FAILURE INVESTIGATION OF 4 STROKE ENGINE HEAT TRANSFER ANALYSES IN CRANK SHAFT SURFACE

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ABSTRACT

The Computer aided modeling and analysis of connecting rod is to study was to evaluate and compare the thermal friction performance of two competing manufacturing technologies for automotive connecting rod, namely EN8 and Automotive alumina. In this study a static simulation analysis and thermal analysis was conducted on two crank, EN8 and automotive alumina, since similar single cylinder four stroke engines. Finite element analyses were performed to obtain the deviation of stress magnitude at critical settings. The Static analysis with thermal transient was done analytically and was verified by simulations in ANSYS. Results achieved from after mentioned analysis was used in optimization of the forged steel connecting crank. Geometry, material and manufacturing processes were optimized allowing for different constraints, manufacturing practicability and cost. The optimization Process included geometry changes compatible with the current engine and consequences in in- creased fatigue strength and abridged cost of the connecting rod, without changing crank shaft and engine block

The Thermal stress analysis with static structural analysis of a 4-cylinder crankshaft is discussed using finite element method in this paper. Reports an investigation that was carrying out on two damaged crankshafts. They were four stock petrol engine crankshafts that were sent to be ground, after a life of about 300,000 km each. Some journals were damaged on every crankshaft. After grinding, and assembling on the connecting pin, the crankshafts lasted about 1000 km each, and the journals were spoiled again. The crankshafts were then sent to be investigating. Different laboratory tests were carrying out in order to discover what could have been the cause of the damage. Different typical crankshaft failures were assessed, and will be discussing in this paper.

The cause of the damaged journals was found to be a erroneous grinding process that created minor thermal fatigue cracks at the centre of the journals, on both crankshafts. These virtually invisible cracks, with shrill edges, acted as knives originating a very quick damaging of the journal bearings, and as significance spoiled find it.

After the process The Computer aided modeling and analysis of connecting crank is to study was to evaluate and compare the thermal friction performance of two competing manufacturing technologies for automotive connecting crank, namely EN8 and Automotive alumina. In this study a static simulation analysis and thermal analysis was conducted on two crank, EN8 and automotive alumina, from similar single cylinder four stroke engines.

Finite element analyses remained performs to attain the variation of stress magnitude at critical locations. The Static analysis with thermal transient was done analytically and was verified by simulations in ANSYS. Results achieved from after mentioned analysis was used in optimization of the forged steel connecting crank. Geometry, material and manufacturing progressions were optimized allowing for different restrictions, manufacturing possibility and cost. The optimization Process involved geometry changes compatible with the current engine, surface thermal with results in-creased fatigue strength and reduced cost of the connecting rod, without changing crank shaft and engine block.

Keyword: *Four stroke, Crank shaft, Composite, Thermal analysis, FEA, Ansys*

1. INTRODUCTION

The objective of this study is to compare the durability of crankshafts from two competing materials, as well as to perform static load and stress analysis. The crankshaft materials used in this study are EN8 and automotive alumina from a four stroke petrol engine. Material composition tests showed that the EN8 material that we used in the crankshaft. Static load analysis was performed to determine the service loading of the crankshafts and FEA was conducted to find stresses at critical locations. Finally, material, and testing processes were optimized for the automotive alumina crankshaft. The stresses on the crankshaft depend on the heat treatment temperatures employed, the depth of hardening and the type of quenching. Process conditions that give rise to compressive residual stresses on the surface of heat treated components are favorable.

The finite element analysis is performed by using computer aided engineering software ANSYS. The main objectives of this project are to investigate and analyze the deformation, stress, strain distribution. The dissertation describes the mesh optimization with using finite element analysis technique to predict the higher stress and Critical region on the component. The failure cause was analyzed by chemical and metallographic examination, evaluation of mechanical properties, determination of depth of the quenched layer, measurement of distance between the quenched layer and the web, observation on the fracture surface as well as value determination of the fillet radius. The originated from the subsurface shrinkage in the unquenched layer of the crankshaft journal .Several aspects of the crankshaft were not up to the technical standards, such as distance between the quenched layer and the web, chemical composition, hardness and microstructure of the quenched layer, yield strength, and impact toughness.

This paper presents the result of a literature survey focused on fatigue performance evaluation and comparisons of EN8 and automotive alumina crankshafts. Crankshaft specifications, operating conditions, and various failure sources are first reviewed. Then design aspects and manufacturing procedures for crankshafts are discussed. This includes a review of the effects of influential parameters such as stresses on fatigue behavior. The common crankshaft material and manufacturing process technologies currently in use are then compared with regards to their durability performance. This is followed by a discussion of results showed that the failure mechanism of the crank-shaft was fatigue fracture resulting from co- effect of bending and twisting, and the crack durability assessment procedures used for crankshafts, as well as bench testing and experimental techniques. Geometric optimization of crankshafts is also briefly discussed and cost analysis and potential cost saving potentials from several studies in the literature are present. The main objective of this study is to investigate weight and cost reduction opportunities for crankshaft. The need of load history in the FEM analysis necessitates performing a detailed dynamic load analysis. Therefore, this study consists of three major sections: static load analysis, FEM and stress analysis. In this study a static simulation was conducted on two crankshafts, EN8 and automotive alumina, from similar single cylinder four stroke engines. Finite element analysis was performed to obtain the variation of stress magnitude at critical locations. The static analysis was done analytically.

1.1 Functions of Crankshafts in IC Engines

The crankshaft, crankshaft and piston constitute a four bar slider-crank mechanism, which converts the sliding motion of the piston (slider in the mechanism) to a rotary motion. Since the rotation output is more practical and applicable for input to other devices, the concept design of an engine is that the output would be in rotations. In addition, the linear displacement of an engine is not smooth, as the displacement is caused by the combustion of gas in the combustion chamber. Therefore, the displacement has sudden shocks and using this input for another device may cause damage to it. The concept of using crankshaft is to change these sudden displacements to a smooth rotary output, which is the input to many devices such as generators, pumps, and compressors. It should also be mentioned that the use of a flywheel helps in smoothing the shocks.

1.2 Service Loads and Failures Experienced by Crankshafts

Crankshaft experiences large forces from gas combustion. This force is applied to the top of the piston and since the crankshaft connects the piston to the crankshaft, the force will be transmitted to the crankshaft. The magnitude of the force depends on many factors which consist of crank radius, crankshaft dimensions, and weight of the crankshaft, piston, piston rings, and pin. Combustion and inertia forces acting on the crankshaft cause two types of loading on the crankshaft structure; torsional load and bending load.

There are many sources of failure in the engine. They could be categorized as operating sources, mechanical sources, and repairing sources. One of the most common crankshaft failures is fatigue at the fillet areas due to bending load caused by the combustion. Even with a soft case as journal bearing contact surface, in a crankshaft free of internal flaws one would still expect a bending or torsional fatigue crack to initiate at the pin surface, radius, or at the surface of an oil hole.

Due to the crankshaft geometry and engine mechanism, the crankshaft fillet experiences a large stress range during its service life. Figure 1.1 shows a crankshaft in the engine block from side view. In this figure it can be seen that at the moment o f 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 crack initiation, leading to fracture.

2. DESIGN OF CONCEPTUAL DESIGN

Crankshaft - shaft with a crank is a central component of any internal combustion engine and is used to convert reciprocating motion of the piston into rotator motion or vice versa. Crankshaft come in many shapes and sizes from small ones found in four- stroke small engines to giant ones found in petrol engines in ships. Crankshaft in automotive engines also varies each one unique to its engine type and make. The crankshaft main journal rotate in asset of supporting bearing (Main bearing), causing the offset rod journals to rotate in a circular path around the main journal centers, the diameter of which is twice the offset of the rod journals. The diameter of that path is the engine 'stroke': the distance the piston moves up and down in its cylinder. The big ends of the connecting rods contain bearing (Rod bearing) which ride on the offset rod journals. The crankshaft consists of the shaft parts which revolve in the main bearing, the crankpins to which the big ends of the connecting rod are connected, the crank arms or webs (also called cheeks) which connect the crankpins and the shaft parts. In the world of component design, there are competing criteria, which require the engineers to achieve a perceived optimal compromise to satisfy the requirement of their particular efforts. Discussion with various recognized experts in the crankshaft field make it abundantly clear that there is no right answer, and opinions about the priorities of design criteria vary considerably.

In contemporary racing crankshaft design, the requirement for bending and torsional stiffness competes with the need for low mass moment of inertia. Several crankshaft experts emphasized the fact that exotic metallurgy is no substitute for proper design, and there little point in switching exotics if there is no fatigue problem to be solved.

Fig -1 LH side crank assembly -Real time model

High stiffness is a benefit because it increases the torsional resonant frequency of the crankshaft, and because it reduces bending deflection of the bearing journals. Journal deflection can cause increased friction by disturbing the hydrodynamic film at critical points, and can cause loss of lubrication because of increased leakage through the greater radial clearances that occur when a journal's axis is not parallel to the bearing axis. The Crankshaft, sometimes abbreviated to crank, is the part of an engine that translates reciprocating linear piston motion into rotation. To convert the reciprocating motion into rotation, 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 typically connects to a flywheel to reduce the pulsation characteristic of the four-stroke cycle, and sometimes a torsional or vibrational damper at the opposite end, to reduce the torsional vibrations often caused along the length of the crankshaft by the cylinders farthest from the output end acting on the torsional elasticity of the metal. right, up (toward the car's ceiling), or down (toward the car's floor) measured relative to the car, but not the direction relative to the Earth, since he did not know what direction the car was facing relative to the Earth when he felt the accelerations. However, by tracking both the current angular velocity of the system and the current linear acceleration of the system measured relative to the moving system, it is possible to determine the linear acceleration of the system in the inertial reference frame.

2.1 Generative the Modeling

Solid Modeling is a powerful tool among the advanced design techniques. It is more than just a way to make 3-D computer pictures of part assemblies. Even if making visual images of design concepts was the only use for solid modeling it will be useful tool, but the advantages go well beyond that. The real advantage of the solid model is the starting point and shared information source containing the geometric definition of the parts and assemblies in a design project.

Once the basic size and shape of product is decided, it's three dimensional model can be generated in a computer system supporting the solid modeling feature. Just by visualizing the 3-D solid model in its realistic form,, with the aid of dynamic viewing capability, the designer will be able to suggest some feasible changes in size and shape of the product. He can make these easily in the model and can immediately decide whether those changes are to be retained or not. For each design he can conduct interferences studies mass property evaluation, structural analysis, thermal analysis etc.

A solid model contains enough information to fully describe the boundaries, surfaces, and the topology of inside and outside of the object. If we cut a solid object the result is another solid object, no and ambiguous collection of partial lines or surfaces. The many CAD/ CAM system that are primarily designed fir drafting typically use a wire frame or a surface representation of the geometry. Although the part geometry may be entered using the same terminology as solid modeler, the resulting object is created only contains with frame or surface information.

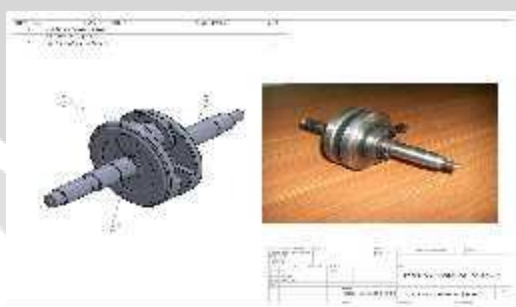

Fig -2 Design of crank Shaft assembly

2.2 Comparing EN8 to automotive alumina

EN8 is usually supplied untreated but can be supplied to order in the normalized or finally heat treated (quenched and tempered to "Q" or "R" properties for limiting ruling sections up to 63mm), which is adequate for a wide range of applications. Please refer to our selection guide for comparisons.

Aluminium (or aluminum) is a chemical element in the boron group with symbol Al and atomic number 13. It is silvery white, and it is not soluble in water under normal circumstances. Aluminium is the third most abundant element (after oxygen and silicon), and the most abundant metal, in the Earth's crust. It makes up about 8% by weight of the Earth's solid surface.

Aluminium metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals. The chief ore of aluminium is bauxite. Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Structural components made from aluminium and its alloys are vital to the aerospace industry and are important in other areas of transportation and structural materials. The most useful compounds of aluminium, at least on a weight basis, are the oxides and sulfates.

Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non- heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions Cast aluminium alloys yield cost effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al-Si, where the high levels of silicon (4.0% to 13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

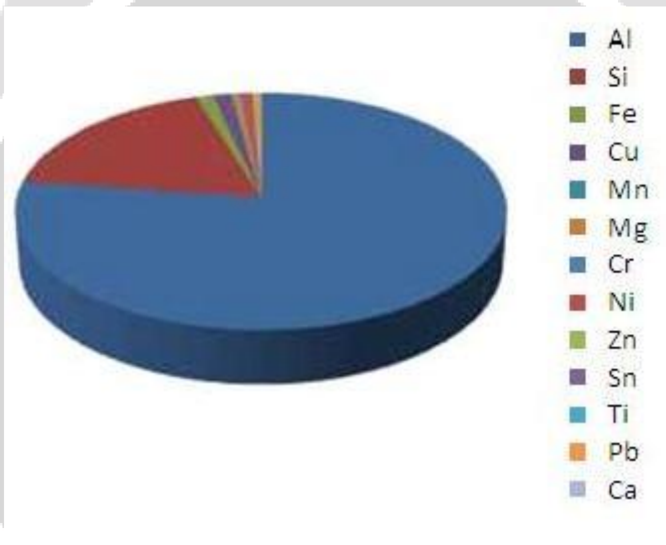

Fig -3 Automotive Alumina Composition

3. THERMAL TRANSIENT ANALYSIS

A thermal transient analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. A thermal transient load can be performed using the ANSYS. The types of loading that can be applied in a static analysis include:

- Externally applied forces and pressures
- Steady-state inertial forces (such as gravity or rotational velocity)
- Imposed (nonzero) displacements
- Temperatures (for thermal strain)

A thermal transient analysis can be either linear or nonlinear. All types of nonlinearities are allowed - large deformations, plasticity, stress stiffening, contact (gap) elements, and hyper elasticity and so on.

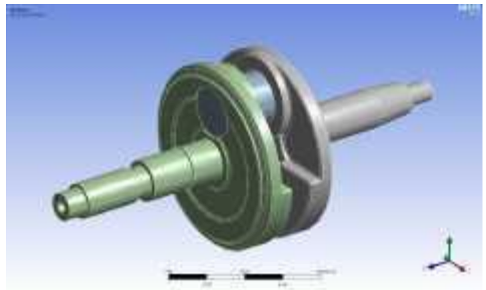

Fig -4 Imported geometry file in ANSYS

3.1 Applying thermal Loads and Supports

For a thermal transient analysis applicable loads/supports are all inertial and structural loads, and all structural supports. Loads and supports vary as a function of time even in a static analysis as explained in the Role of Time in Tracking. In a static analysis, the load's magnitude could be a constant value or could vary with time as defined in a table or via a function.

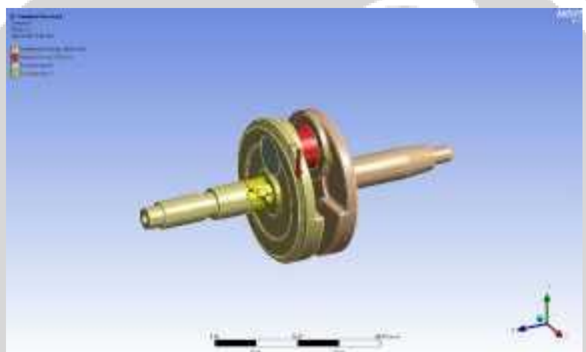

Fig -5 Applying thermal Loads and Supports

Details of how to apply a tabular or function load are described in Applying Tabular and Function Loads. In addition, see the Apply Loads and Supports section for more information about time stepping and ramped loads. When performing a nonlinear analysis you may encounter convergence difficulties due to a number of reasons. Some examples may be initially open contact surfaces causing rigid body motion, large load increments causing non-convergence, material instabilities, or large deformations causing mesh distortion that result in element shape errors. To identify possible problem areas some tools are available under Solution Information object Details view. Solution Output continuously updates any listing output from the solver and provides valuable information on the behavior of the structure during the analysis. Any convergence data output in this printout can be graphically displayed as explained in the Solution Information section. Result Tracker is another useful tool that allows you to monitor displacement and energy results as the solution progresses. This is especially useful in case of structures that possibly go through convergence difficulties due to buckling instability.

3.2 Total Deformation Occurred

In engineering, deflection is the degree to which a structural element is displaced under a load. It may refer to an angle or a distance. The deflection distance of a member under a load is directly related to the slope of the deflected shape of the member under that load and can be calculated by integrating the function that mathematically describes the slope of the member under that load

Table -1 Deformation results numerically

Material	Maximum Deflection in (mm)	Minimum Stress
EN 8	1.0	0.99

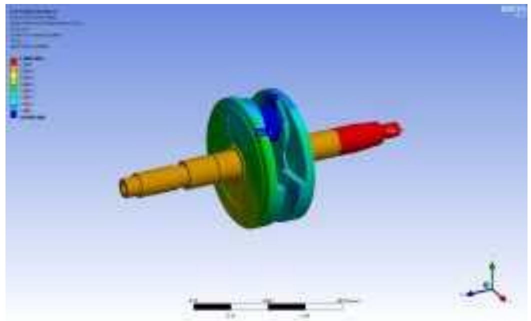

Fig -6 Total structural transient Deformation in EN8

3.3 Total heat flux

This type of technique to handling to finding the total heat flux of the total component of the part .this heat flux is consider as It's the rate of heat transfer per unit area. If you want to calculate the heat transfer rate and you know the heat flux, integrate the heat flux over the area.

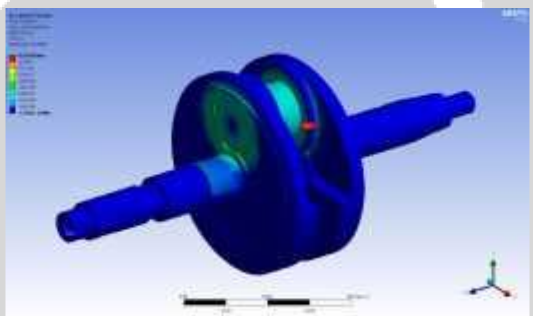

Fig -7 Total heat flux

Table -2 Total Heat Flux [W/mm^2]

Material	Max heat flux	Min heat flux
EN8	0.16	0

4. CONCLUSIONS

Analysis results from testing crankshaft under transient thermal load containing stresses and deflection are tabulated above. Since we found that automotive alumina material is may be occur less deformation, Stresses and strains than EN8 and also having better structural and thermal behaviors. So it is better to change the formal crankshaft material EN8 into automotive alumina for better durability.

5. REFERENCES

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