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Design and Optimization of Crankshaft in Multiaxle Vehicle

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Abstract: *The globalization and economic reforms have drastically changed world economy in the last few years. The main emphasis is on product quality, faster design, development, and cheaper product. At the same time, for optimal use of these technologies, one has to converge them in a better way. To sustain in the competitive market, industries have to acquire new skills and knowledge to offer world-class products. Automobile Industry has profited a lot with the development of CAD/CAM technologies, from engine performance to aesthetic appeal. The lead time to manufacture automobiles has drastically reduced in the recent times, because of advancements in Computer Integrated Manufacturing. Design of Internal Combustion (IC) Engine parts plays a crucial role in improving the functioning of an automobile. Many advance concepts have been involved for cylinder head, connecting rod, crankshaft, piston and carburetor. Fuel injection pump and other engine components. Specially redesign of Crankshaft is carried out to get enough strength to resist the gas pressure and to have the better thermal stability. Also one of new researches are undergoing on to select an alternate material to face up with the existing load cases, to get higher compression ratio, to reduce the inertia forces to increase the speed of the vehicle (by reducing the weight of the reciprocating masses). The modal analysis of a 4-cylinder crankshaft is discussed using finite element method in this paper. The analysis is done on two different materials* **AISI-4140 alloy steel (EN 19C) and ASTM A536 100-70-03 (GGG7O)** *which are based on their composition. Three dimensional models of diesel engine crankshaft was created using Catia v 5 software. The finite element analysis (FEM) software ANSYS was used to analyze the static and dynamic modal of the crankshaft later. The maximum stress parts and dangerous areas are found by the deformation analysis of crankshaft. The results will provide a valuable theoretical foundation for the optimization and improvement of engine design especially on engine parts like crankshaft.*

Keywords: Crankshaft, AISI-4140 alloy steel (EN 19C), ASTM A536 100-70-03 (GGG7O), Catia V 5, FEM

1. Introduction

Crank shaft is a large component with a complex geometry in the i.c engine, which converts the reciprocating displacement of the piston to a rotary motion with a four bar link mechanism. crankshaft consisting of shaft parts, two journal bearings and one crankpin bearing. the shaft parts which revolve in the main bearings, the crank pins to which the big end of the connecting rod are connected, the crank arms or webs which connect the crank pins and shaft parts. in addition, the linear displacement of an engine is not smooth; as the displacement is caused by the combustion chamber therefore the displacement has sudden shocks. the concept of using crankshaft is to change these sudden displacements to as smooth rotary output, which is the input to many devices such as generators, pumps and compressors. it should also be stated that the use of a flywheel helps in smoothing the shocks crankshaft experiences large forces from gas combustion this force is applied to the top of the piston and since the connecting rod connects the piston to the crank shaft, the force will be transmitted to the crankshaft. the magnitude of the forces depends on many factors which consist of crank radius, connecting rod dimensions, weight of the connecting rod, piston, piston rings, and pin combustion and inertia forces acting on the crankshaft. 1. Torsional load 2.Bending load. crankshaft must be strong enough to take the downward force of the power stroke without excessive bending so the reliability and life of the internal combustion engine depend on the strength of the crankshaft largely. The crank pin is like a built in beam with a distributed load along its length that varies with crank positions. each web is like a cantilever beam subjected to bending and twisting. 1. Bending moment which causes tensile and compressive stresses. 2. Twisting moment causes shear stress. There are many sources of failure in the engine one of the most common crankshaft failure is fatigue at the fillet areas due to the bending load causes by the combustion. the moment of combustion the load from the piston is transmitted to the crankpin, causing a large bending moment on the entire geometry of the crankshaft. at the root of the fillet areas stress concentrations exist and these high stress range locations are the points where cyclic loads could cause fatigue crank initiation leading to fracture.

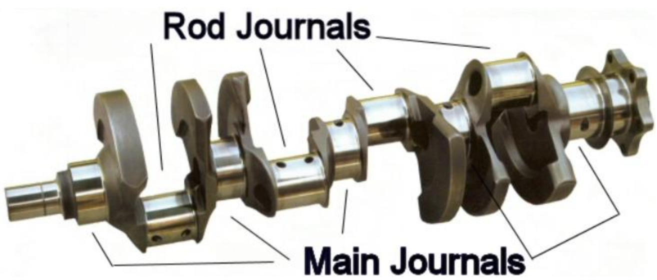

Figure 1: Crankshaft

2. Objectives

The general goal of this investigation was to assess and look at the weariness execution of two contending producing advancements for car crankshafts, namely ASTM A536 100-70-03 (EN-GJS-700-2, GGG70, Ductile Iron, SG Iron) and AISI-4140 alloy steel(EN 19C). Moreover, weight and cost decrease for enhancement of the produced steel crankshaft were likewise researched.

Objective - Research the crankshaft design to be cast of in a heavy duty vehicle by preparing and comparing two categories of crankshaft material for crankshaft strength and weakness.

3. Design of crankshaft

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

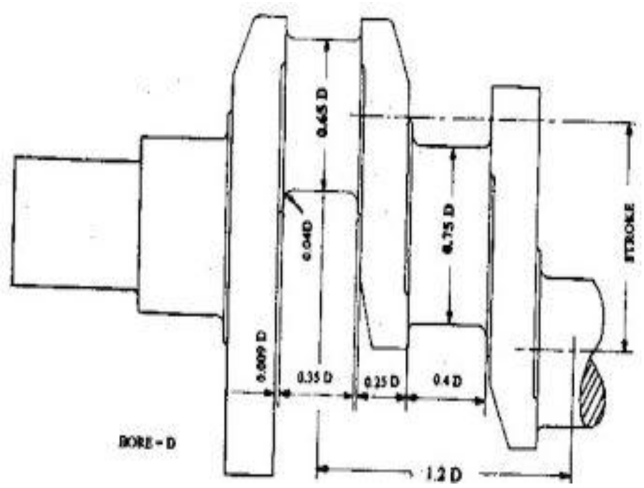

Figure 2: Crankshaft dimensional nomenclature

Chamber bore measurement = D = 104mm
Chamber focus remove = 1.20 D = 124.8mm
Enormous end diaries measurement = 0.65 D = 62.4mm
Primary end diary distance across = 0.75 D =78mm
Enormous end diary width = 0.35 D=36.4mm
Fundamental end diary width = 0.40 D =41.6mm
Web thickness = 0.25 D =26mm
Filet span of diary and networks = 0.04 D =4.16mm
Crankpin pin overlap= Main diameter + crankpin – stroke / 213.7={(64.2+78)/2-E
E = 57.4 mm
E is eccentric length or distance between main and crankpin diameter.

3.1 Modeling of crankshaft

This model of crankshaft is prepared on CATIA with above dimensions-

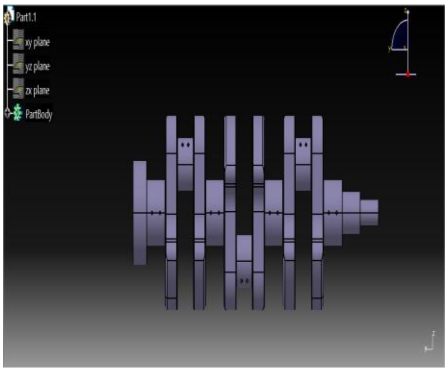

Figure 3: Front view of Crankshaft

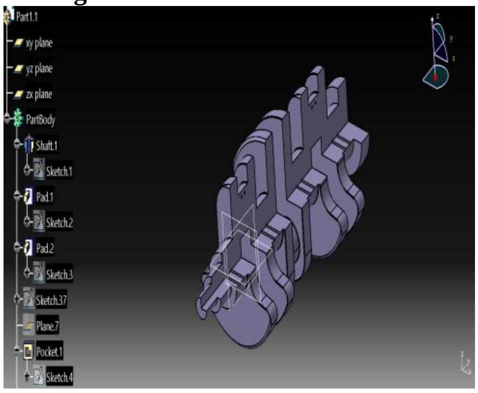

Figure 4: Isometric view of Crankshaft

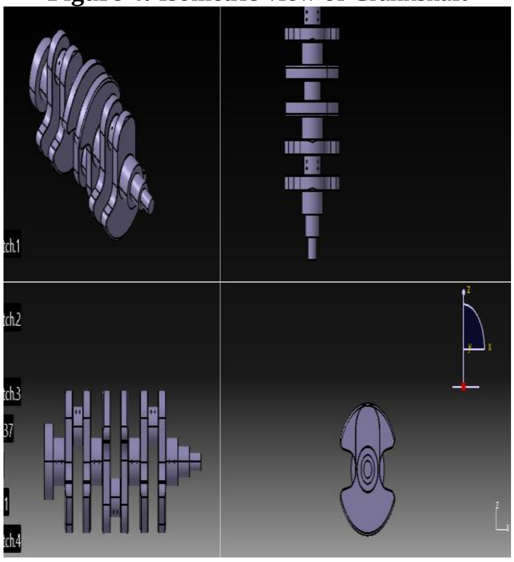

Figure 5: Isometric view of Crankshaft

4. Material of Crankshaft

4.1 AISI 4140

It is a low-alloy steel containing chromium and molybdenum as reinforcing specialists. Its substance synthesis is seen roar. AISI/SAE 4140 review is a flexible compound with great air erosion obstruction and sensible quality up to around 600º F (315º C.) It indicates great general blends of quality, durability, wear opposition and exhaustion quality. It has high exhaustion quality, scraped area and effect opposition, durability, and torsional quality. Combination steels are assigned by AISI four-digit numbers. They include various types of steels having synthesis surpassing the constraints of B, C, Mn, Mo, Ni, Si, Cr, and Va set for carbon steels. AISI or SAE 4140 steel compound is a low-composite steel containing chromium and molybdenum as fortifying operators. Its substance creation is seen roar. AISI/SAE 4140 review is an adaptable composite with great air consumption opposition and sensible quality up to around 600º F (315º C.) It indicates great general mixes of quality, sturdiness, wear obstruction and exhaustion quality. It has high weariness quality, scraped area and effect opposition, sturdiness, and torsional quality. AISI-4140 compound steel has high flexibility. It can be shaped utilizing customary procedures in the strengthened condition. It requires more weight or power for framing since it is harder than plain carbon steels. The combination is promptly machinable.

4.2 GGG 70 ASTM

I GGG 70 is a kind of high rigidity pliable cast press (SG cast press, nodular cast press) material review. It has relatively high rigidity, and great grating opposition. In this way, this cast press review is appropriate to deliver mechanical parts with high obligation. GGG70 has a pearlitic structure with higher mechanical properties than those of GGG50 and GGG60, bringing about stunningly better scraped area opposition. Regardless of the high hardness, this material is sensibly simple to machine and the surface can be done to an exclusive expectation. It is reasonable for some applications where high quality and a completely pearlitic base structure are required; e.g. cast press and stamping machine passes on, exceedingly focused on machine parts, toothed wheels, running haggles.

5. Properties of AISI 4140 material

AISI 41403 It is a low-alloy steel containing chromium and molybdenum as reinforcing specialists. Its substance synthesis is seen roar. AISI/SAE 4140 review is a flexible

5.1 Chemical Properties

The following direct the chemical composition of AISI-4140 alloy steel.
Chromium Cr Content : 0.80 – 1.10(%)
Manganese, Mn Content : 0.75 - 1.0(%)
Carbon, C Content : 0.380 - 0.430(%)
Silicon, Si Content: 0.15 - 0.30(%)
Molybdenum, Mo Content: 0.15 - 0.25 (%)
Sulfur, S Content : 0.040(%)
Phosphorous, P Content: 0.035(%)

5.2 Mechanical Properties

These are following outlines the properties of AISI-4140 alloy steel:
Tensile strength as: 95000psi
Yield strength as: 60200psi
Bulk modulus (typical for steel) as: 20300ksi
Shear modulus (typical for steel)as : 11600ksi
Elastic modulus as: 27557-30458ksi)
Poisson's ratio as: 0.27-0.30
Elongation at break in 50 mm as : 25.70
Hardness, Brinell as: 197
Hardness, Knoop (it is converted from the Brinell hardness) as: 219
Hardness, Rockwell B (it is converted from the Brinell hardness) as: 92
Hardness, Rockwell C (it is converted from the Brinell hardness. The Value below a normal HRC range, and for the comparison purposes) as: 13
Hardness, Vickers (it is converted from the Brinell hardness) as: 207
Machinability (it is based on a AISI-1212 as hundred machinability) as: 65

6. Properties of AISI 4140 material

The principle contrast between malleable iron and dim iron is the morphology of the graphite particles which go up against a nodular or relatively circular shape after appropriate medicines are made to the liquefy. They look like those found in moldable iron, yet are more round. Like dark iron the lattice might be ferritic, pearlitic or martensitic depending components, for example, science and different process factors.

6.1 Chemical Properties

The following direct the chemical composition of GGG 70 ductile steel
Element Percentage
Carbon: 3.50 - 3.90%
Silicon :2.25 - 3.00%
Manganese :0.15 - 0.35%
Sulphur :0.025% Max
Phosphorus :0.05% Max

6.2 Mechanical Properties

Hardness properties for various diameters are shown in the table. Hardness properties were listed are minimum and maximum across bar. For rectangles, squares and other shapes, the hardness properties will depend on a minimum and maximum section thickness and it will be supplied on to the request. **Mechanical Properties**
Tensile strength psi (min):100,000
Yield strength psi (min):70,000
Elongation (min): 3%

7. Results and Comparison

7.1 Rotational Analysis

Properties	AISI-4140 alloy steel	GGG 70ASTM A536 100-70-03
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

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7.2 Horizontal Analysis

Properties	AISI-4140 alloy steel	GGG 70ASTM A536 100-70-03
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

7.3 Vertical Analysis

Properties	AISI-4140 alloy steel	GGG 70ASTM A536 100-70-03
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

8. Conclusion

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 studying material 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. AISI/SAE 4140 is a low-alloy steel containing chromium and molybdenum as reinforcing specialists where as GGG 70 is a kind of high rigidity pliable cast press (SG cast press, nodular cast press) material. AISI/SAE 4140 review is a flexible compound with great air erosion obstruction and sensible quality up to around 600º F (315º C. where as GGG 70 has relatively high rigidity, and great grating opposition. Both alloys steel had good machinability in form as the annealed condition as annealing diminishes inside burdens and help machining. AISI/SAE 4140 Hardness is comparatively high then GGG 70 indicates great general blends of quality, durability, wear opposition and exhaustion quality. It has high exhaustion quality, scraped area and effect opposition, durability, and torsional quality.

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