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Design and Stress Analysis of Crankshaft for Single Cylinder 4 Stroke Diesel Engine

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***Abstract*-In this paper a static simulation is conducted on a crankshaft from a single cylinder 4- stroke diesel engine. A three dimension model of diesel engine crankshaft is created using CATIA V5 software. Finite element analysis (FEA) is performed to obtain the variation of stress magnitude at critical locations of crankshaft in. The static analysis is done using FEA Software HYPERMESH which resulted in the load spectrum applied to crank pin bearing. This load is applied to the FEA model in HYPERMESH, and boundary conditions are applied according to the engine mounting conditions**

I. INTRODUCTION

conversion between reciprocating motion and rotational. In a reciprocating engine, it translates reciprocating motion of the piston into rotational motion; whereas in reciprocating, 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.
It is typically connected to a flywheel to reduce the pulsation characteristic of the four-stroke cycle, and sometimes a torsion or vibration damper at the opposite end, to reduce the tensional vibrations often caused along the length of the crankshaft by the cylinders farthest from the output end acting on the tensional elasticity of the metal.

Crankshafts find many applications in various branches of engineering. They are used whenever there is the need to translate reciprocating linear motion into rotation or vice-versa. In their more varied configurations, crankshafts are usually used in internal combustion engines but also in piston steam engines. It lays on the former the vaster and varied range of applications of crankshafts. The internal combustion engines cover various fields of uses, from small scale model planes to large maritime engines. So crankshafts produced by the various methods apply to: e.g. engines for road, rail and maritime transport, portable machinery, electrical generators, agricultural and industrial machinery. Crankshafts are also used in driven machinery such as air compressors and reciprocating pumps. The industrial potential for a new crankshaft manufacturing process is huge, as the existing and common methods, forging; casting and machining are very costly. The former two demand high volume production to be cost effective, as the investment in tools and machinery is huge.

Forging demands for several dies to achieve the final component and casting requires non-permanent, usually sand, molds. These two processes also need various finishing operations, such as grinding and balancing. As for the machining process, it is only viable for unitary or low production, as the material waste and machining time is enormous, despite not requiring much in the way of balancing. The prototype tool developed in this paper, allows to overcome the shortcomings associated with the conventional processes, as the pre-form used is a round bar, with the same diameter as the final diameter of the crankshaft journals, is easily manufactured which makes it cost effective and enables the production of crankshafts of varied geometry and size. This process is fast, non-material wasting and does without most of the finishing operations, being viable for mass production, when automated, to medium or small scale or even unitary production. In addition to the previously mentioned, the crankshafts produced by this method can be forged in unit with the components necessary to their operation, e.g. main and big end bearings, flywheel mounting flange and timing gear. All this is achieved in a single movement of the yoke where the tool is installed. Despite alloy steel being the prime material for crankshaft production, this paper concerned on the manufacture of an annealed aluminum crankshaft which allowed evaluating the conception and the process' mechanics of deformation based on the knowledge of buckling of solid rods under compression.
They say that the heart of the engine is the camshaft, since it is one of the key components that dictate the engine's power level, power band, idle quality, and other characteristics. If the cam is the heart, then the crankshaft is the spine. The crankshaft also dictates power and power band, but in a much more ambivalent way (through its stroke which, along with the bore size, dictates the engine's cubic-inch displacement). The crank is what transfers the up and down reciprocating
Movement of the piston and rod into the rotating motion required to drive the transmission. It arrives the weight of all eight rods and pistons, and must deal with the shock loads of the combustion process. A stock crank does this fine...in a stock engine. But when power levels start to climb, that stock crank will eventually give under the tremendous loads imposed upon it. Aftermarket crankshafts are hugely popular in the Mustang world, since they are required for stroke kits and are usually necessary when an engine goes from bolt-on status

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to real power. But not all aftermarket cranks are created equal. There are different materials, different manufacturing processes, and different ways to prep a crank. One of the most respected crankshaft manufacturers is Scat Enterprises, in Redondo Beach, California.

Scat has been in business for 35 years, and builds more than15, 000 crankshafts per year. Some of their customers include NHRA Top Fuel, Indy car, and Winston Cup teams, and they also build the cranks sold by Ford Racing Performance Parts in its 347, 393 and 514 stroke kits, among others. You would be shocked to learn how many aftermarket stroke kits use Scat cranks and rods. Scat makes everything from inexpensive cast cranks, to forgings, to the ultimate got-have-it custom billet-steel piece that will withstand more power than you can build in a small-block Ford. We wanted to see what went into building a custom crankshaft, so we spent a day at Scat's 42,000 square-foot facility to follow along as a billet crank is created, from the heavy chunk of steel to the finished beauty.

Fig 1.1: Crank Shaft of I.C Engines

1.1 FORGING AND CASTING

Crankshafts can be forged from a steel bar usually through roll forging or cast in ductile steel. Today more and more manufacturers tend to favor the use of forged crankshafts due to their lighter weight, more compact dimensions and better inherent damping. With forged crankshafts, vanadium micro alloyed steels are mostly used as these steels can be air cooled after reaching high strengths without additional heat treatment, with exception to the surface hardening of the bearing surfaces. The low alloy content also makes the material cheaper than high alloy steels. Carbon steels are also used, but these require additional heat treatment to reach the desired properties. Iron crankshafts are today mostly found in cheaper production engines (such as those found in the Ford Focus diesel engines) where the loads are lower. Some engines also use cast iron crankshafts for low output versions while the more expensive high output version use forged steel.

1.2 MACHINING

Crankshafts can also be machined out of a billet, often a bar of high quality vacuum remelted steel. Though the fiber flow (local in homogeneities of the material's chemical composition generated during casting) doesn't follow the shape of the crankshaft (which is undesirable), this is usually not a problem since higher quality steels, which normally are difficult to forge, can be used. These crankshafts tend to be very expensive due to the large amount of material that must be removed with lathes and milling machines, the high material cost, and the additional heat treatment required. However, since no expensive tooling is needed, this production method allows small production runs without high costs. In an effort to reduce costs, used crankshafts may also be machined. A good core may often be easily reconditioned by a crankshaft grinding process. Severely damaged crankshafts may also be repaired with a welding operation, prior to grinding, that utilizes a submerged arc welding machine. To accommodate the smaller journal diameters a ground crankshaft has, and possibly an over-sized thrust dimension, undersize engine bearings are used to allow for precise clearances during operation.

Fig 1.2: Machining Process of Crank Shaft

1.3 STRESSES ON CRANK SHAFT

The shaft is subjected to various forces but generally needs to be analyzed in two positions. Firstly, failure may occur at the position of maximum bending; this may be at the center of the crank or at either end. In such a condition the failure is due to bending and the pressure in the cylinder is maximal. Second, the crank may fail due to twisting, so the condor needs to be checked for shear at the position of maximal twisting. The pressure at this position is the maximal pressure, but only a fraction of maximal

II.INTRODUCTION TO CAD/CAM

2.1 SOLID MODELING USING CAD SOFTWARE

CAD software, also referred to as Computer Aided Design software and in the past as computer aided drafting software, refers to software programs that assist engineers and designers in a wide variety of industries to design and manufacture physical products.

It started with the mathematician Euclid of Alexandria, who, in his 350 B.C. treatise on mathematics "*The Elements*" expounded many of the postulates and axioms that are the foundations of the Euclidian geometry upon which today's CAD software systems are built.

More than 2,300 years after Euclid, the first true CAD software, a very innovative system (although of course primitive compared to today's CAD software) called "Sketchpad‖ was developed by Ivan Sutherland as part of his PhD thesis at MIT in the early 1960s.

First-generation CAD software systems were typically 2D drafting applications developed by a manufacturer's internal IT group (often collaborating with university researchers) and primarily intended to automate repetitive drafting chores. Dr. Hanratty co-designed one such CAD system, named DAC (Design Automated by Computer) at General Motors Research Laboratories in the mid-1960s.

2.2 INTRODUCTION TO CAD/CAM/CAE

The Modern world of design, development, manufacturing so on, in which we have stepped can't be imagined without interference of computer. The usage of computer is such that, they have become an integral part of these fields. In the world market now the competition in not only cost factor but also quality, consistency, availability, packing, stocking, delivery etc. So are the requirements forcing industries to adopt modern technique rather than local forcing the industries to adapt better techniques like CAD / CAM / CAE, etc.

The Possible basic way to industries is to have high quality products at low costs is by using the computer Aided Engineering (CAE), Computer Aided Design (CAD) And Computer Aided Manufacturing (CAM) set up. Further many tools is been introduced to simplify & serve the requirement NX, PRO-E, UG, CATIA are some among many.

This penetration of technique concern has helped the manufacturers to

Increase productivity
Shortening the lead-time
Minimizing the prototyping expenses
Improving Quality
Designing better products

CAD: Computer Aided Designing (Technology to create, Modify, Analyze or Optimize the design using computer.
CAE: Computer Aided Engineering (Technology to analyze, Simulate or Study behavior of the cad model generated using computer.
CAM: Computer Aided Manufacturing (Technology to Plan, manage or control the operation in manufacturing using computer.

2.3 NEED FOR CAD, CAE & CAM

The usage of CAD CAE & CAM have changed the overlook of the industries and developed healthy & standard competition as could achieve target in lean time and ultimately the product reaches market in estimated time with better quality and consistency. In general view, it has led to fast approach and creative thinking.

2.4 INTRODUCTION TO CATIA

CATIA (Computer Aided Three-dimensional Interactive Applications) is multi-platform CAD/CAM/CAE commercial software developed by the French company dassault system directed by Bemard Charles .written in the C++ programming language, CATIA is the cornerstone of the dassault systems software suite.

2.5 RELEASE HISTORY

Table 1- Release History of CATIA

Name/Version	Version History Value	Release Date
Catia v5	R17	1998
Catia v6	R18	2008
Catia v6	R19	2011
Catia v6	R20	2013
Catia v6	R21	2014

2.6 SCOPE OF APPLICATION

Commonly referred to as a 3D Product Lifecycle Management software suite, CATIA supports multiple stages of product development (CAx), including conceptualization, design (CAD), engineering (CAE) and manufacturing (CAM). CATIA facilitates collaborative engineering across disciplines around its 3d experience platform, including surfacing & shape design, electrical fluid & electronics systems design, mechanical engineering and systems engineering.

CATIA facilitates the design of electronic, electrical, and distributed systems such as fluid and HVAC systems, all the way to the production of documentation for manufacturing.

2.6.1 Mechanical engineering

CATIA enables the creation of 3D parts, from 3D sketches, sheet metal, composites, and molded, forged or tooling parts up to the definition of mechanical assemblies. The software provides advanced technologies for mechanical surfacing & BIW. It provides tools to complete product definition, including functional tolerances as well as kinematics definition. CATIA provides a wide range of applications for tooling design, for both generic tooling and mold & die.

2.6.2 Design

CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether started from scratch or from 2D sketches. CATIA is able to read and produce STEP format files for reverse engineering and surface reuse.

2.6.3 Systems engineering

The CATIA Systems Engineering solution delivers a unique open and extensible systems engineering development platform that fully integrates the cross-discipline modeling, simulation, verification and business

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process support needed for developing complex 'cyber-physical' products. It enables organizations to evaluate requests for changes or develop new products or system variants utilizing a unified performance based systems engineering approach. The solution addresses the Model Based Systems Engineering (MBSE) needs of users developing today's smart products and systems and comprises the following elements: Requirements Engineering, Systems Architecture Modeling, Systems Behavior Modeling & Simulation, Configuration Management & Lifecycle Traceability, Automotive Embedded Systems Development (AUTOSAR Builder) and Industrial Automation Systems Development (Control Build).

CATIA uses the open Modelica language in both CATIA Dynamic Behavior Modeling and Dymola, to quickly and easily model and simulate the behavior of complex systems that span multiple engineering disciplines. CATIA & Dymola are further extended by through the availability of a number of industry and domain specific Modelica libraries that enable user to model and simulate a wide range of complex systems – ranging from automotive vehicle dynamics through to aircraft flight dynamics.

2.6.4 Electrical systems

CATIA offers a solution to facilitate the design and manufacturing of electrical systems spanning the complete process from conceptual design through to manufacturing. Capabilities include requirements capture, electrical schematic definition, interactive 3D routing of both wire harnesses and industrial cable solutions through to the production of detailed manufacturing documents including form boards.

2.6.5 Fluid systems

CATIA offers a solution to facilitate the design and manufacturing of routed systems including tubing, piping, Heating, Ventilating & Air Conditioning (HVAC). Capabilities include requirements capture, 2D diagrams for defining hydraulic, pneumatic and HVAC systems, as well as Piping and Instrumentation Diagram (P&ID). Powerful capabilities are provided that enables these 2D diagrams to be used to drive the interactive 3D routing and placing of system components, in the context of the digital mockup of the complete product or process plant, through to the delivery of manufacturing information including reports and piping isometric drawings.

2.7 WORKING PRINCIPLE BEHIND RAPID PROTO TYPING

2.7.1 CREATION OF CAD MODEL

First, the object to be built is modeled using Computer-Aided Design (CAD) software. Solid modelers, such as Pro-E, NX and Autodesk Inventor tend to represent 3-D objects more accurately than wire-frame modelers such as AutoCAD, and will therefore yield better results. A pre-existing CAD file or a newly created CAD file for prototyping purpose can also be used. This process is identical for all of the RP build techniques.

In this present project our component is modeled in CATIA as shown in below figures.

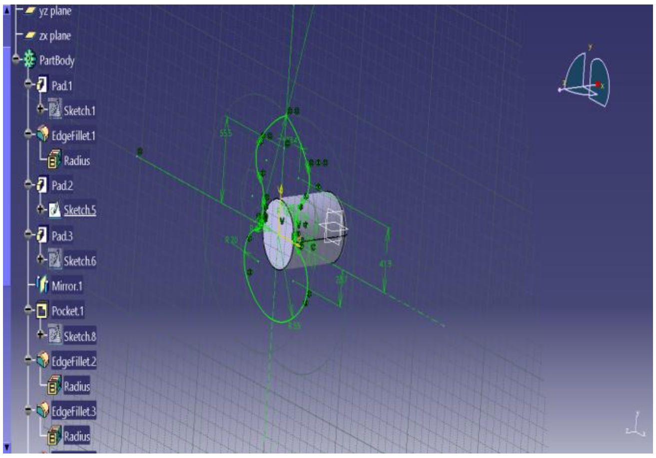

Fig 2.1: Geometrical Dimensions of Crankshaft

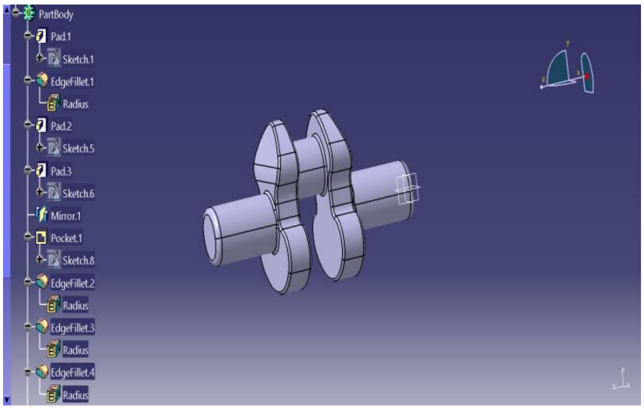

Fig 2.3: Cad Model Crankshaft

III. FINITE ELEMENT ANALYSIS

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures".

By the early 70's, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters.

In recent years, FEA has been used almost universally to solve structural engineering problems. One discipline that has relied heavily on this technology is the Automotive and Aerospace industry. Due to the need to

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meet the extreme demands for faster, strfc onger, efficient and light weight Automobiles and Aircrafts, manufactures have to rely on the Technique to stay components and the high media coverage that the Industry is exposed to, Automotive and Aircraft companies need to ensure that none of their components fail, that is to cease providing the Service that the design intended.

The finite element method is a very important tool for those involved in engineering design; it is now used routinely to solve problems in the following areas:
Structural Strength design
Structural interaction with fluid flows
Analysis of shock (underwater & in materials)
Acoustics Thermal analysis

IV.RESULT AND CONCLUSIONS

4.1 STATIC ANALYSIS
4.1.1 MATERIAL PROPERTIES TABLE

Material	Young's modulus(MPa)	Density(ton/mm^3)	Poisson's ratio
Cast Steel	$1.2e^5$	$7.9e^{-9}$	0.28

Table 4.1: Material Properties Table

4.1.2 MESH MODEL OF CRANK SHAFT

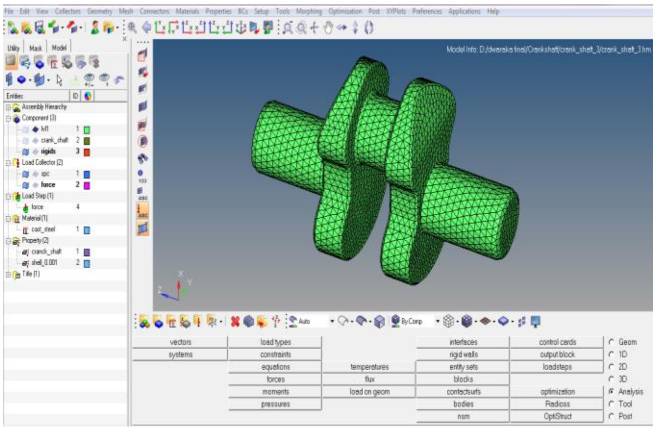

Fig4.1: Meshed Model of Crankshaft

4.1.3 LOADS AND BOUNDARY CONDITION OF CRANKSHAFT

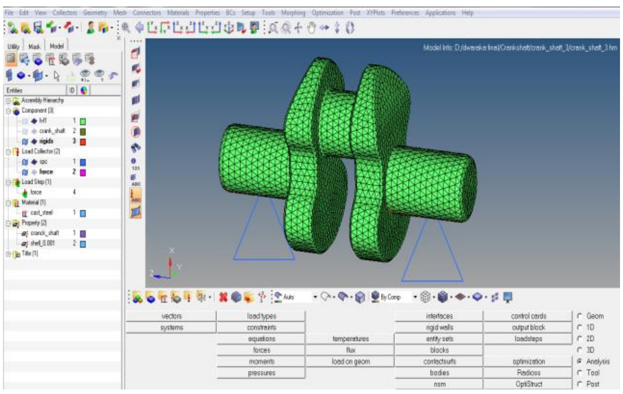

Fig 4.2: Boundary condition of Crankshaft

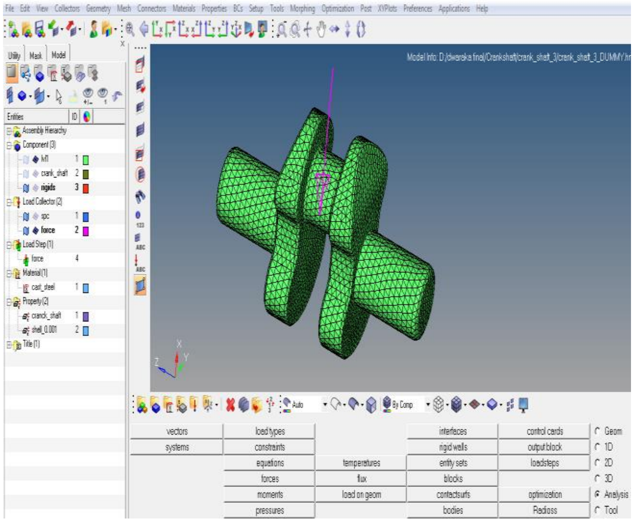

Fig 4.3: Applying Tangential Force on Crankshaft

4.1.4 DISPLACEMENT DIGRAM OF CRANKSHAFT

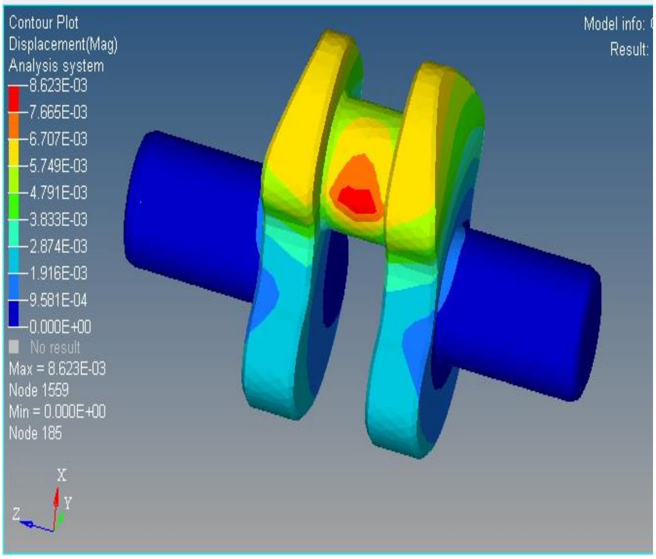

Fig4.4: Displacement of Crankshaft Is 0.0086mm

4.1.5 STRESS DIGRAM OF CRANKSHAFT

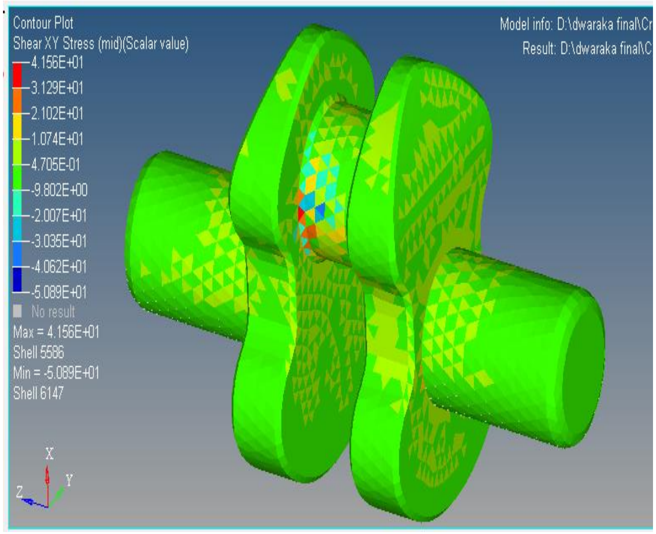

Fig4.5: Shear Stress On Xy Plane Is 41.59 N/mm^2

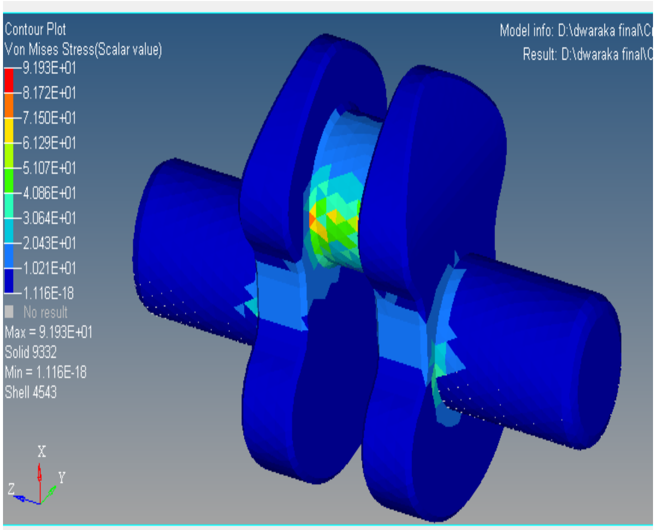

Fig 4.6: Von-Mises Stress Analysis Is 91.93 N/mm^2

CONCLUSIONS

In this paper, the crankshaft model was created by CATIAV5 software. Then, the model created by CATIAV5 was imported to HYPERMESH software.

RESULT TABLE:

S.NO	TYPES OF STRESS	THEORETICAL	FEA ANALYSIS
1	Von-Misses Stresses N/mm^2	121.15	91.93
2	Shear Stresses N/mm^2	57	41.59

Table 5.1: Result table of crank shaft

Above Results Shows that FEA Results Conformal matches with the theoretical calculation so we can say that FEA is a good tool to reduce time consuming theoretical Work. The maximum deformation appears at the center of crankpin neck surface. The maximum stress appears at the fillets between the crankshaft journal and crank cheeks and near the central point Journal. The edge of main journal is high stress area.

The Value of Von-Misses Stresses that comes out from the analysis is far less than material yield stress. So our design is safe and we should go for optimization to reduce the material and cost.

VI. REFERENCES

[1]. Jaimin Brahmbhatt Design And Analysis Of Crankshaft For Single Cylinder 4-Stroke Diesel Engine, International Journal of Advanced Engineering Research and Studies- E-ISSN2249–8974
[2]. Yu Ding and Xiaobo Li.,2011, “ Crankshaft Strength Analysis of a Diesel Engine Using Finite Element Method,” Asia-Pacific Power and Energy Engineering Conference
[3]. Jian Meng., Yongqi Liu., Ruixiang Liu.,2011,“Finite Element Analysis of 4Cylinder Diesel Crankshaft, ” I.J. Image, Graphics and Signal Processing, 5, 22-29
[4]. Yu Gongzh.i, Yu Hongliang., DuanShulin., 2011, “Crankshaft Dynamic Strength Analysis for Marine Diesel Engine,” Third International Conference on Measuring Technology and Mechatronics Automation.
[5]. GuYingkui, Zhou Zhibo.,2011,“Strength Analysis of Diesel Engine Crankshaft Based on PRO/E and ANSYS,” Third International Conference on Measuring Technology and Mechatronics Automation
[6]. Shenoy, P. S. and Fatemi, A., 2006, “Dynamic analysis of loads and stresses in connecting rods, ”IMechE, Journal of Mechanical Engineering Science, Vol. 220, No. 5, pp. 615624