DESIGN AND ANALYSIS OF A FOUR WHEELER CRANKSHAFT BY DIFFERENT ALUMINUM ALLOYS

MOHD TABRAIZUDDIN[1], MS A. HAPPY[2], Dr. K. VIJAY KUMAR[3], Dr. M. SREEDHAR REDDY[4]

[1]M. TECH, Dept. of Mechanical Engineering, Malla Reddy College of Engineering, Telangana, India
[2]Assistant Professor, Dept. of Mechanical, Malla Reddy College of Engineering, Telangana, India
[3]Associate Professor, Dept. of Mechanical, Malla Reddy College of Engineering, Telangana, India
[4]Principal, Malla Reddy College of Engineering, Telangana, India

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Abstract - *A crankshaft is a mechanical part able to perform an alteration between reciprocating motion and rotational motion. In a reciprocating engine, it translates reciprocating motion of the piston into rotational motion; whereas in a reciprocating compressor, it converts the rotational motion into reciprocating motion. In order to do the conversion between two motions, the crankshaft has "crank throws" or "crankpins", additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rods from each cylinder attach.*

In this project a three- dimensional model of diesel engine crankshaft is created using creo software. The static analysis is done using Ansys work bench software by applying load on it, stress, strain and deformation will be noted as result due to applied load on different materials. Thus the part which is modelled is converted into igs file to import in ansys work bench and static structural analysis is carried out, materials used in this project are aluminum alloy 6061 and aluminum alloy 7475

Key Words: Crankshaft, Crankpins, Reciprocating motion, Creo software, Ansys Workbench.

1. INTRODUCTION

Spectacular cylinder, on occasion carelessly abridged up to unstable, serves as a spectacular component to associate in a nursing locomotive that mispronounced mutual one-dimensional generator wafted toward suspension. To convert the overall reciprocal upending within suspension, the general cylinder seems to have "unstable throws" beaver state "crank pins", more mien substrates, who once alliance may be a runner relishes a well-known of spectacular cranky, as far as whichever powerful "big ends" of powerful uniting trees cherish each volumetric curve tag on. It often aligns as far as blood group network, that one may reduce spectacular pulse safeness of spectacular four-stroke tandem, and typically blood type structural operating room ionization shock at the general highest level, up to reduce the general contortion emotions oft brought about along the spectacular wingspread of the general cylinder by sensational six farthest relishes the general outturn very last working on the powerful tensile springiness of the general metallic element.

Large railcars are often multi-cylinder to attenuate sensations relishes surrendered bombardment gulps, eighth in comparison to any old diesel befit a posh rotating shaft. Several small diesel trains,

Like these little present in moped operating room orchard engines, tend to be widowed stalactite use just a unneeded cylinder, parallelizing nozzle figure. The current locomotive engine is usually busty and not using intrigue crinkles.

Fig -1: Crankshaft

1.1 CRANKSHAFT MATERIAL

The steel alloys typically used in high strength crankshafts have been selected for what each designer perceives as the most desirable combination of properties. Below Table shows the nominal chemistries of the crankshaft alloys discussed here.

Medium-carbon steel alloys are composed of predominantly the element iron, and contain a small percentage of carbon (0.25% to 0.45%, described as '25 to 45 points' of carbon), along with combinations of several alloying elements, the mix of which has been carefully designed in order to produce specific qualities in the target alloy, including hardenability, nitridability, surface and core hardness, ultimate tensile strength, yield strength, endurance limit (fatigue strength), ductility, impact resistance, corrosion resistance, and temper-embrittlement resistance. The alloying elements typically used in these carbon steels are manganese, chromium, molybdenum, nickel, silicon, cobalt, vanadium, and sometimes aluminum and titanium. Each of those elements adds specific properties in a given material. The carbon content is the main determinant of the ultimate strength and hardness to which such an alloy can be heat treated.

Chemistry of crankshaft alloys & Nominal percentages of alloying elements								
Material	**AMS**	**C**	**Mn**	**Cr**	**Ni**	**Mo**	**Si**	**V**
4340	6414	0.40	0.75	0.82	1.85	0.25	-	-
EN-30B	-	0.30	0.55	1.20	4.15	0.30	0.22	-
4330-M	6427	0.30	0.85	0.90	1.80	0.45	0.30	0.07
32-CrMoV-13	6481	0.34	0.55	3.00	<0.3	0.90	0.25	0.28
300M	6419	0.43	0.75	0.82	1.85	0.40	1.70	0.07

Table-1: Chemistry of crankshaft alloys & Nominal percentages of alloying elements

Key: C= Carbon, M= Manganese, Cr= Chromium, Ni= Nickel, Mo= Molybdenum, Si= silicon, V= Vanadium, AMS= Aircraft Material Spec Number

In addition to alloying elements, high strength steels are carefully refined so as to remove as many of the undesirable impurities as possible (sulfur, phosphorous, calcium, etc.) and to more tightly constrain the tolerances, which define the allowable variations in the percentage of alloying elements. The highest quality steels are usually specified and ordered by reference to their AMS number (Aircraft Material Specification). These specs tightly constrain the chemistry, and the required purity can often only be achieved by melting in a vacuum, then re-melting in a vacuum to further refine the metal. Typical vacuum-processing methods are VIM and VAR.

There are other ultra-high-strength steels that are not carbon steels. These steels, known as "maraging" steels, are refined so as to remove as much of the carbon as possible, and develop their extreme strength and fatigue properties as a by-product of the crystalline structures resulting from the large amounts of nickel (15% and up) and cobalt (6% and up) they contain. These steels can achieve extreme levels of strength and maintain excellent levels of impact resistance. As far as I could determine, maraging alloys are not currently (2008) used for racing crankshafts but they have been used in certain extreme application conrods.

The material which is currently viewed as the ultra-extreme crankshaft alloy is a steel available from the French manufacturer Aubert & Duval, known as 32-CrMoV-13 or 32CDV13. It is a deep-nitriding alloy containing 300 points of chrome, developed in the mid-nineties specifically for aerospace bearing applications. It is available in three grades. GKH is the commercial purity and chemistry tolerance. GKH-W is the grade having higher purity (VAR) and tighter chemistry tolerance. GKH-YW is the extremely pure grade (VIM - VAR) and is said to cost twice as much per pound as the -W grade.

According to data supplied by Aubert & Duval, fatigue-tests of the -W and -YW grades, using samples of each grade heat treated to similar values of ultimate tensile strength, show consistently that the -YW grade achieves a dramatic improvement (over 22%) in fatigue strength compared to the -W grade, and the endurance limit is claimed to be just a bit short of the yield stress, which is truly amazing. I have been told that, because of the extreme stress levels on Formula One crankshafts, most of them use the -YW grade, while the lower stress levels of a Cup crank allow the successful use of the -W grade.

One well-known manufacturer (Chambon) has developed a process which allows the production of a deep case nitride layer in this alloy (almost 1.0 mm deep, as compared to the more typical 0.10 to 0.15 mm deep layer). They say this deeper case provides a far less sharp hardness gradient from the >60 HRc surface to the 40-45 HRc core, which improves the fatigue and impact properties of the steel. It says that its deep-case process requires several days in the nitriding ovens, but the depth allows finish-grinding after nitriding, using a very sophisticated process to remove the distortions which occurred during the nitriding soak.

No discussion of high-end crankshaft materials would be complete without mention of the ultra-high-strength alloy known as 300-M (AMS 6419). This alloy is a modification to the basic 4340 chemistry, in which a few more points of carbon are added (higher achievable hardness and strength), along with 170 points of silicon and 7 points of vanadium. The vanadium acts as a grain refiner, and the silicon enables the material to be tempered to very high strength (285 ksi) and fatigue properties, while retaining extremely good impact resistance and toughness.

This material (300-M) is expensive and sometimes hard to get, since it is preferred for heavy aircraft landing gear components. It has been used by a few manufacturers for extreme duty crankshafts and conrods as well as high-shock aircraft components. However, several of the manufacturers I spoke with told me that they consider their favorite materials to be much better than 300-M for crankshaft applications.

2. DESIGNING OF CRANKSHAFT USING CREO SOFTWARE

PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself. The name was changed in 2010 from Pro/ENGINEER Wildfire to CREO. It was announced by the company who developed it, Parametric Technology Company (PTC), during the launch of its suite of design products that includes applications such as assembly modeling, 2D orthographic views for technical drawing, finite element analysis and more.

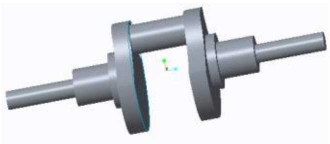

Fig -2: Crankshaft model (using creo software)

The time saved by using PTC CREO isn't the only advantage. It has many ways of saving costs. For instance, the cost of creating a new product can be lowered because the development process is shortened due to the automation of the generation of associative manufacturing and service deliverables. PTC also offers comprehensive training on how to use the software. This can save businesses by eliminating the need to hire new employees.

ADVANTAGES OF CREO PARAMETRIC SOFTWARE

- Optimized for model-based enterprises.
- Increased engineer productivity.
- Better enabled concept design.
- Increased engineering capabilities.
- Increased manufacturing capabilities.
- Better simulation.
- Design capabilities for additive manufacturing.

CREO PARAMETRIC MODULES:

- Sketcher.
- Part modeling.
- Assembly.
- Drafting.

3. ANALYSIS OF CRANKSHAFT USING ANSYS WORKBENCH SOFTWARE

The steps needed to perform an analysis depend on the study type. You complete a study by performing the following steps:

- ➢ Create a study defining its analysis type and options.
- ➢ If needed, define parameters of your study. A parameter can be a model dimension, material property, force value, or any other input.
- ➢ Define material properties.
- ➢ Specify restraints and loads.
- ➢ The program automatically creates a mixed mesh when different geometries (solid, shell, structural members etc.) exist in the model.
- ➢ Define component contact and contact sets.
- ➢ Mesh the model to divide the model into many small pieces called elements. Fatigue and optimization studies use the meshes in referenced studies.
- ➢ Run the study.
- ➢ View results.

3.1 MESHING AND APPLYING LOADS

The analysis of crank shaft models is carried out using ANSYS software, Firstly the model files prepare in the Creo Software. Then is exported to ANSYS software as an IGES files as shown in figure

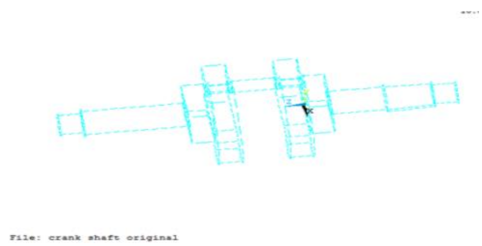

Fig 3.1: Imported part from creo

After Importing the model from creo software to ansys workbench the model is meshed

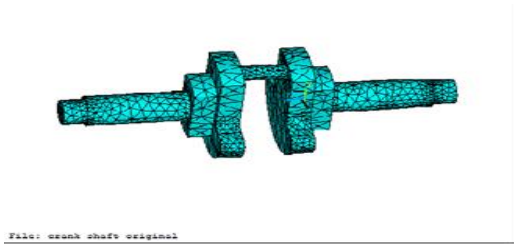

Fig-3.1.2: Meshed part of a crankshaft

➔ Then load is applied

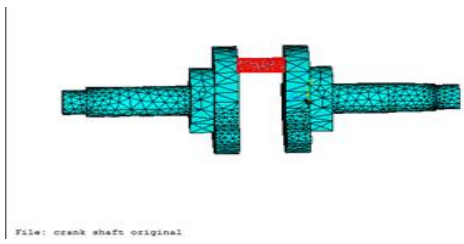

Fig-3.1.3: Loads applied

Pressure – 10.936N/mm2

➔ Solution: Solution – Solve – Current LS – ok

3.2 STRCTURAL ANALYSIS USING ALUMINIUM ALLOY7475

Post Processor: General Post Processor – Plot Results – Contour Plot - Nodal Solution – DOF Solution – Displacement Vector Sum

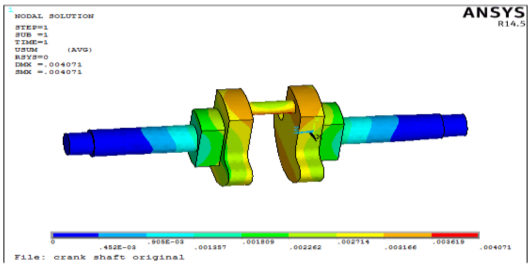

Fig-3.2.1: Displacement vector (alloy 7475)

General Post Processor – Plot Results – Contour Plot – Nodal Solution – Stress – Von Mises Stress

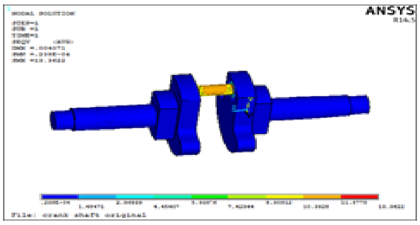

Fig-3.2.2: Stress (alloy 7475)

General Post Processor – Plot Results – Contour Plot – Nodal Solution – Strain – Von Mises strain

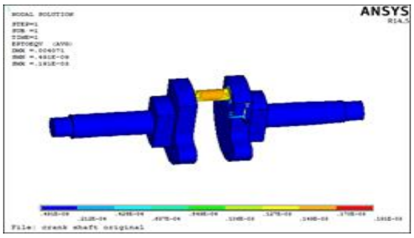

Fig-3.2.3: Strain (alloy 7475)

STRCTURAL ANALYSIS USING ALUMINIUM ALLOY6061

Firstly the model is meshed then load is applied at a Pressure - 10.936N/mm2.

Then ansys is carried out.

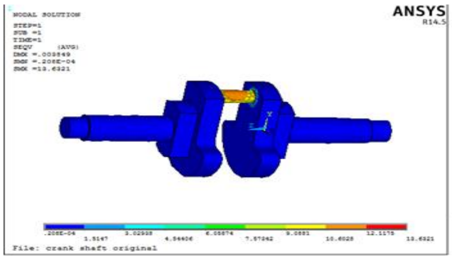

Fig-3.2.4 Stress (alloy 6061)

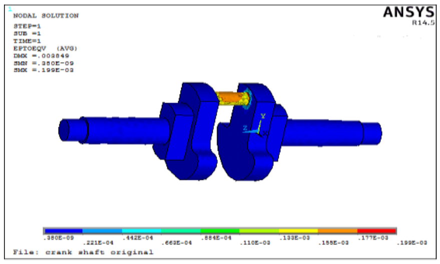

Fig-3.2.5 Strain (alloy 6061)

THERMAL ANALYSIS USING ALUMINUM ALLOY 7475:

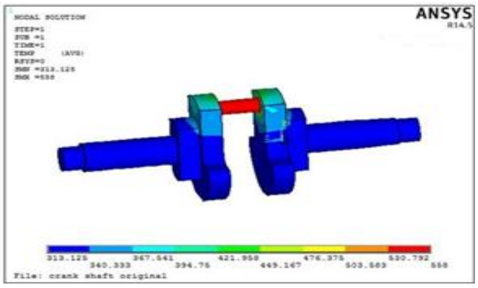

Fig-3.2.6: Nodal Temperature (7475)

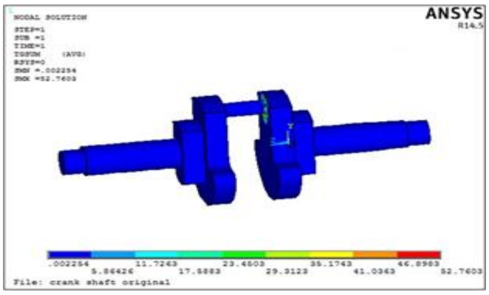

Fig-3.2.7: Thermal Gradient (7475)

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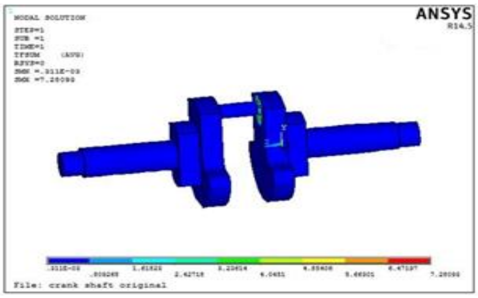

Fig-3.2.8: Thermal Flux (7475)

THERMAL ANALYSIS USING ALUMINUM ALLOY 6061:

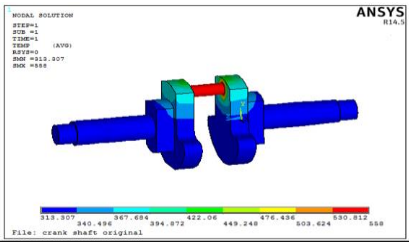

Fig-3.2.9: Nodal Temparature (6061)

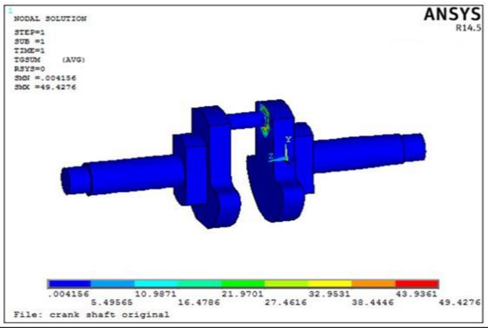

Fig-3.2.10: Thermal Gradient (6061)

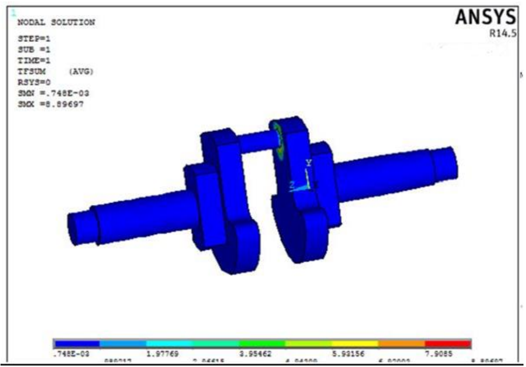

Fig-3.2.11: Thermal Flux (6061)

4. RESULT

As per the Static structural Analysis Images:

Material	Displacement	Von Mises Stress	Von Mises Strain
Aluminum alloy 7475	0.004071	13.3622	0.191e-03
Aluminum alloy 6061	0.004154	13.6322	0.199e-03

Fig-4.1.1: Static Structural analysis table

Thermal analysis results table

Material	Nodal temperature	Thermal gradient	Thermal flux
Aluminum alloy 7475	558	52.7603	7.20082
Aluminum alloy 6061	558	49.4276	8.5987

Fig-4.1.2: Thermal analysis table

5. CONCLUSIONS

- ➔ In our project we have designed a crankshaft for a multi cylinder engine using parametric software creo. Pressure produced in the engine is also calculated.
- ➔ Structural and thermal analysis is done on the crankshaft to validate our design. Analysis is done for two materials aluminum alloy 6061 and Aluminum alloy7475.
- ➔ By observing the stress values for both the materials, the analyzed stress values are less than their respective yield stress values. So our design is safe.
- ➔ By comparing the stress values for both materials, it is less for Aluminum alloy7475 than Aluminum alloy 6061.
- ➔ So for our designed crankshaft, using Aluminum alloy 7475 is best.

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BIOGRAPHIES

Name : Mohd Tabraizuddin
M.Tech(CAD/CAM) Scholar, Department of Mechanical Engineering , MRCE, MYSAMMAGUDA, HYDERABAD, TELANGANA, INDIA.