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FLANGE DESIGN OPTIMIZATION FOR ENGINE ASSEMBLY AND REPAIR FIXTURE

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Abstract Engine assembly and repair fixture is use to hold the engine during assembly and maintenance. 6 pin design permits 360-degree rotation of engine during operation. This research paper deals with the static structural analysis of flange where pins and shaft were mounted on flange via M12 bolt. Stress and Factor of safety (FOS) of flange were studied with varying thickness of flange (22 mm, 25 mm and 28 mm) and load condition (250 kg, 300 kg and 350 kg). The result suggests that flange with 22 mm has exceed minimum yield strength of 250 MPa. Whereas flange with 25 mm and 28 mm has minimum 1.21 and 1.5 FOS respectively for maximum load conditions. With desirable FOS value of 1.5, flange with 28 mm thickness hold positive for all loading conditions.

***Index Terms*—Finite Element Analysis, Fixture, Design Optimization, Static Structural Analysis**

I. INTRODUCTION[1]

Now a day's all manufacturing industries attempts to bring down the manufacturing time and resources. For that purpose, they have in search of various types of specific manufacturing systems. Fixtures are one of the means that it accomplishes this need effectively. Fixture is a special purpose tool which is used to facilitate production (machining, assembling and inspection operations) when workpieces are to be produced on a mass scale. Fixtures provide a means of manufacturing interchangeable parts since they establish a relation, with predetermined tolerances, between the work and the cutting tool. [1]

There is different type of flexible fixture developed for different application but most of them were dedicated for specific machines or cost of that fixture is too much. Warren R Seibert [2] patented a universal engine repair fixture, comprising a base structure having a base plate adapted to be secured to work bench or the like, said plate having a device thereon with a pivot axis disposed substantially parallel thereto and a swinging support having one end thereof pivotally mounted on said pivot device for swinging motion between positions substantially perpendicular and substantially parallel to said base plate, and an engine holder having an engine mounting platform with an engine. Matin Magwan et. all. [3] an undergraduate form BIT developed a universal stand for the different type of engine. It was having and Cartesian arrangement to hold the engine and an indexing plate mounted to the column. Due to such construction it was difficult to hold engine effectively as stability of stand was poor due to vertical alignment of the stand. Bizin Shirinzadeh et all. [4] proposed a flexible fixture design. This fixture has a design capable of hold the multiple kind of object and also was capable of guiding the tools. It was able to constraint the work piece and was sensor-based system to carry out the task.

Present research paper deals with the static structural analysis of flange used in engine assembly and repair fixture for V8 and V12 engine. This engine has weight range from 250 kg to 350 kg. And hence the loading condition selected was 250 kg, 300 kg and 350 kg. The thickness of flange selected for analysis was 22 mm, 25 mm and 28 mm. The analysis includes the study of maximum stress induce in flange limited to minimum yield strength of structural steel. Considering the feasibility under factor of safety for different load set, thickness optimization of flange was done.

II. ANALYSIS MODEL

A. Geometry Model

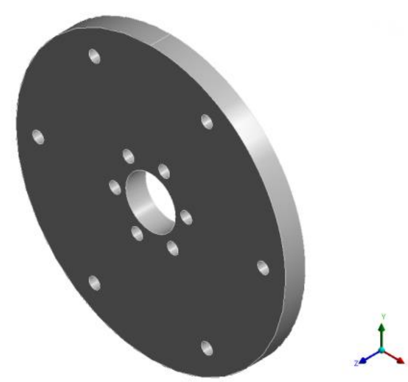

Figure 1 Geometry Model

Flange was connected to the pins and the shaft with collar was connected to flange with M12 bolt. The dimension of flange is mention in Table 1. Thickness of flange is varied according to available structural steel metal plate available via Steel Authority of India (BHILAI) [5]. Figure 1 shows the geometry of flange.

Table 1 Dimension of Flange

Measurement	Value (mm)
Diameter of Flange	300
Thickness of Flange	22, 25 and 28
Pin Hole (M12 Bolt)	12
PCD (Pin Hole)	250
Diameter of Shaft	55
Collar Hole (M12 Bolt)	12
PCD (Collar Hole)	80

B. Meshing Model

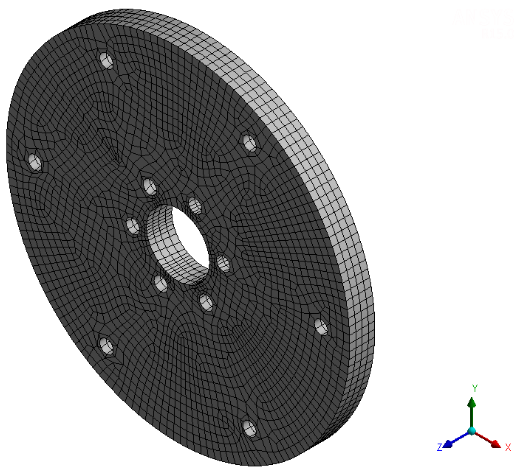

Figure 2 Mesh Model

The model is meshed with fine refinement of elements with curvature control. Figure 2 Shows the mesh model. Table 2 shows the element and node developed in three different set of flange model i.e. of 22 mm, 25 mm and 28 mm thickness. Table 3 shows mesh control parameters which are all under acceptable limits.

Table 2 Elements and Node of Mesh

Sr. No.	Flange with thickness	Number of Nodes	Number of Elements
1	22	44469	8972
2	25	53337	11110
3	28	53561	11155

Table 3 Quality Parameter of Mesh

Sr. No.	Parameters	Thickness		
		22	25	28
1	Element Quality	0.902	0.91	0.92
2	Aspect Ratio	1.495	1.454	1.411
3	Jacobian Ratio	1.369	1.363	1.334

C. Boundary Conditions

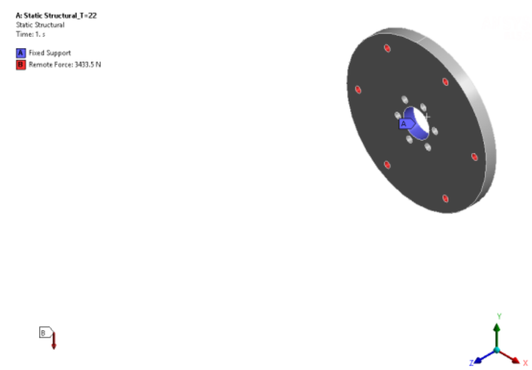

Figure 3 Boundary Conditions

Flange, pin and shaft physical model was converted into computational model by considering the relation between pin and flange as cantilever beam. Material selected for flange was structural steel (A36). Remote load was applied to flange where M12 bolt was connected. This allow load as well as moment to transfer from loading condition i.e. engine to pin to flange. Shaft was considered as fix support during the analysis. Figure 3 shows the applied boundary conditions.

III. Result and Discussion

Figure 4 to 12 shows the stress introduce in flange of different thickness i.e. 22 mm, 25 mm and 28 mm during of different loading condition of 250 kg, 300 kg and 350 kg.

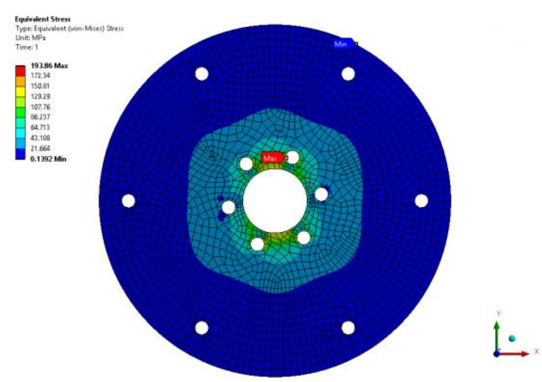

Figure 4 Thickness = 22 mm, Loading = 250 Kg

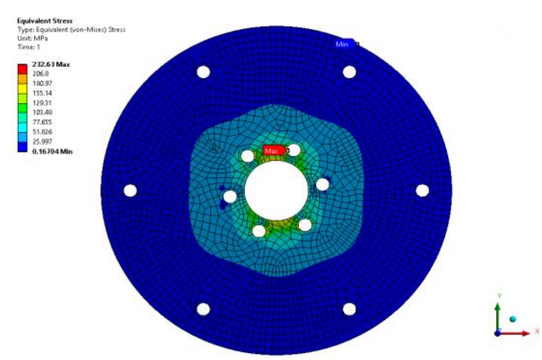

Figure 5 Thickness = 22 mm, Loading = 300 Kg

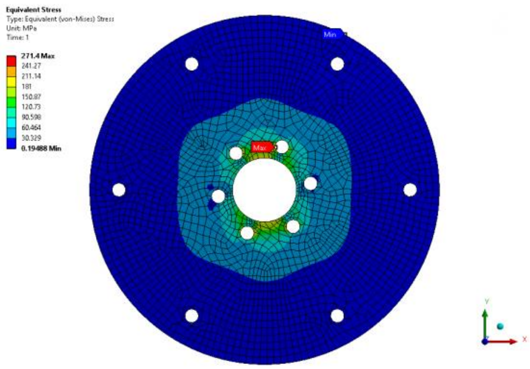

Figure 6 Thickness = 22 mm, Loading = 350 Kg

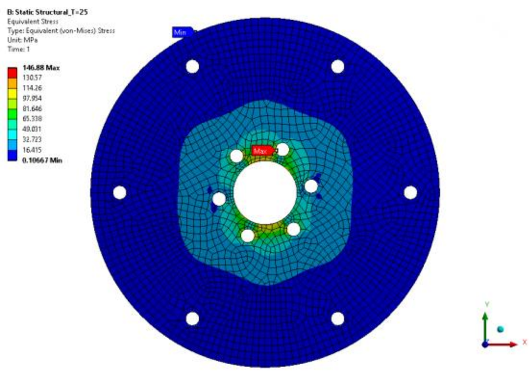

Figure 7 Thickness = 25 mm, Loading = 250 Kg

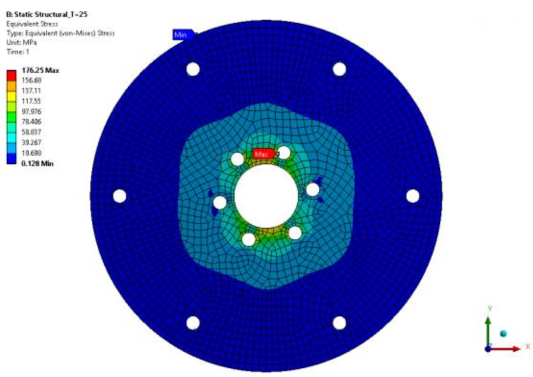

Figure 8 Thickness = 25 mm, Loading = 300 Kg

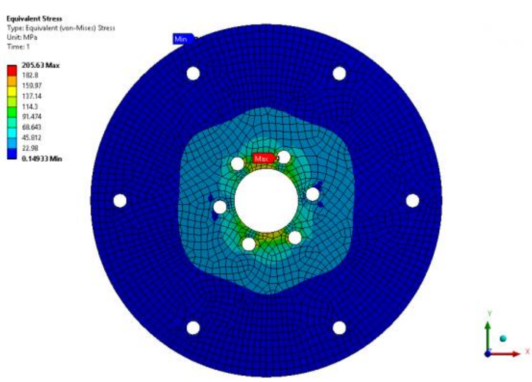

Figure 9 Thickness = 25 mm, Loading = 350 Kg

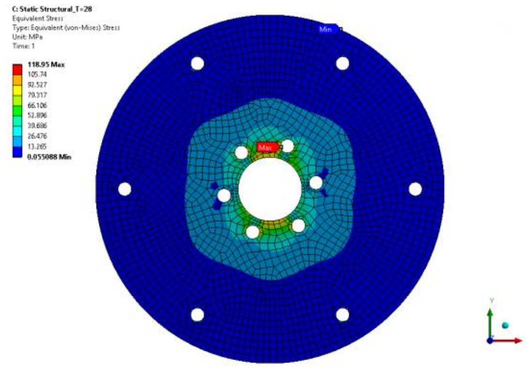

Figure 10 Thickness = 28 mm, Loading = 250 Kg

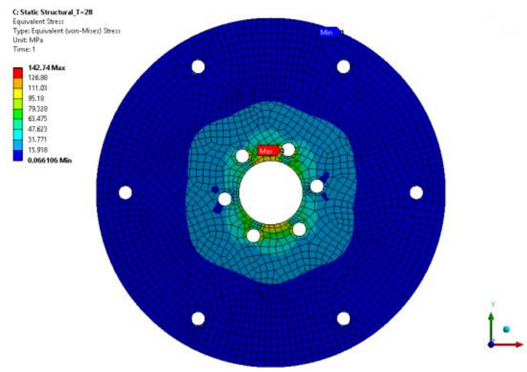

Figure 11 Thickness = 28 mm, Loading = 300 Kg

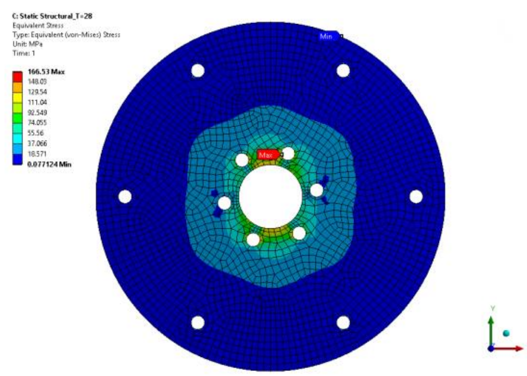

Figure 12 Thickness = 28 mm, Loading = 350 Kg

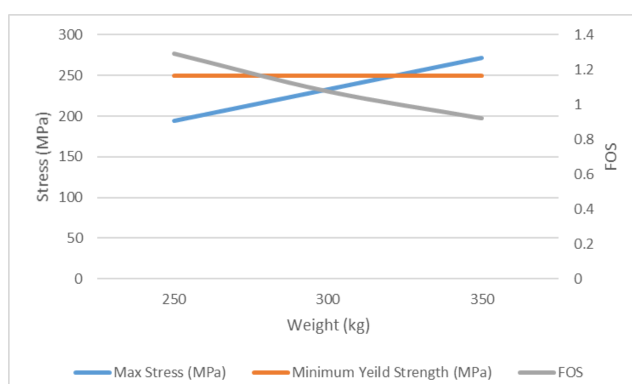

Figure 13 Analysis of flange with thickness = 22 mm

Figure 13 shows the effect of different loading condition on flange of 22 mm thickness. It was found that the value of maximum stress increases from 193.86 MPa to 232.63 MPa to 271.4 MPa as load increases from 250 kg to 300 kg to 350 kg respectively. Which leads to substitutional decrement of factor of safety from 1.28 to 1.07 to 0.92 as load increases. It was noticed that the for the loading condition of 350 kg, the structural steel has crossed the minimum yield strength value of 250 MPa [6] and leads to plastic deformation.

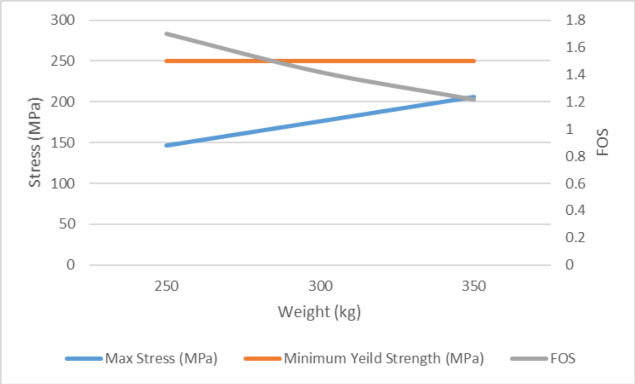

Figure 14 Analysis of flange with thickness = 25 mm

Figure 14 shows the effect of different loading condition on flange of 25 mm thickness. It was found that the value of maximum stress increases from 146.88 MPa to 176.25 MPa to 205.63 MPa as load increases from 250 kg to 300 kg to 350 kg respectively. Which again leads to substitutional decrement of factor of safety from 1.7 to 1.4 to 1.21 as load increases. It was noticed that the for the loading condition of 300 kg and 350 kg the value of factor of safety lies below 1.5, which is 1.41 and 1.21 respectively.

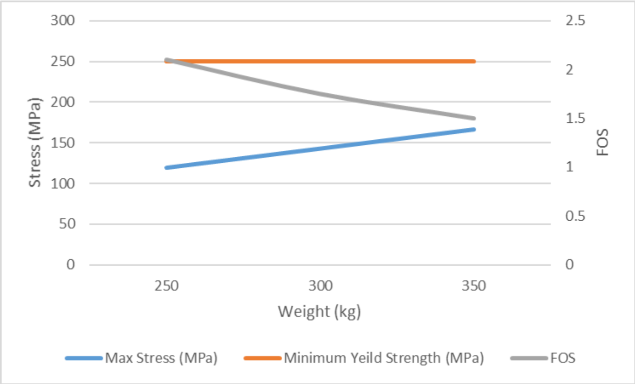

Figure 15 Analysis of flange with thickness = 28 mm

Figure 15 shows the effect of different loading condition on flange of 28 mm thickness. It was again found that the value of maximum stress increases from 118.95 MPa to 142.74.63 MPa to 166.53 MPa as load increases from 250 kg to 300 kg to 350 kg respectively. Which again leads to substitutional decrement of factor of safety from 2.1 to 1.75 to 1.5 as load increases. It could be notice that the value of factor of safety lies above 1.5 for all loading conditions.

IV. Conclusion

Static Structural Analysis of flange of different thickness for different loading condition shows that that the flange with 22 mm undergoes plastic deformation during loading conditions. The flange with 25 mm performs well if we consider our desirable value of FOS above 1 and below 1.5. Hence it can be considered as an option if we do not require high factor of safety. As to be on safer side, we highly recommend flange with 28 mm of thickness to be use as flange for engine assemble and repair fixture for V8 and V12 engines as it has FOS above 1.5 for all loading conditions.

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