Design and Optimization of Crankshaft in Multiaxle Vehicle Using FEA

Balram Yadav[#1], Vishal Achwal[*2], Dr.Suman Sharma[#3]
[#f]*Department of Mechanical Engineering,*
Sagar Institute of Research and Technology Indore (M.P.) India

Abstract
To evaluate and compare the fatigue performance of two competing manufacturing technologies Computer aided modelling and optimization analysis of crankshaft is done for two automotive crankshafts namely AISI-4140 alloy steel (EN 19C) and ASTM A536 100-70-03 (GGG7O). A dynamic simulation was conducted on two crankshafts, AISI-4140 alloy steel (EN 19C) and ASTM A536 100-70-03 (GGG7O) from similar single cylinder four stroke engines. Finite element analyses have been performed to obtain the variation of stress magnitude at critical locations. The dynamic analysis was done analytically and was verified by simulations in ANSYS. Results achieved from mentioned analysis were used in optimization of the forged steel crankshaft. Geometry, material and manufacturing processes were optimized considering different cost, manufacturing feasibility and constraints. The optimization process included geometry changes compatible with the current engine ,fillet rolling and result in increased fatigue strength and reduced cost of the crankshaft, without changing connecting rod and engine block.

Keywords - *Crankshaft, AISI-4140 alloy steel (EN 19C) and ASTM A536 100-70-03 (GGG7O), FEM..*

I. INTRODUCTION

Crankshaft is one of the most important moving parts in internal combustion engine. It must be strong enough to take the downward force of the power stroked without excessive bending. So the reliability and life of internal combustion engine depend on the strength of the crankshaft largely. And as the engine runs, the power impulses hit the crankshaft in one place and then another. The torsional vibration appears when a power impulse hits acrank pin toward the front of the engine and the power stroke ends. If not controlled, it can break the crankshaft. Strength calculation of crankshaft becomes a key factor to ensure the life of engine. Beam and space frame model were used to calculate the stress of crankshaft usually in the past. But the number of node is limited in these models. With the development of computer, more and more design of crankshaft has been utilized finite element method (FME) to calculate the stress of crankshaft. The application of numerical simulation for the designing crankshaft helped engineers to efficiently improve the process development avoiding the cost and limitations of compiling a database of real world parts. Finite element analysis allows an inexpensive study of arbitrary combinations of input parameters including design parameters and process conditions to be investigated. Crankshaft is a complicated continuous structure. The vibration performance of crankshaft has important effect to engine. The calculation of crankshaft vibration performance is difficult because of the complexity of crankshaft structure, the difficult determinacy of boundary condition. Dynamic matrix method and dynamic sub structural method combined with FME were used to calculate the vibration of crankshaft. The method of three-dimensional finite element was carried to analyses dynamical characteristic of diesel crankshaft. In the paper, 3-D finite element analysis are carried out on the modal analysis of crankshaft and the thermal analysis of crankshaft, And the FME software ANSYS was used to simulate the modal analysis of the crankshaft. The results of natural frequencies and mode shape were obtained and deformation distributions of crankpin were obtained by using ANSYS software. The results are regarded as a theory basis to optimize the design of crankshaft and thermal analysis of crankshaft.

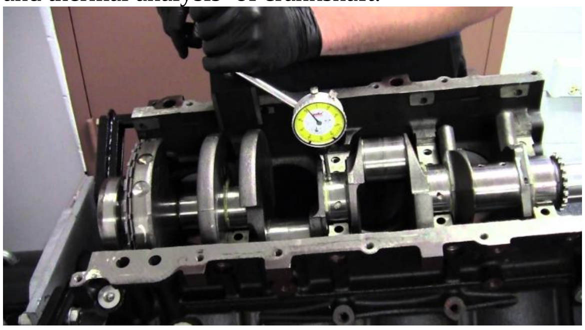

Fig 1: Crankshaft

II. OBJECTIVES

Design of crankshaft and Numerical prediction of Fatigue life of a crankshaft by analysing the behaviour of crankshaft by varying the material and Optimizing the fatigue life of crankshaft with the numerical prediction.

III.DESIGN IN CATIA

A CATIA stands for Computer Aided Three-**dimensional** Interactive Application. It's a CAD software used for physical modelling in various industries including Mechanical and Aerospace. It was developed by Dassault Systems in early 80's mainly for aerospace industry.

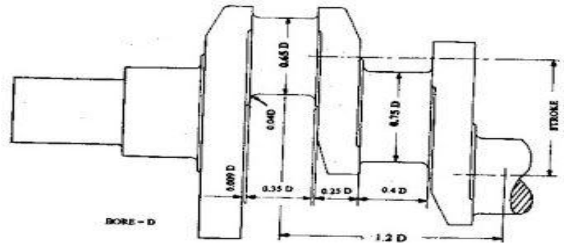

Fig 2: Crankshaft design parameter

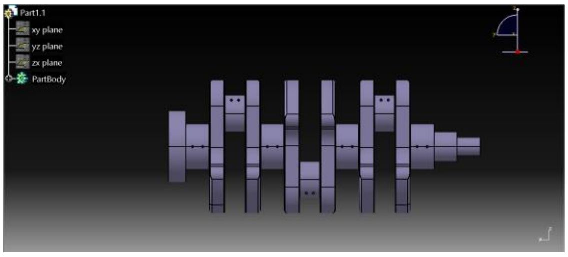
Fig 3: Side view of crankshaft

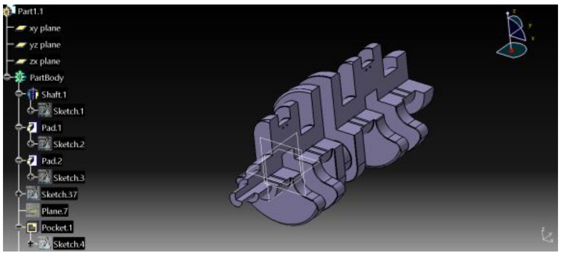
Fig 4: Isometric view of crankshaft

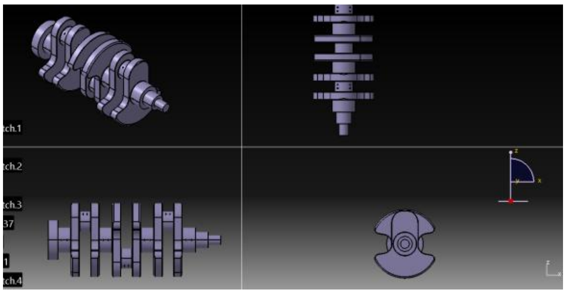
Fig 5: Views of crankshaft

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Recommended font sizes are shown in Table Title must be in 24 pt Regular font. Author name must be in 11 pt Regular font. Author affiliation must be in 10 pt Italic. Email address must be in 9 pt Courier Regular font.

IV. BOUNDARY CONDITIONS

After carefully studying all aspects related to the problem it was important that the boundary conditions for which the analysis was to be performed to be set up.

The final boundary conditions were:

1. Constant the Angular velocity of a crankshaft 2100 RPM (Revolution per minute) calculated.
2. Moment of 128 Nm
3. 6500 of force horizontally as well as vertically separately on the instant of time on TDC (Top dead centre)

One parameter is varying which is material and they are ASTM A536 100-70-03 (EN-GJS-700-2, GGG70, Ductile Iron, SG Iron) and AISI-4140 alloy steel(EN 19C).

V. TEST RUNS

Before performing real examination some trials were performed to check the precise speed at which the material would be facture and taking a shot at all of the parts the of material component. Various trials were finished with and without minute and additionally the differing the powers that are following up on the crankshaft vertically and in addition on a level plane.

VI. ANALYSIS OF CRANKSHAFT

After performing the test runs and verifying proper functioning of all the components actual material properties were used to perform analysis. Firstly by keeping the same angular velocity and varying material. Record the corresponding the fatigue according to Goodman's theory and tabulate the readings. Also perform some experimental runs vertically as well as horizontal forces acting on the crankshaft.

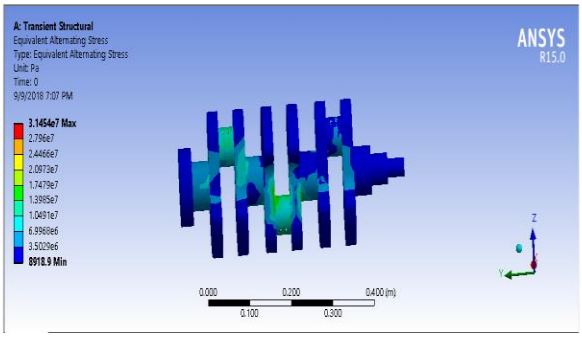

Fig 6: Analysis of equivalent alternating stress material GGG 70

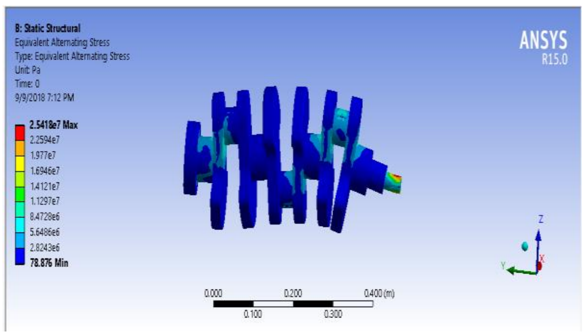

Fig 7: Analysis of equivalent alternating stress material GGG 70

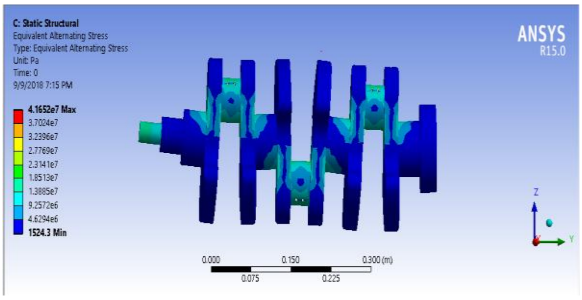

Fig 8: Analysis of equivalent alternating stress material GGG 70

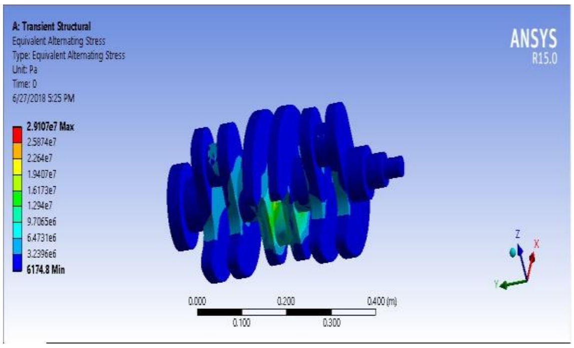

Fig 9: Analysis of equivalent alternating stress material AISI 4041

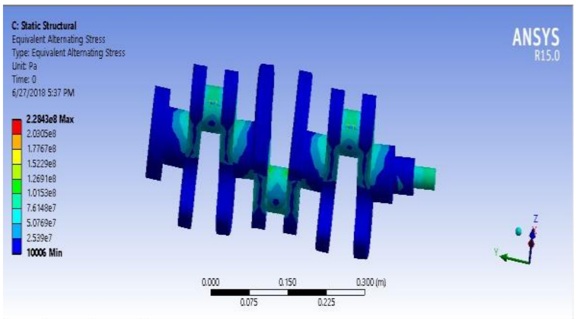

Fig 10: Analysis of equivalent alternating stress material AISI 4041

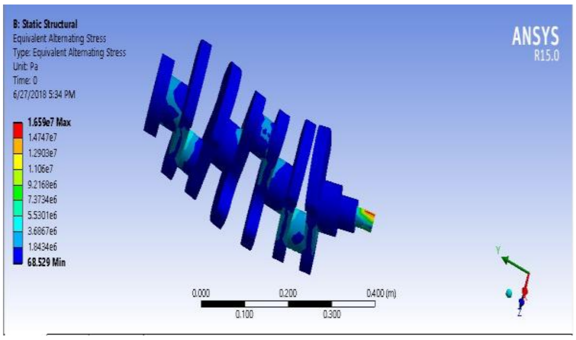

Fig 11: Analysis of equivalent alternating stress material AISI 4041

VII. RESULTS AND COMPARISON

Properties	AISI-4140 alloy steel	GGG 70ASTM A536 100-70-03
Rotational analysis		
Equivalent Elastic Strain	1.4805e-005 m/m	1.652e-004 m/m
Shear Elastic Strain	4.544e-006 m/m	5.2433e-005 m/m
Shear Stress	3.6352e+006 Pa	3.6828e+006 Pa
Total Deformation	50.15 m	69.118 m
Life	1.e+006 cycles	1.e+006 cycles
Safety Factor	2.9615	3.1181
Equivalent Alternating Stress	2.9107e+007 Pa	2.7645e+007 Pa
Damage	1000	1000
Fatigue	1.e+6	1.e+6

Properties	AISI-4140 alloy steel	GGG 70ASTM A536 100-70-03
Horizontal analysis		
Equivalent Elastic Strain	1.1575e-004 m/m	1.3797e-003 m/m
Equivalent Stress	2.2843e+008 Pa	2.32e+008 Pa
Shear Elastic Strain	1.5099e-004 m/m	3.5272e-004 m/m
Total Deformation	6.33e-6	11.8e-7
Life	15995 cycles	15166 cycles
Safety Factor	0.37137	0.37155
Equivalent Alternating Stress	2.2843e+008 Pa	2.32e+008 Pa
Damage	62518	65936
Fatigue	1.e+6	1.e+6

Properties	AISI-4140 alloy steel	GGG 70ASTM A536 100-70-03
Vertical analysis		
Equivalent Elastic Strain	1.4805e-005 m/m	1.652e-004 m/m
Equivalent Stress	3.6352e+006 Pa	3.6828e+006 Pa
Shear Elastic Strain	4.544e-006 m/m	5.2433e-005 m/m
Total Deformation	6.11e-4	11.8e-6
Life	1.e+006 cycles	1.e+006 cycles
Safety Factor	2.9615	3.1181
Equivalent Alternating Stress	2.9107e+006 Pa	2.7645e+007 Pa
Damage	1000	1000
Fatigue	1.e+6	1.e+6

VIII. CONCLUSIONS

In this undertaking the appropriate substitute material has been AISI-4140 alloy steel (EN 19C) Steel distinguished and examined for the diesel motor camshaft rather ASTM A536 100-70-03 (GGG7O) high ductile than material. Since the current material requires visit substitution prompting loss of time and cash. Mechanical properties, for example, hardness, sturdiness and wear opposition of both the material were considered. The outcomes got from Ansys test showed that the shear for exerted on the ASTM A536 100-70-03 (GGG7O) high ductile than material is more as compared to AISI-4140 alloy steel (EN 19C) before enlistment solidifying. Effect test demonstrated that the weight of AISI-4140 alloy steel (EN 19C) is 3kg higher than ASTM A536 100-70-03 (GGG7O). Moreover, ANSYS comes about demonstrated that AISI-4140 alloy steel (EN 19C) camshaft endured bring down dislodging than ASTM A536 100-70-03 (GGG7O) camshaft for all heap conditions. From these outcomes it can be watched that AISI-4140 alloy steel (EN 19C) camshaft influenced utilizing has higher administration life due to high measure of strain is considerably high. Due to above the shear force , heap conditions , Rigidity, Tensile strength as well as yield strength is high.

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