

Evaluation of Fatigue Failure of Crankshaft Work on its Bearing and Crank Pin Analytically and Numerically - A Review

Suryakant Rathod¹, Qaimi Mudassar²

¹P.G. Student, Department of Mechanical Engineering, Dr.D.Y.Patil Institute Of Engineering & Technology, Ambi Pune, Maharashtra, India

²Assistant Professor, Department of Mechanical Engineering, Dr.D.Y.Patil Institute Of Engineering & Technology, Ambi, Pune, Maharashtra, India

Abstract: *The objective of this paper is to update its readers the failure of crank shaft due to the dynamic load and rotating system exerts repeated bending and shear stress due to torsion, which are common stresses acting on crankshaft and mostly responsible for crankshaft failure. Hence, fatigue strength and life assessment plays an important role in crankshaft development and its parts considering its safety and reliable operation. The single cylinder petrol engines are extensively used by BAJAJ AUTO LTD in their two wheeler like Pulsar 220, Discover all model. The bearing failure of the crank shaft is the major problem of above said vehicle which results replacing crankshaft and piston assembly which results in increase of overall cost. In this present study crankshaft failure will study analytically and numerically. The study detail overview of failure analysis process including theoretical method and result integration for predicting life of component as compared to life estimation by means of suitable software. The analysis is doing for different engine speeds and as a result critical engine speed and critical failure region on the crankshaft will obtain. An analysis of these changes makes it possible to determine the life and strength of the crankshaft.*

Keywords: Crankshaft, Bearing, Crankpin, Fatigue fracture, Failure analysis

1. Introduction

Crankshaft is one of the critical components of an IC engine, failure of which may result in disaster and makes engine useless costly repair performed. It possesses intricate geometry and while operation experiences complex loading pattern. In IC engines, the transient load of cylinder gas pressure is transmitted to crankshaft through connecting rod, which is dynamic in nature with respect to magnitude and direction. However, the piston along with connecting rod and crankshaft illustrate respective reciprocating and rotating system of components. The dynamic load and rotating system exerts repeated bending and shear stress due to torsion, which are common stresses acting on crankshaft and mostly responsible for crankshaft fatigue failure. Hence, fatigue strength and life assessment plays an important role in crankshaft development and its parts considering its safety and reliable operation. The single cylinder petrol engines are extensively used by BAJAJ AUTO LTD in their two wheeler like Pulsar 220, discover all models. The bearing failure of the crankshaft is the major problem of above said vehicles which results replacing crankshaft and piston assembly. In this presents study crankshaft fatigue failure will study analytically and numerically. In this presents study detail overview of failure analysis process including theoretical methods and result integration for predicting life of components as compared to life estimation by means any suitable software. The analysis is doing for different engine speeds and as a result critical engine speed and critical failure region on the crankshaft will obtain. In this paper efforts have been made to present various cost effective reliable analytical, numerical and experimental techniques developed by various researchers for fatigue failure analysis of crankshaft. In this paper the effect of various parameters like fatigue failure, life cycle of crankshaft, bearing subjected to vibration for different loading condition have been reviewed.

2. Literature Review

H. Bayrakceken [1] have Presented to some characterization studies and fact graphic analysis are carried out to assess the failure reason. However, the cranks have some miner design differences, both failure are occurred after a fatigue process. One of the failed cranks has important heat treatment error. Failure analyses of crankshafts of two single cylinder diesel engines are carried out. Both shafts are made from the same material however one of them has undergo a surface hardening heat treatment and the other is used under the annealed conditions. The failure has began at the sharp fillet region and the lubrication holes influenced the crack growing direction.

M. Fonte, Bin Li[2] have presented a case study of a crankshaft catastrophic failure of a motor vehicle and its failure analysis is presented. The crankshaft suffered a mechanical seizure on the crankpin no. 2 after 3 years in service. It was repaired and after 30,000 km the vehicle had a damage again, with a catastrophic failure on the same crankpin. A transversal macrograph of the crankpin revealed that the crankpin was rectified and filled with a metal alloy for the same nominal diameter. Two fatigue cracks growing to the centre of the crankpin where the final fracture occurred. The symmetric semi-elliptical crack front profile confirms the effect of a pure mode under alternating bending. The catastrophic failure was a consequence of the inadequate repairing by a non-authorized manufacturer. The morphology of the fracture surface of the crankpin clearly indicates that fatigue was the root cause for the catastrophic failure. The crack initiation zone on the crankpin web-fillet was on the interface of the base metal and added metal alloy layer, aggravated also by the HTZ of the welding. The absence of heat treatment on the added metal alloy surface as well as the probably misalignment of the crankshaft, have surely

contributed to this premature catastrophic failure. When a seizure occurs and the removed material exceeds the undersized limit recommended by the manufacturer, the crankshaft should be replaced by a new one without resorting to an added metal alloy.

Rajesh M. Metkar [3] have presented to investigate the dynamic loaded stress analysis of the crankshaft has been performed to predict and compare the fatigue life of the crankshaft by LEFM and CDA methods, which are based on the fracture mechanics approach and evidenced by analytical method. Rather Ansys and nCode commercial software, which are also been used for predicting the fatigue life but are based on the stress and strain method. The present study provides an insight of LEFM and CDA methods along with its benefits to the design engineers to correctly assess the life of crankshaft at early stage of design. This study also gives a detailed overview of failure analysis process including analytical methods and result integration for predicting life of components as compared to life estimation by means of analysis tools. Also have find out Critical locations on the crankshaft geometry are all located on the fillet areas because of high stress gradients in these locations which result in high stress concentration factors.

Farzin H. Montazersadgh [4] has presented the Dynamic loading analysis of the crankshaft results in more realistic stresses whereas static analysis provides an overestimate results. Accurate stresses are critical input to fatigue analysis and optimization of the crankshaft. There are two different load sources in an engine; inertia and combustion. These two load source cause both bending and torsional load on the crankshaft experimental and FEA results showed close agreement, within 7% difference. These results indicate non-symmetric bending stresses on the crankpin bearing, whereas using analytical method predicts bending stresses to be symmetric at this location. The lack of symmetry is a geometry deformation effect, indicating the need for FEA.

GulCevik [5] have presented a correlation of rolling load, surface hardness and residual stress distribution with bending moment developed by crankshaft rig test results and by X-ray measurement of residual stresses. Optimum conditions for rolling load, fillet geometry and material were identified. In order to enable an optimization of safety factors, experimental data was used as input data for CAE analysis. A crankshaft fatigue optimization study was conducted bending fatigue testing of steel crankshafts. Effects of different rolling loads, web thicknesses and undercut radii were analyzed. In-service dynamic simulations were conducted to determine the loads on the fillet region and calculate the safety factors at these critical regions. In a study fatigue tests of non-hardened crankshafts with fillet and hardened and non-hardened crankshafts without a fillet were conducted. By analyzing of the test results and a procedure of fatigue testing was proposed to obtain the in-service fracture patterns of motorcycle crankshafts.

R.K. Pandey [6] has presented Recurrence of premature breakage of diesel engine crankshafts was reported from a plant. These crankshafts were used in tractors with a two cylinder 35 HP engine. The failure time of the crankshafts varied between 30 h and about 700 h. As such, the design life

of crankshafts was expected to be very high. A study was necessitated to determine causes of the failure of the crankshafts. The crankshaft material was a C45 steel forging with supposedly good cleanliness. The forging had been normalized to give a hardness of HB 180-207 prior to machining. The crankshaft was induction hardened on pins and journals (up to a depth of about 2–5 mm) and finished ground prior to assembling. Fillets were, however, not induction hardened. The failure in the crankshafts has been initiated mostly from the crank pin-web fillet region by a fatigue mechanism. The estimated stress level for fatigue initiation is in the range of 175 MPa. To avoid fatigue initiation from the pin-web fillet region, induction hardening of the fillet resulting in a tempered martensitic structure is desirable. It may be noted that only pin and journal regions have been induction hardened in the crankshafts. The crankshaft material is quite sensitive to local metallurgical defects in the pin-web fillet region. Once a fatigue crack has nucleated from the surface defects in combination with occasional high stressing, its further propagation under cyclic loading is possible even at a quite low nominal stress (of the order of 80 MPa). To prevent fatigue initiation the fillet radius needs to be further increased.

F. Jiménez Espadafor [7] has presented the analyses a catastrophic crankshaft failure of a four-stroke 18 V diesel engine of a power plant for electrical generation when running at a nominal speed of 1500 rpm. The rated power of the engine was 1.5 MW, and before failure it had accumulated 20,000 h in service operating mainly at full load. The fracture occurred in the web between the 2nd journal and the 2nd crankpin. The mechanical properties of the crankshaft including tensile properties and surface hardness evaluated.

3. Discussion

Earlier authors all the authors were discussed about the failure of the crankshaft by using various methods and techniques. According to some researchers changes the crankshaft materials like aluminium, composites. They were discussed about the crack occurring after uses and done the analysis by using software as well as experimentation and took the results. They also discussed about the materials used for manufacturing the crankshaft. As well as they working on various structures for manufacturing crankshaft with studied effect of crack depth, occurrence of crack. They also done the analysis on software and shows the result in the graphical as well as images created by ANSYS. Some researchers were studied on the manufacturing process of the crankshaft to increase the strength of crankshaft by using heat treatment process like surface hardening, annealing etc. The physical dimensions, boundary conditions and the material properties of the structure play important role for the determination of fatigue failure, strength. Some researchers were studied on Test plan according to staircase test methodology has been effectively used and accelerated the fatigue testing of the crankshafts to construct S-N curves and Dixon-Mood method based on Maximum Likelihood Estimation has enabled obtaining endurance limit conveniently.

4. Conclusion

It has been observed that the changes in methods and materials the life of the crank shaft increases. Some researchers have considered composite structures in their study to analyse the strength and failure occurs in it. Various models have been developed by researchers using various theories and concepts to study the fatigue failure in crankshaft due to dynamic and static loading. The failure in the crankshafts has been initiated mostly from the crank pin-web fillet region by a fatigue mechanism. Shafts are made from the same material however one of them has undergone a surface hardening heat treatment and the other is used under the annealed conditions.

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