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Design and Finite Element Analysis of Differential Multi-Gauging System

Nishant Neve, V. K. Kurkute

Abstract: ***Objective to checked four-wheeler transmission or differential assembly. To reduce or minimize the differential assembly end play, for that we must calculate gap and put standard shim at the end of shaft while assembly. For that requirement of customer to give customized gauging system which gives precise measurement, Effort less, easy process, Time saving and productivity improvement. The require system in three stages to distance B, distance A and Gap between both distance. Therefore, the work on design and customized gauging system for shim selection method through design calculation and finite element analysis. The system will fully reliable and strong with the help of Finite element analysis of multi- gauging system for future aspect. As study of system Main Locator and Moving plate have more load and forces while gauging condition. For that we study the design and complete FEA analysis. Also, to ensure the reliability of the differential measurement system, the researcher was required to verify the precision and accuracy of the measurement system by repeatability trials. In the differential housing bearing to bearing distance measurement and inspection procedure, operator and the indirect gauging mechanism are the two key elements.***

Keywords: four-wheeler transmission. indirect gauging mechanism.

I. INTRODUCTION

The measurement system had three components and three gauging stations. This measurement system appears to be allowing defective product to not be shipped to the customer. Measure the accurate and precise measurement of differential housing bearing to bearing face distance. To reduce the error in Production and Manufacturing. It’s very difficult to find out is the exact type of shims which will fit in assembly. This type of complicated gauging system is difficult to Design and Manufacturing. Also, this Gauging system are to be reliable, because they use year and year with continuous mass production. The given parameter of the component and actual value of component that result co-relation and gauge proven is difficult.

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II. CONCEPT FINDING & REQUIREMENT STUDY

Concept creation for the three fixtures so at every station below three parameters are to be checked. So as per customer requirement there is manual loading on fixture assembly but Automatic cycle with rotation are considered in gauging system.

Gauging Fixtures: -

1. Station “B”- Measure Distance from Top Bearing Face to Bottom Bearing Face of Differential Housing.
2. Station “A”- Measure Distance from Groove Face to Upper Resting Face of Hypoid Pinion.
3. Shim Station – To check required Shim value.

III. DESIGN OF DIFFERENTIAL ASSEMBLY GAUGING FIXTURE

The design of gauging system total three fixture assembly system at three stations. For checking bearing to bearing distance checking required in the system but bearing to bearing required the force on top face of taper roller bearing. Also, while assembly taper roller bearing required to settle down with the help of gearing housing carrier rotation. With the top force and rotation, we will calculate the bearing distance, so differential housing assembly fixture design considered with pneumatic cylinder and timing belt pulley assembly by motor rotation. For checking hypoid pinion height pneumatic clamp and spring-loaded assembly are used in hypoid pinion distance fixture assembly. For shim confirmation the single cylinder used to check the spacer height checking fixture design.

IV. CONSIDERATION OF FORCE CALCULATION

Above fixture design and manufacturing multiple material used as per requirement and application. Mainly Mild steel, OHNS, EN-31 steel, brass is used. But as per study the mainly load and forces are acting on bearing to bearing face distance due to pneumatic cylinder force and component self-weight. The maximum load and forces are generated on main locator and moving plate whether all assembly are rested, also cylinder forces are acting on it. Fixed support is bottom face of locator which rested on sliding plate. Fixed support of sliding plate is bolted with rail block. So, for locator EN-Steel material used, and mild steel used for sliding plate.

Table - I FEA Parameter of Locator and Sliding Plate

Sr. No.	Element type	FEA Parameter	Element type	FEA Parameter
1	Locator Material type	EN-31 Steel	Sliding Plate	Mild Steel

Sr. No.	Element type	FEA Parameter	Element type	FEA Parameter
2	Tensile Strength	750 N/mm²	Tensile Strength	440 Mpa
3	Yield Stress	450 N/mm²	Yield Stress	370 Mpa
4	Reduction of Area	0.45	Reduction of Area	0.40
5	Elongation	0.3	Elongation	0.29
6	Force on Top Face of Locator (F)	1277 N	Force of Assm. Resting Face on Sliding Plate (F)	1522 N
7	Force on Top Face of Locator (F)	1446 N	-	-

V. FINITE ELEMENT ANALYSIS OF MAIN LOCATOR AND MOVING PLATE

In finite element analysis we are observed the output results of locator. Locator have 25 mm thickness and material is EN – 31 Steel. On top face of locator 1277 N force generating due to top pneumatic cylinder and self-weight of component. Also 1442 N force generating on bottom face of locator due to overall assembly located on bottom face of locator.

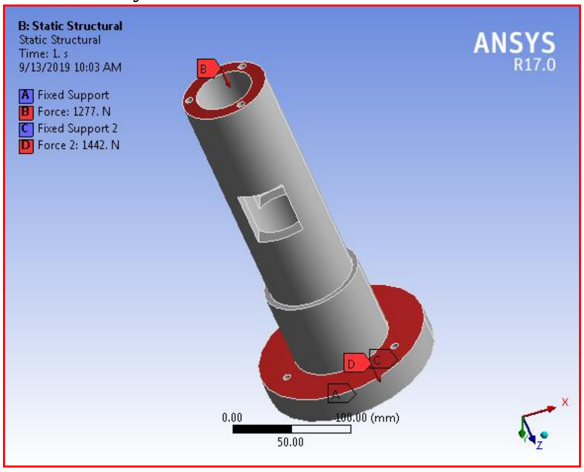
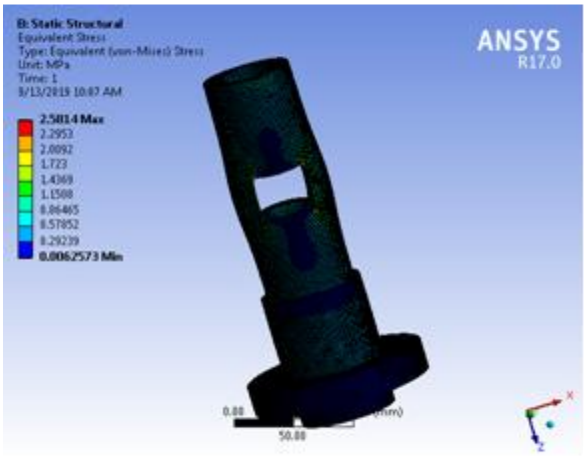


Fig. 1.(a) Fixed Support and Forces



(b) Stress Distribution of Main Locator

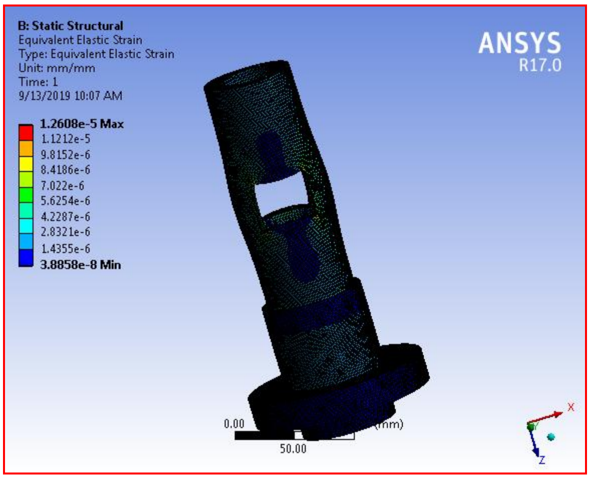
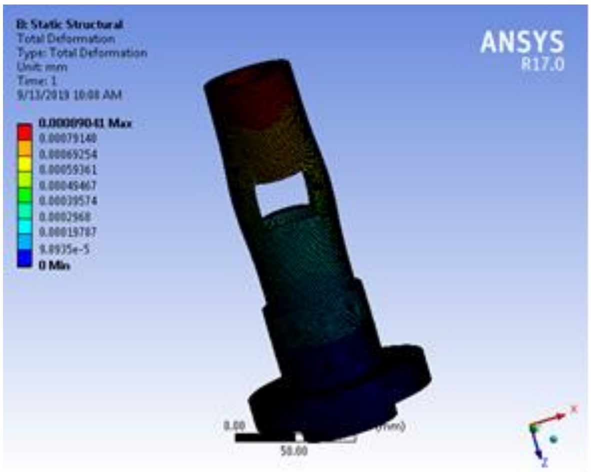


Fig. 2.(a) Strain Distribution of Main Locator



(b) Total Deformation of Main Locator

The modal frequencies are:

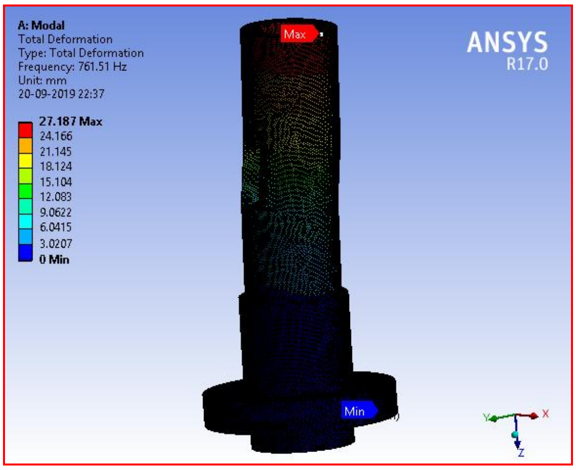
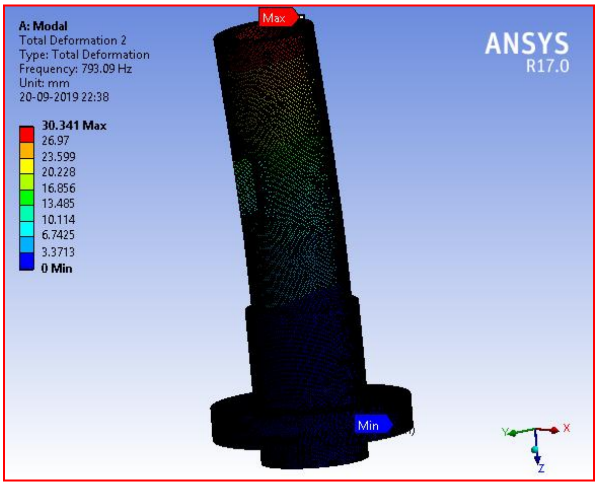


Fig. 3.(a) Model Phase 1 of Main Locator



(b) Model Phase 2 of Main Locator

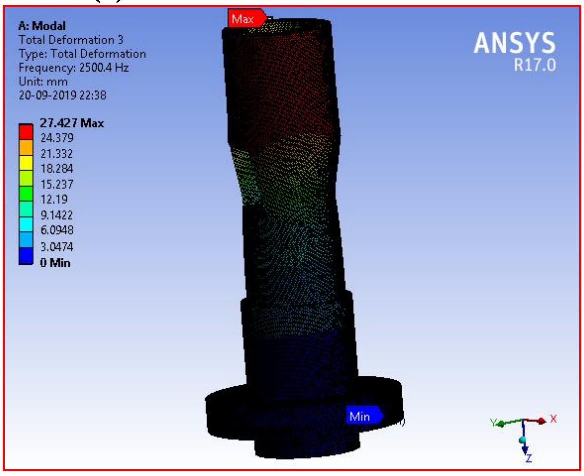
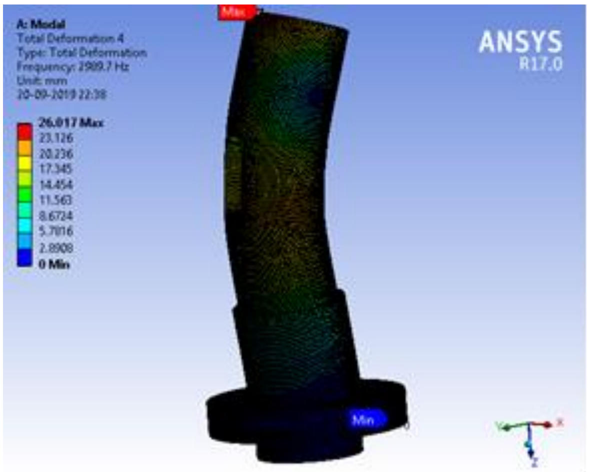


Fig. 4.(a) Model Phase 3 of Main Locator



(b) Model Phase 4 of Main Locator

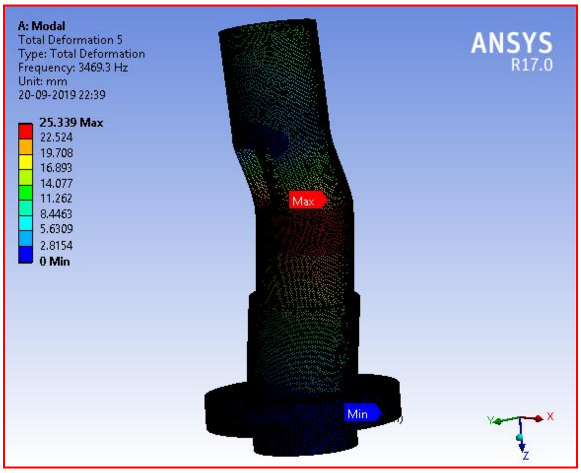
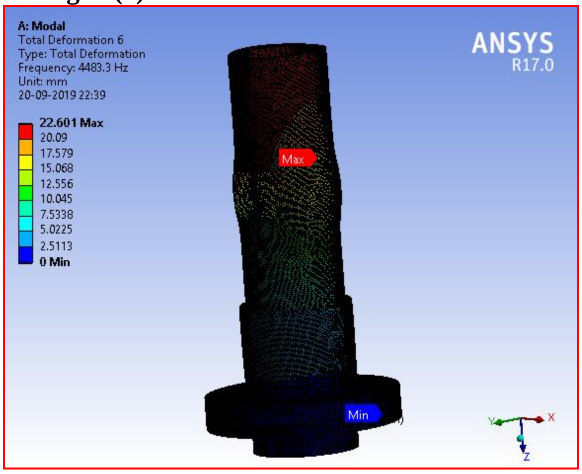


Fig. 5.(a) Model Phase 5 of Main Locator



(b) Model Phase 6 of Main Locator

In model analysis of locator have first natural frequency of locator is 781.56 Hz. It is taken as the natural frequency of system. The value of the natural frequency is higher than excitation frequency of 60 Hz. So, system is safe.

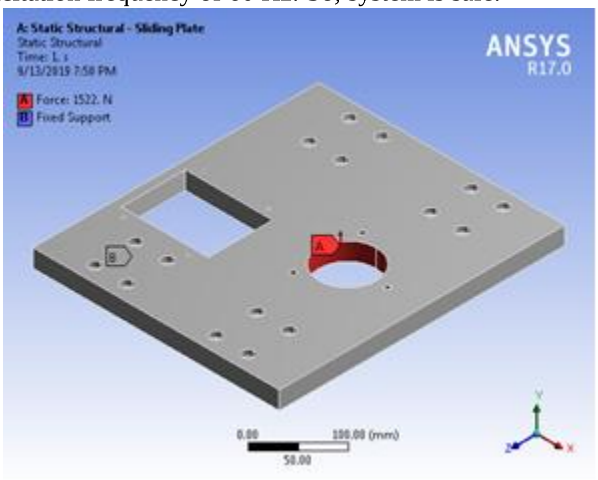
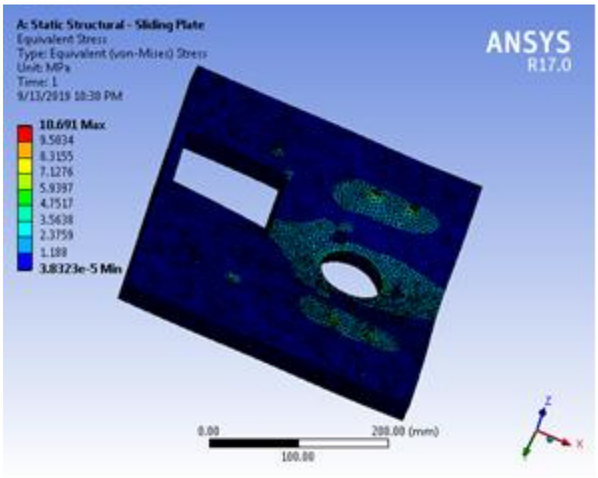


Fig. 6.(a) Fixed Support and Forces on Moving Plate



(b) Stress Distribution of Moving Plate

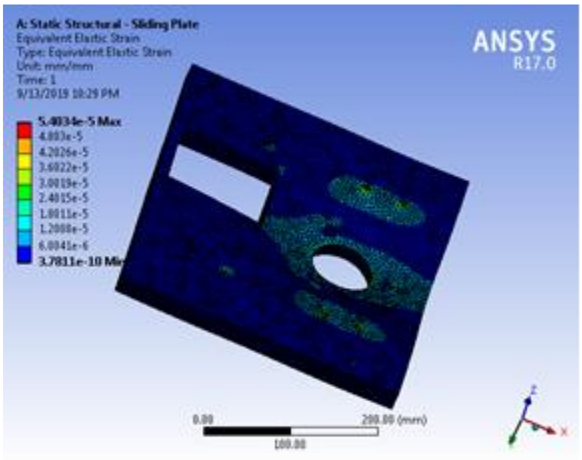
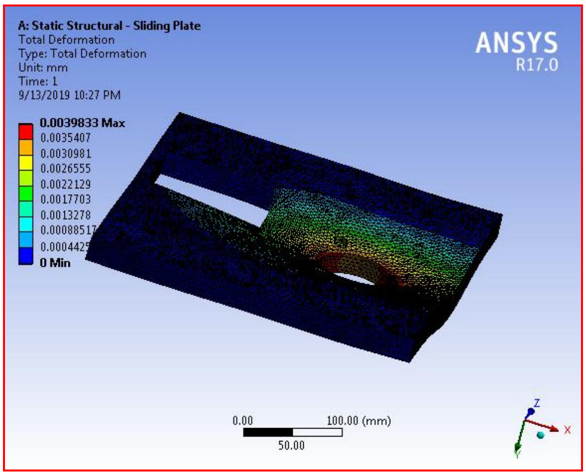


Fig. 7.(a) Stress Distribution of Moving Plate



(b) Total Deformation of Moving Plate

The modal frequencies are:

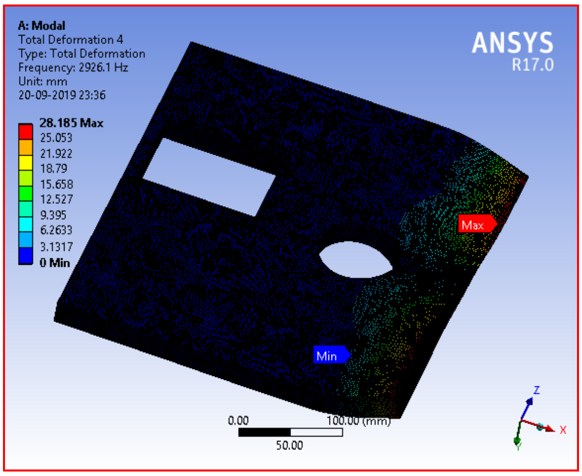
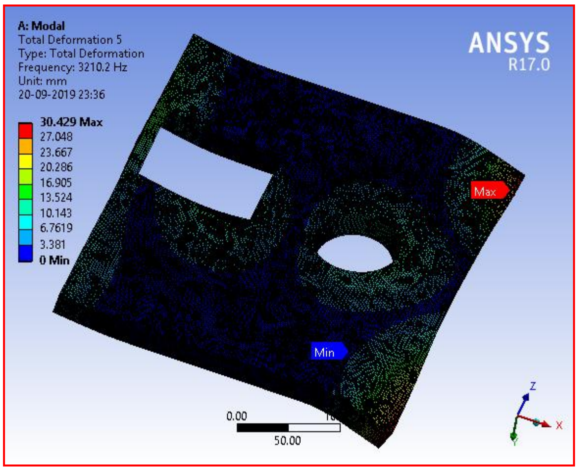
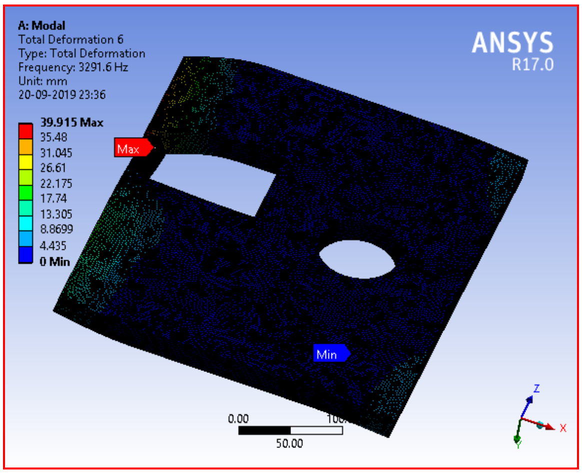


Fig. 8 (a) Model Phase 4 of Moving Plate



(b) Model Phase 5 of Moving Plate



(c) Model Phase 6 of Moving Plate

In model analysis of sliding plate have first natural frequency of moving plate is 1552.6 Hz. It is taken as the natural frequency of system. The value of the natural frequency is higher than excitation frequency of 60 Hz. So system is safe.

VI. RESULTS AND DISCUSSION

As above figure shows, Main locator and moving plate in finite element analysis results shows the locator in static structural analysis not reach ultimate level, also model analysis main locator ensured resonance avoided. Moving plate static structural analysis shows that moving plate not reach ultimate level, also in modal analysis of moving plate resonance is avoided. As FEA results shows, design and manufacturing of differential housing assembly system completed which gives accurate results by repeatability, GRR and SPC analysis. Below are following points:

1. From above figures the total deformation form in main locator and moving plate are not going above limit, where maximum deformation formed in locator is 0.00008 mm i.e. near about 1-micron deflection in main locator which is negligible.
2. Similarly in moving plate maximum deflection formed in sliding plate is 0.0039 mm i.e. near about 4-micron deflection in sliding plate which is negligible.
3. Repeatability Trial results are,

Sr. No.	"B" Distance	"A" Distance	"SHIM" Height
1	93.574	89.893	3.681
2	93.575	89.894	3.683
3	93.573	89.894	3.682
4	93.574	89.892	3.681
5	93.572	89.894	3.681
6	93.574	89.896	3.680
7	93.574	89.894	3.681
8	93.573	89.894	3.682
9	93.574	89.895	3.683
10	93.574	89.894	3.681
Diff.	**0.003**	**0.004**	**0.004**

Repeatability results are below 0.010 mm i.e. 10 microns. As per standard of gauge repeatability and reproducibility (GRR) repeatability below 10 microns are satisfactory and accepted.

VII. CONCLUSION

In this study, we have focuses on the design and finite element analysis of a differential assembly gauging system. Differential assembly gives results as below following: -

1. Automatic system for differential assembly checking
2. Accurate and Precise results
3. Productivity Improved
4. Time saving.
5. One System for Multiple parameter.
6. SPC analysis and Database saving.

The above research is depending on basic principles of design, finite element analysis and checking of differential assembly gauging system, so from above method we can design and finite element analysis for any component or part.

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