
3) *Range:* The gauge should be designed with an appropriate range to measure the required angles. In the case of measuring the angle between high-pressure inlet and magnetic knob, the gauge should be designed to measure a specific range of angles, typically between 0 and 360 degrees.
4) *Display:* The gauge should have a clear and easy-to-read display to provide instant and accurate readings of the measured angles. The display can be a simple LCD screen or a more advanced graphical display.
5) *Size and shape:* The size and shape of the gauge should be designed to suit the specific application. The gauge should be compact and lightweight enough to be easily transported and used in different locations.

B. CAD Model and Meshing

The cad model has been displayed in below figure.

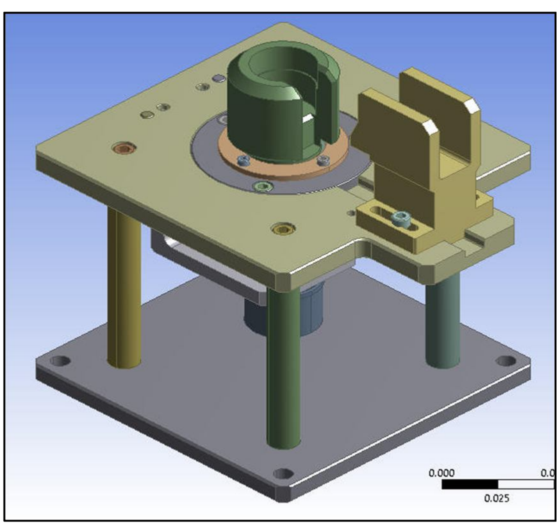

Figure 2: CAD Model

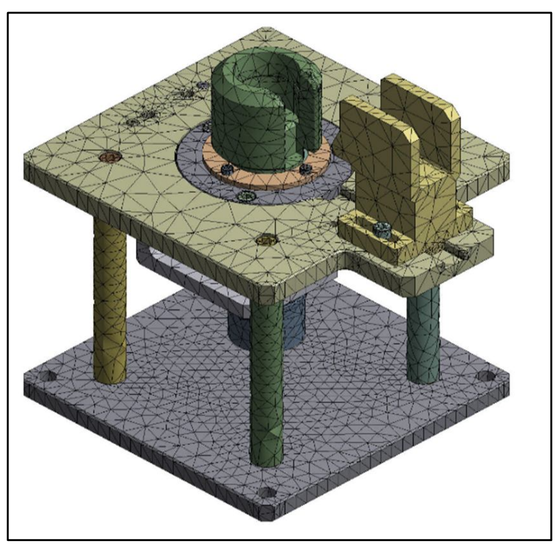

Figure 3: Mesh Model

Ansys meshing capabilities help reduce the amount of time and effort spent to get to accurate results. Since meshing typically consumes a significant portion of the time it takes to get simulation results, Ansys helps by making better and more automated meshing tools.

The meshing of the model is seen in this figure. In meshing statistics, the total number of nodes and elements is presented. The entire number of nodes is 160200, while the total number of elements is 88674. Elements size is 0.152860 mm.

C. Materials

Stainless steel grade of 440B has been selected to manufacture the gauge. The mechanical properties and chemical composition are presented in below tables.

Properties	**Value**
Density (kg/m^3)	7740
Youngs Modulus (MPa)	200000
Poisson's ratio	0.27-0.30
Yield Strength (MPa)	440
Ultimate Strength (MPa)	740

Element	**Content (%)**
Iron, Fe	80
Chromium, Cr	16.0-18.0
Manganese, Mn	1.0
Silicon, Si	1.0
Carbon, C	0.75-0.95
Molybdenum, Mo	0.75
Phosphorous, P	0.040
Sulfur, S	0.030

Table 1: Mechanical properties and Chemical composition

IV. RESULTS AND DISCUSSION

A. Boundary Conditions

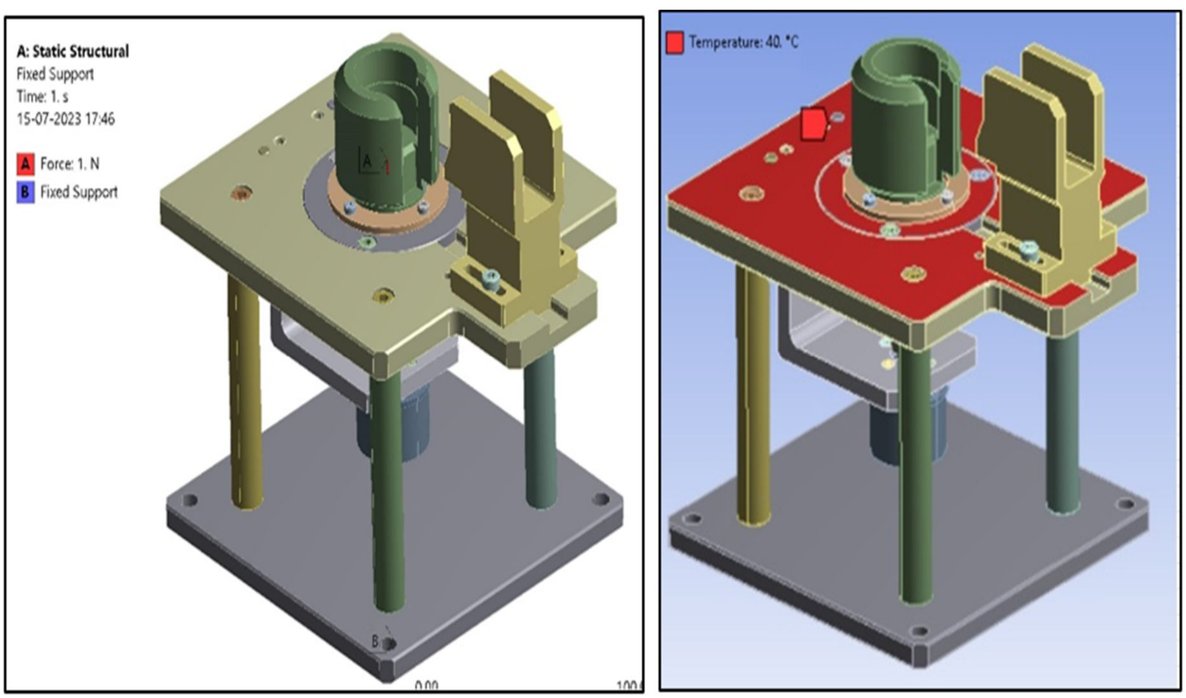

Figure 4: Boundary conditions

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B. Displacement

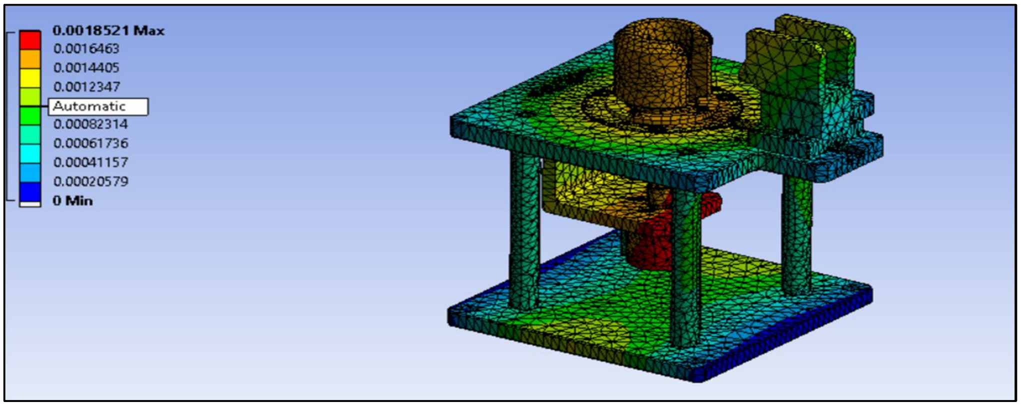

Figure 5: Total Displacement

In figure above, as the Single Injector is approximately 500 grams. Keeping Factor of Safety as 2 we have applied point Load of 1N. The maximum displacement occurred on gauge is 0.0018521mm and minimum displacement on gauge 0.0002057mm. Hence the Displacement value are very negligible as this analysis is done for Static.

C. Von-mises Stress

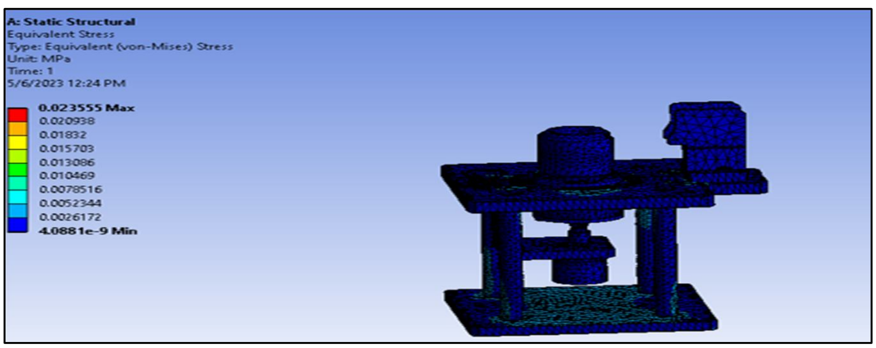

Figure 6: Von-mises Stress

The maximum Equivalent Stress occurred is 0.02355 MPa and the minimum Equivalent Stress is -4.088 x 10^{-9} MPa.

D. Elastic Strain

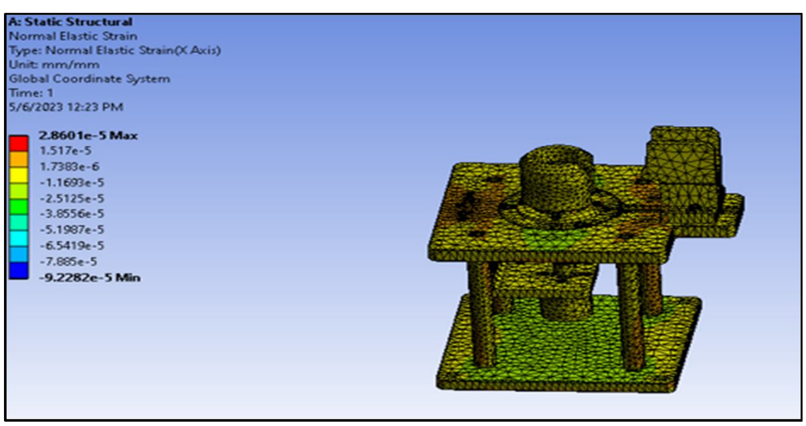

Figure 7: Elastic Strain

The maximum strain occurred is 2.86×10^{-5} and the minimum strain is -9.22×10^{-5}.

E. Temperature Distribution

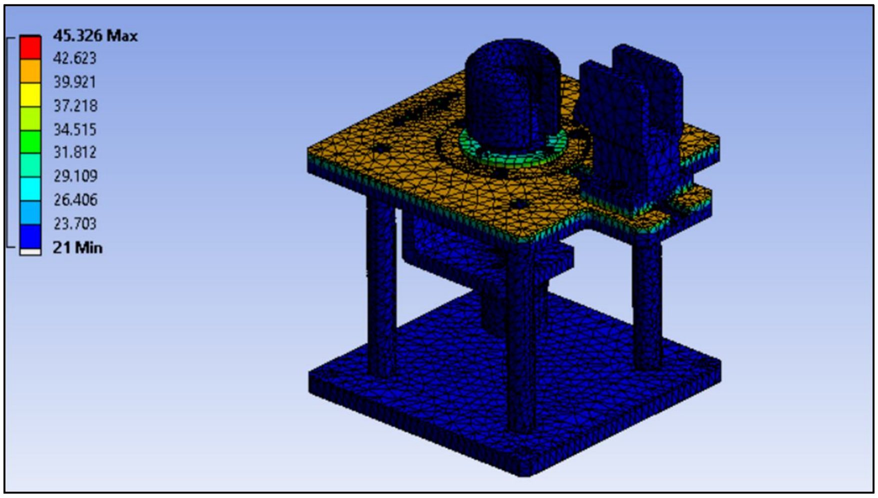

Figure 8: Temperature distribution

The transient temperature refers to the changing temperature of the system over time. In this case, the transient temperature is 45.356 °C.

V. CONCLUSION

The design has been tested with the worst-case condition and found to be ok. The generated stress is 0.2 MPa and it is negligible when compared with SS 440B's yield strength. The maximum displacement is 0.001 mm, and it will not have any diverse effect on measuring dimensions and its tolerance.

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