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Automobile Camshaft Structural Analysis for Various Material and Modified Design

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ABSTRACT: The purpose of this research was to find the most suitable material for manufacturing camshaft for modified design. There are various factors that lead to a camshaft failure like material properties, vibration, contact fatigue etc. In this research structural analysis of camshaft was done in ANSYS for three different materials and results for both standard camshaft model and modified camshaft model was obtained and compared. ANSYS results for total deformation, maximum stress, maximum strain and factor of safety are considered.

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I. INTRODUCTION

In engine unit camshaft is used to poppet the intake and exhaust valve which has a very high impact on the performance of engine in terms of efficiency. Camshaft is made out of push rod various machining process such as milling, grinding, turning etc. camshaft are driven by series of gear which are connected to engine through crankshaft. Gears are used in a way that camshaft rotates according to our desired timing for opening and closing of intake and exhaust valve. There are main two type of camshaft one is with flat tappet and other is with roller lobe. The shape of lobe has impact on performance of engine at various speed. On V8 engine flat shape lobe is used and for the more rpm and less friction application such as racing cars uses roller lobe. Another important factor is Lobe Shaft Angle generally known as LSA of camshaft. LSA is the angle between the centerline of intake and exhaust lobe as shown in the figure below.

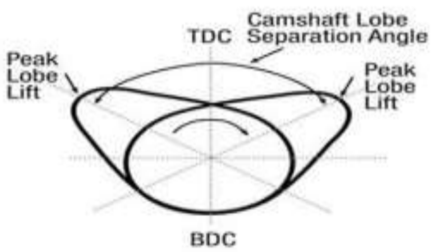

Fig. 1 LSA angle

LSA ranges from 104 to 115 degree. 107 degree LSA means that angle between intake and exhaust lobe centerline will be 107. The type of impact LSA have on engine is mentioned below on table.

Lower LSA	Higher LSA
High cylinder pressure	Low cylinder pressure
High engine knock	Low engine knock
Poor fuel economy	High fuel economy
Low rpm	High rpm
More valve overlap	Less valve overlap

2. Design Description: In this research two model of camshaft was used. First was the standard basic design model and other was modified version of same model. Both of them are shown in the figure below. Both of this design was made on solid works and then imported into ANSYS for the analysis. Here there are two difference between standard model and modified design which are as follows.

(1) Through hole at the centerline
(2) There are two small holes on the lobe

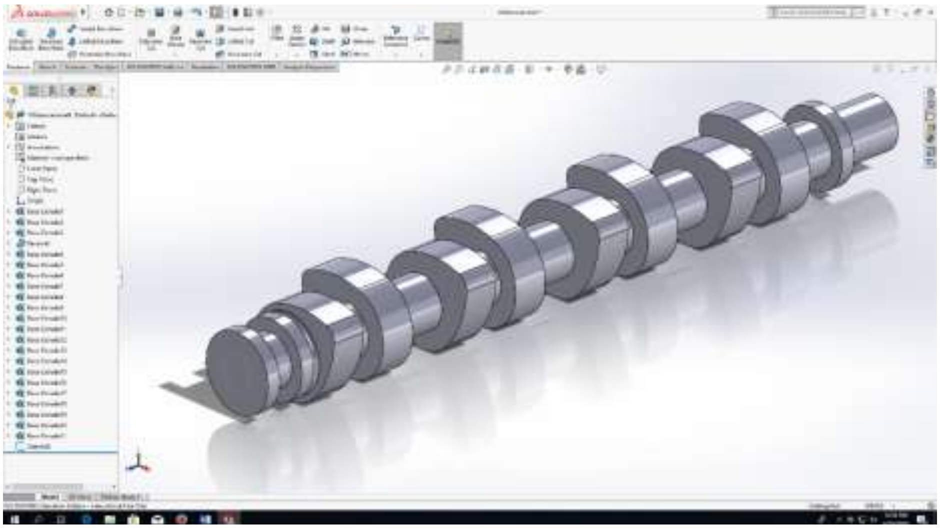

Fig. 2 Standard model

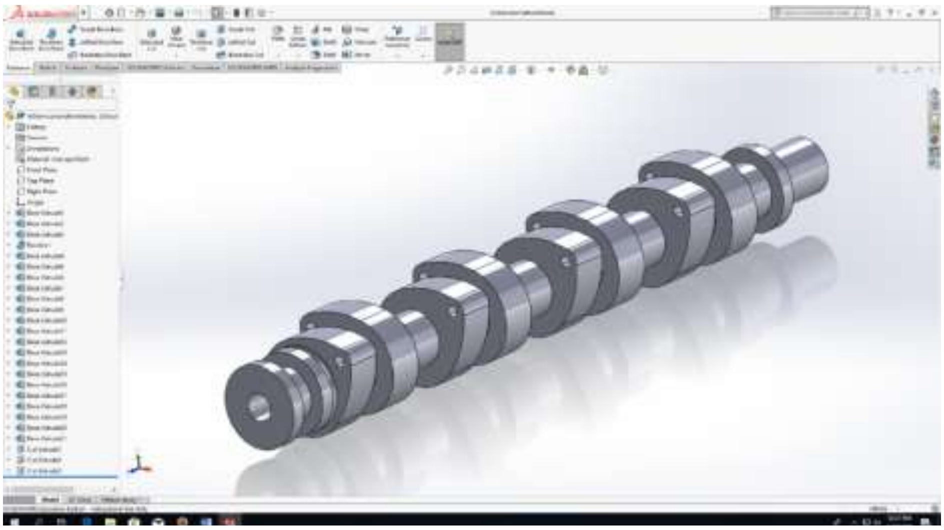

Fig. 3 Modified model

Here both shafts have 8 lobes which is basically used for 4-cylinder engine and total length of model is 450mm, lobe width is 20mm and rod diameter is about 30mm throughout the whole model with LSA is of 114 degree. The modified model has center hole of 15mm diameter and holes on the lobe are of 6mm in diameter.

3. ANSYS analysis: Here for this research ANSYS workbench 19.1 was used. The material properties are mentioned below.

Name of material	Young's modules	Poisons ratio
42CrMo4	2.1e+005	0.3
Aluminum alloy	71000	0.33
Magnesium alloy	45000	0.35

First the design model was imported to ANSYS in the structural analysis. Then material properties were specified. And the boundary condition of fixed support and load was applied to the model and then results were compared.

Meshing: fine course meshing of 0.009m was used for both standard and modified model. The number of nodes and element are shown in the table

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For standard model	For modified model
Nodes – 7561	Nodes – 11087
Element – 3892	Element - 5725

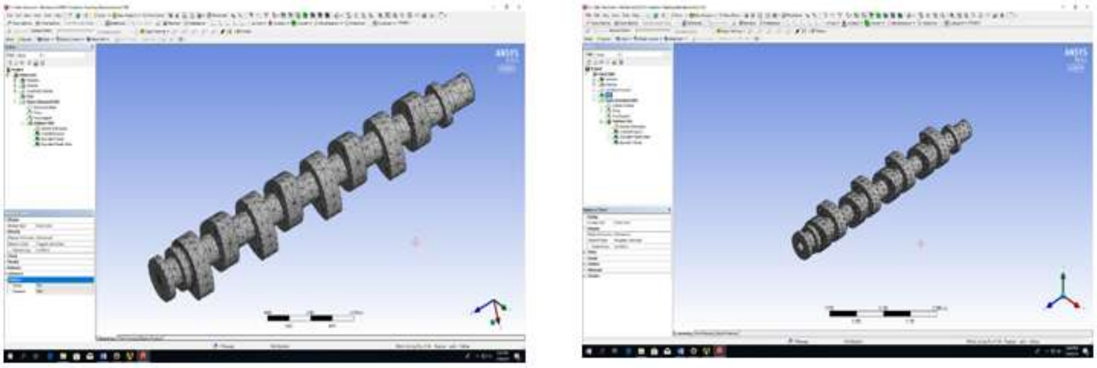

Fig. 4 Meshing

Fixed support and load application: fixed support was selected where the gears are connected to the camshaft and load of 400N-m was applied in the negative x-direction as shown in the figure below.

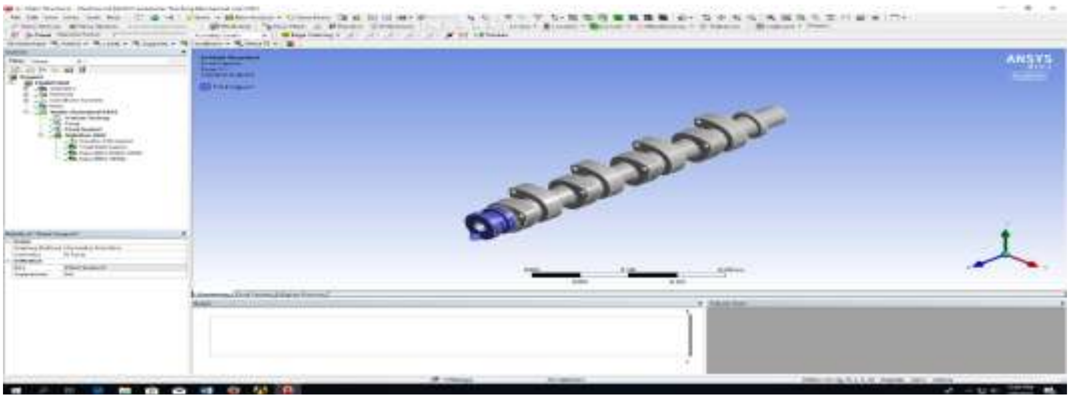

Fig. 5 Fixed support

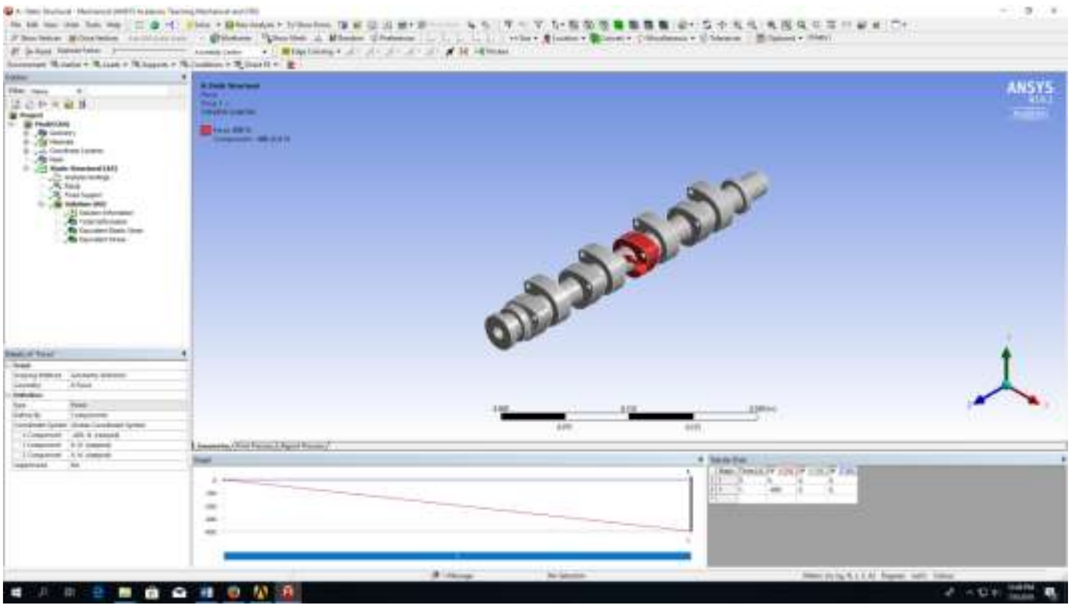

Fig. 6 Load application

4. Structural analysis results: For all three material results for total deformation, maximum stress and maximum strain are obtained and compared for both standard and modified design. Which are shown below with the image.

(1) 42CrMo4: For standard model deformation was about 205.82m and for the modified design it was about 222.86m.

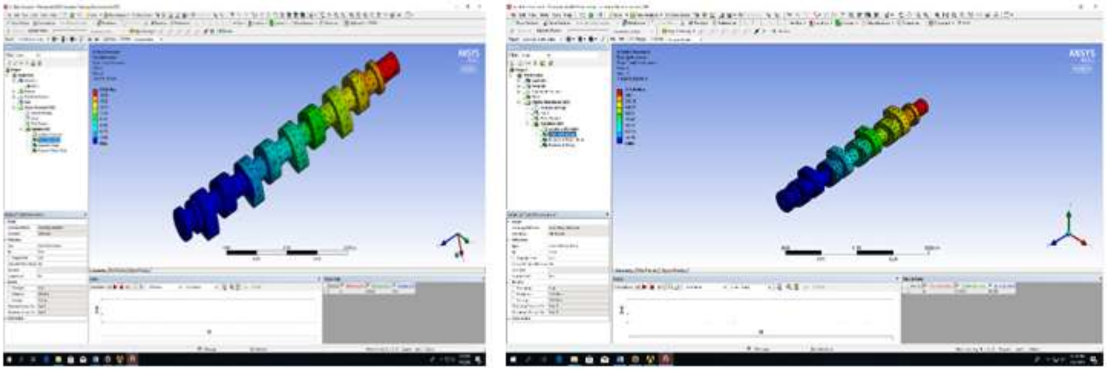

Fig**. 7** Total deformation for 42CrMo4

Maximum stress: Value for maximum stress for standard model was about 2.4966e+007 and for modified design was about 2.6009e+007.

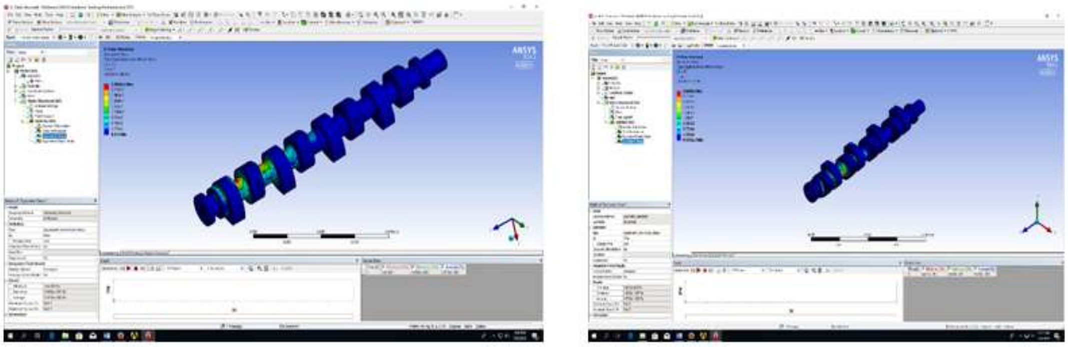

Fig.8 Maximum stress for 42CrMo4

Maximum strain: For standard model strain is about 118m/m and for modified model is about 124.25m/m.

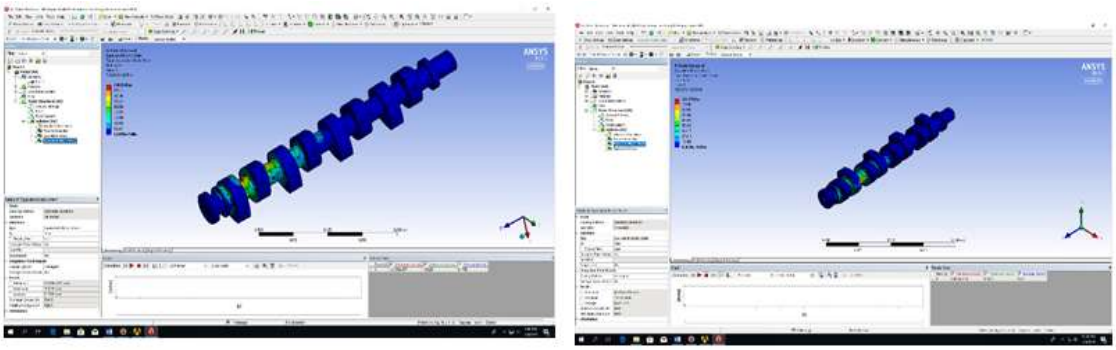

Fig.9 Maximum strain for 42CrMo4

(2) Aluminum alloy: Total deformation for standard model was about 602.57m and for modified design was about 652.58m.

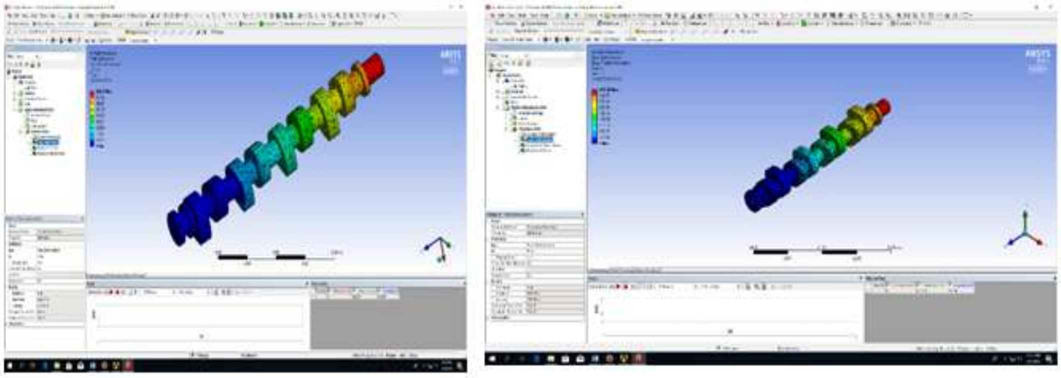

Fig. 10 Total deformation for Aluminum alloy

Maximum stress: Value for maximum stress for standard model was about 2.5017e+007 and for modified design was about 2.6053e+007.

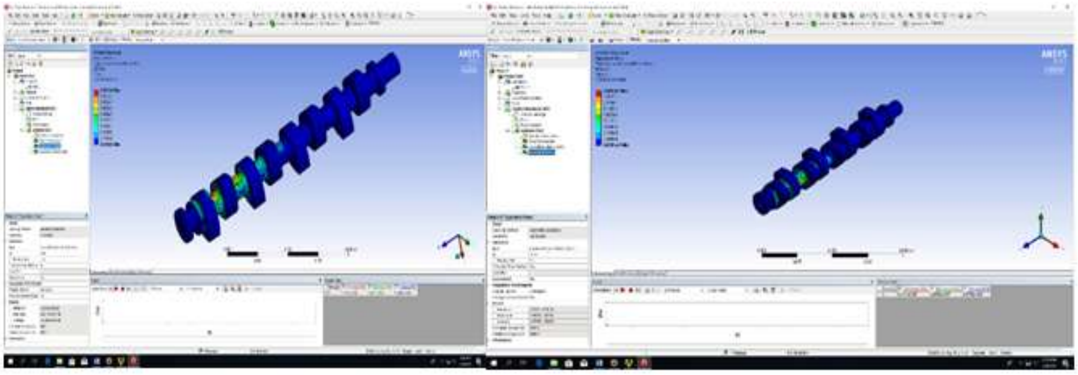

Fig. 11 Maximum stress for Aluminum alloy

Maximum strain: For standard model strain is about 352.68m/m and for modified model is about 368.18m/m.

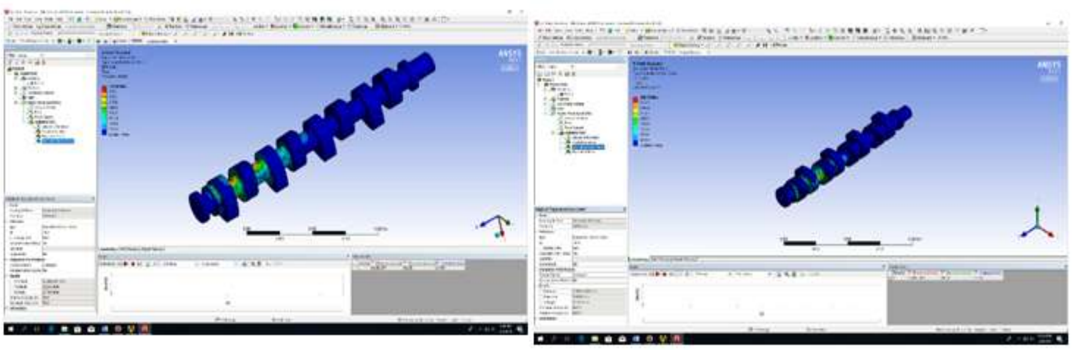

Fig. 12 Maximum strain for Aluminum alloy

(3) Magnesium alloy: Total deformation for standard model was about 943.60m and for modified design was about 1022.10m.

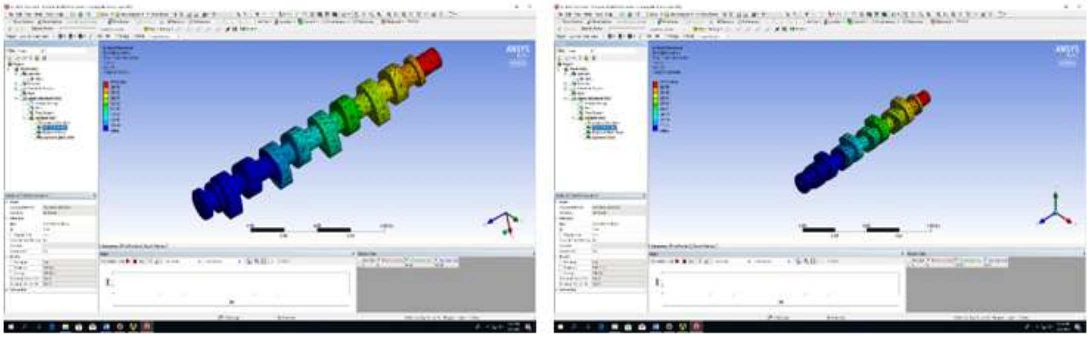

Fig**. 13** Total deformation for Magnesium alloy

Maximum stress: Value for maximum stress for standard model was about 2.5052e+007 and for modified design was about 2.6094e+007.

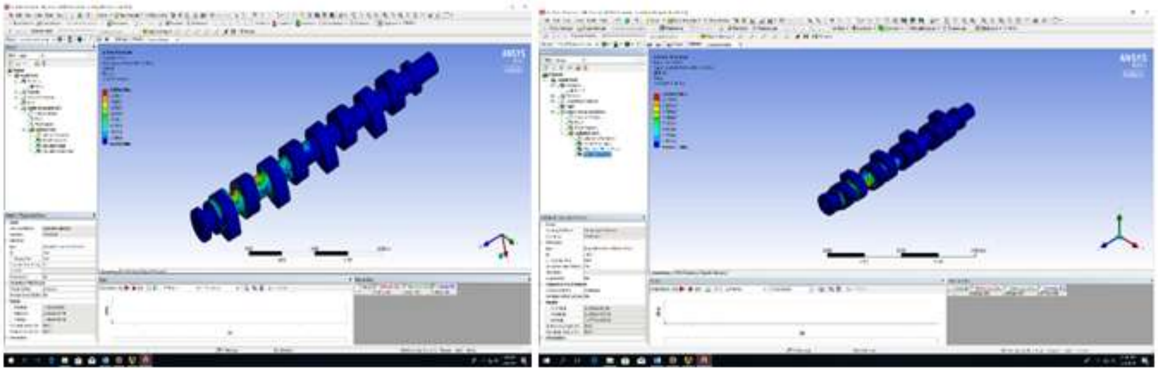

Fig. **14** Maximum stress for Magnesium alloy

Maximum strain: For standard model strain is about 557.27m/m and for modified model is about 581.82m/m.

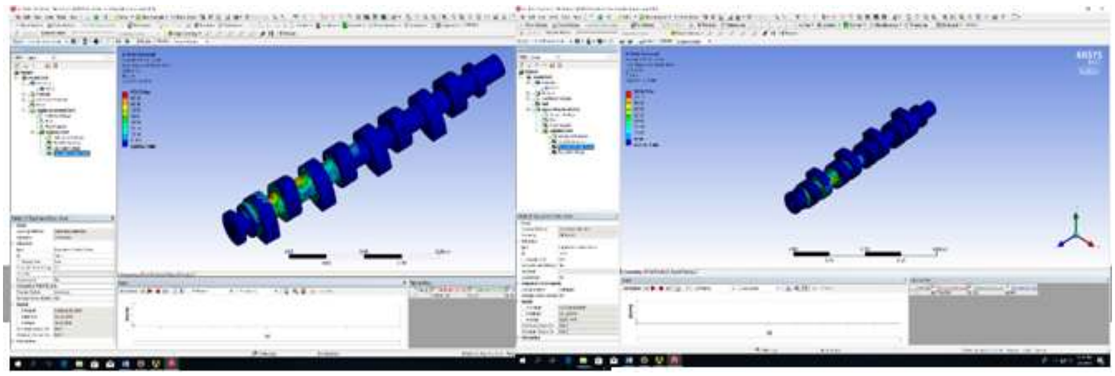

Fig. 15 Maximum strain for Magnesium alloy

5. Comparison of results:
Standard model

Name of material	Total deformation	Maximum stress	Maximum strain	Factor of safety
42CrMo4	205.82	2.4966e+007	118.99	4.0055e-005
Aluminum alloy	602.57	2.5017e+007	352.68	3.9973e-005
Magnesium alloy	943.60	2.5052e+007	557.27	3.9916e-005

Modified model

Name of material	Total deformation	Maximum stress	Maximum strain	Factor of safety
42CrMo4	222.86	2.6009e+007	124.25	3.8448e-005
Aluminum alloy	652.58	2.6053e+007	368.18	3.8383e-005
Magnesium alloy	1022.10	2.6094e+007	581.82	3.8324e-005

Difference in the results

Name of material	Total deformation	Maximum stress	Maximum strain	Factor of safety
42CrMo4	17.04	0.1043e+007	5.26	0.1607e-005
Aluminum alloy	50.01	0.1036e+007	15.5	0.1590e-005
Magnesium alloy	78.5	0.1042e+007	24.55	0.1592e-005

II. CONCLUSION:

(1) Analysis of camshaft for two different model was done in the project. And results for total deformation, maximum stress and maximum strain was compared.

(2) Form the results if we are designing the camshaft for less deformation and making changes in design 42CrMo4 is best suitable material as it has very less deformation as compare to other material that we have used in this project. Also, it has very less strain difference.

(3) If you are designing camshaft in a way that it can handle more stress than you should prefer aluminum alloy. Brief details for all three materials are mentioned below.

42CrMo4: - From the results we can say that this will be the most suited material if we are making any type of design changes in the camshaft because it has very less deformation difference along with very less difference in the value of strain. The difference in value of F.O.S is 0.1607e-005.

Aluminum alloy: - From the results we can say that if we want to design camshaft to handle more stress then aluminum is best suited material because it has very less difference in the value of maximum stress. The difference in value of F.O.S is 0.1590e-005 which is higher than magnesium alloy and lower than 42CrMo4.

Magnesium alloy: - This material should be used when you want your camshaft design in a way that it can handle moderate amount of stress as it has less difference in stress as compare to 42CrMo4 and more difference as compare to aluminum alloy. The difference in value of F.O.S is 0.1592e-005 which is least of them all so this is the safest material to make camshaft with.

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