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Design Modification of Engine Crank Shaft Assembly

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Abstract: The crankshaft is a compact revolving element present in IC engines that transform the rectilinear motion of the piston into continuous rotary motion. The proper design and assembly of the crankshaft can ensure the smooth conversion of mechanical energy from reciprocating pistons to the drive system. The power dissipation, energy losses, noise, and vibration that are produced during operation directly affects the efficiency of the vehicle. The existing design of the crankshaft is a track-proven model for many decades. The manufacturing process of this involved large number of machining operation. Even though, during the long course of application, the crankshaft assembly produces some noise, vibration that leads to discomfort in ride and sharp fall in mileage of the vehicle that reduces efficiency. In order to overcome these problems, the design modification is done to improve the life and performance of the crankshaft assembly. A detailed study and analysis of the existing model are undertaken. Based on the experimental and analytical reviews; suitable design modification is made to suit the compact assembly in place of existing high weight and large crankshaft assembly. In the present work, design modification and numerical investigation of a crankshaft assembly is carried out. This crankshaft assembly is used mainly in a single cylinder, four strokes internal combustion engine. The stress comparison study is carried out between the existing design and the modified design by doing finite element analysis. The result shows that the modified design exhibits better performance and low stress than the existing model.

Keywords: Crank Shaft; Automobile; Engine; Design; Stress Analysis;

I. INTRODUCTION

The crankshaft is an essential part of the vehicle. It is shaft driven using a crank mechanism. It consists of a series of cranks and crankpins. The crankpins are attached with the connecting rod of the engine. It is a mechanical part apt to give a translation between reciprocating action and rotational action. In the engine, it con verts the reciprocating motion of the piston into rotational motion.

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It encounters a significant fraction of load periods during its service life. Thus, the fatigue behavior, including the durability of the part has to be accounted for the design. Manufacturing of crankshaft assembly involves various machining process. It includes a complicated method of production which take a lot of time. It also makes the number of the defective product to get the increase. It also causes the cost of the product to get a boost.

Farzin et al. had carried out the FE simulation of the crankshaft to find out the stress magnitude at the critical regions. The analysis is done using Abaqus, and boundary conditions are applied according to the engine mounting restraints. It is done for varying engine speed and results are noted. The FE results are checked by doing experimental analysis. The result correlation of the FE analysis and the experimental is done. It is used for the prediction of the better performance of the crankshaft and optimization of the crankshaft [1]. The Finite Element Method and Boundary Element Method are utilized by Henry et al. [2] to predict the stress in the fillet region of the crankshaft. The numerical analysis result validated with the experimental data of the 1.9-liter diesel engine. The fatigue life prediction is made, and the durability of the parts is enhanced by developing a conceptual plan and geometry optimization of the crankshaft. The marine engine crankshaft analysis is proposed by Guagliano. They have considered two different models for the study. Both models of the crankshaft are numerically investigated. The stress correlation of the crankshaft is done by the validation of the result of analysis and experiment. They have also determined the stress concentration factor [3].

The 3D model of 4 cylinder crankshaft of the diesel engine is created by using pro/E software and analyzed with two different materials in ANSYS and FEM (finite element modelling). They are used to analyze the vibration models, maximum stress point and deformation areas for the given crankshaft. The maximum deformation and maximum stress appearance can be analyzed and located. Based on the analysis results, we can foretell the occurrence of mutual contact between the crankshaft and other parts. The results obtained from the analysis can be used to improve engine design [4]. This study is related to the comparison of two sets of materials used in the assembly of the piston, crankshaft and the coupling rod of a petrol engine to run as a rigid mechanism by using static, dynamic and thermal analysis. The rigid-body analysis and flexible-body analysis are included to determine the forces in the components as the engine reciprocates in a rigid mechanism.

These forces are later used to calculate the dynamic stress in the connecting rod. In case of Al-2618 Piston, High Alloy Steel Crankshaft and Titanium Connecting rod displacement and stress values are less. When Al-6061 Piston, Al-6061 Connecting rod and EN308 Crankshaft are considered the heat transfer rate is more efficient [5].

The crankshaft model proposed by Borges et al. revealed that the stress distribution is uniform in the model. The FEA analysis is performed in Ansys. The static load analysis is carried out at a different crank angle. The result exhibits that the stress distribution is uniform all over the crankshaft except the fillet region, where stress concentration is high [6]. Shenoy had conducted a numerical analysis of connecting rod element that is attached to the crankshaft [7]. Zoroufi et al. concentrated on stability performance validation. The comparison of forged steel and cast iron made crankshaft is done. The study focusses on the various working situations of the crankshaft and various failure sources. The fatigue behavior of crankshaft is also analyzed. The review also covered the cost analysis of the component [8]. In this paper, we have analyzed the manufacturing process of 350cc flywheel crankshaft assembly of Royal Enfield bike like its casting, machining etc. The crankshaft of 350cc is analyzed to predict stress over the region. The main problem in manufacturing of 350cc is number of operations carried out in manufacturing this flywheel assembly. Since flywheel manufacturing contain lot many processes, this increases the chance of getting defective items, and also requires a lot of power consumption. This leads to increase in cost of the component. By gathering knowledge from the literature survey we have made necessary design modification at manufacturing of 410cc crank shaft assembly. The machining operation of 410cc crankshaft is reduced in comparison with the 350cc. The stress analysis of the crankshaft is carried and result is compared with the 350cc engine crankshaft.

II. MANUFACTURING METHOD OF 350 CC

The 350cc flywheel crank shaft is manufactured by casting of flywheel separately and the shaft separately. The flywheel is followed by various machining process and assembled with crank shaft by pressing operation. These manufacturing process is carried out by fourteen machining process. These process consist of turning, facing, milling, broaching, drilling, and grinding. Each process take two to three minutes for completion. The 350cc flywheel crank shaft assembly consist of two flywheel namely right hand (RH) side flywheel and left hand (LH) side flywheel. These two flywheel are attached by crank pin and these flywheel are attached with crank shaft. This flywheel is circular in shape.

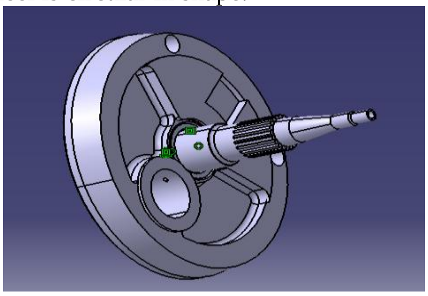

Fig.1. Shaft attached RH Flywheel of 350cc

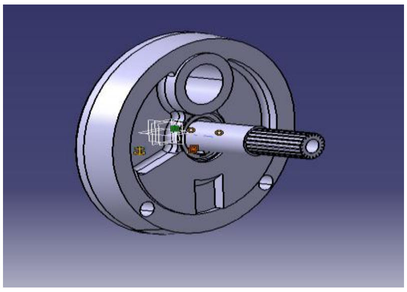

Fig. 2. LH flywheel attached with shaft of 350cc

The right hand side flywheel consist of one hole with key way for shaft attachment and another shaft of major diameter for crank pin attachment. The cross hole is drilled between crank pin hole and crank shaft hole for lubrication. The left hand side flywheel consist of one hole with key way for shaft attachment and another shaft of major diameter for crank pin attachment.

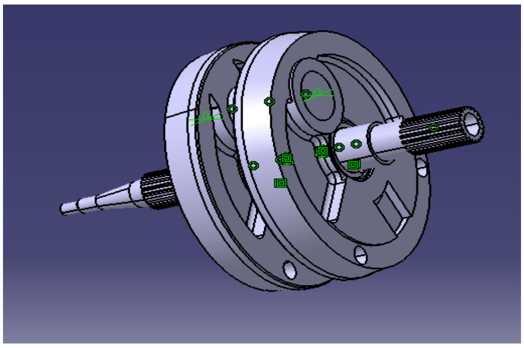

Fig. 3. Assembly of 350cc engine

III. MANUFACTURING METHOD OF 410CC

The problem faced during machining of the component of 350cc shows that it has high chances of getting defect. Thus, we have modified the design and manufacturing process of 410cc flywheel. In this design the crankshaft is directly attached with the flywheel. We have made the attachment of crank shaft with flywheel at the stage of raw manufacturing i.e. casting. Hence, we have reduced the number of machining operation to a greater extent. The right hand side flywheel is manufactured by facing, turning and by boring operation. In additional to that forging operation is done at crank shaft of the flywheel. While the left hand side flywheel is manufactured by facing, turning and by boring operation. The overall weight of the component of 410cc is less than 350cc flywheel. Hence, the consumption of the material is reduced which further reduces the cost. After completion of above machining process the flywheel is send to induction hardening at MK auto components.

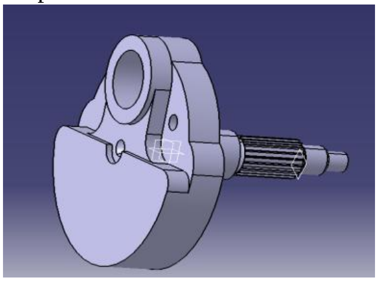

Fig. 4. RH Crankshaft of 410cc

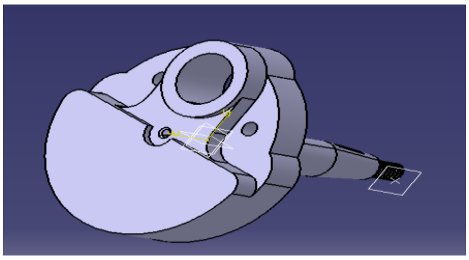

Fig. 5. LH Crankshaft 410cc

IV. FINITE ELEMENT ANALYSIS

Fig. 6. Steps involved in FEA

The law of the universe states that every object in the world has a defect that can be identified by evaluating it. The evaluation is done by experimenting it. The problem lies in the experiment is that it required all the specific parameter must opt to the standard. If it does not follow the norm, the test has to be repeated. This will leads to various issues such as material wastage, time-consumption, and so. The researchers are evolving in the technical field of identifying an alternate way to the experiment that could reduce the testing criterion. Finite element analysis is developed as an ideal way for the researchers and also as an alternative way for the physical test. The FEA of both the 350cc and 410cc component is carried out in Ansys.

The CAD (Computer-Aided Design) model of each part involved in the assembly is designed using Catia. The assembly of the component is done in Catia. After the completion of the assembly of the component, it is imported into the Ansys workbench to carry out further analysis. The material selected for the analysis is forged steel. Ansys is a developed software to perform finite element analysis. Ansys is known for its structural analysis. The static structural analysis is done on both the component. The stress developed between the crankshaft and the flywheel is analyzed for both the flywheel. The one end of the component is fixed while the moment is applied at other ends. The crankshaft of the flywheel is fixed at both ends. The moment of 500N-m is applied. The meshing is a process of discretizing the component into the finite element. The tetrahedral element is preferred for meshing operation due to its complexity of the parts. After the completion of the pre-processing, it is allowed to solve by the Ansys solver. The post-processing involved the stress determination on the component. The results of equivalent Von-Mises stress of both the component is noted, and comparison study is done.

V. RESULT AND DISCUSSION

The post-processing of the component involves the determination of the stress developed in the component. Von-mises stress is selected for the comparison study. The von mises stress of the 350cc is selected and noted. The von-Mises stress of 350cc is 19.058 MPa. The stress is generated between the crankshaft and flywheel. This indicates the chance of failure is high between the crankshaft and flywheel of 350cc vehicle.

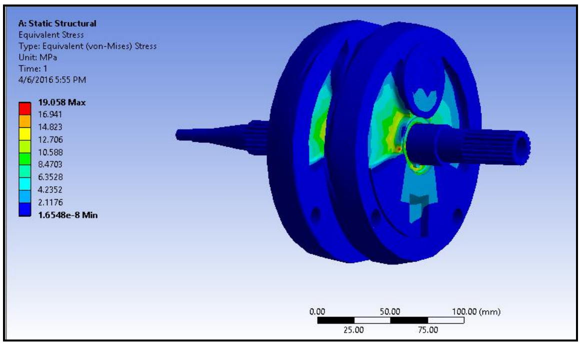

Fig. 7. Stress developed in 350cc

Similarly, the stress of the 410cc component is noted. The result of 410cc flywheel shows the maximum von-mises stress of 0.16282 MPa. The stress is generated between the crankshaft and flywheel. The von mises stress comparison study shows that the stress developed in the 410cc crankshaft assembly is very less than the stress developed in the 350cc crankshaft assembly.

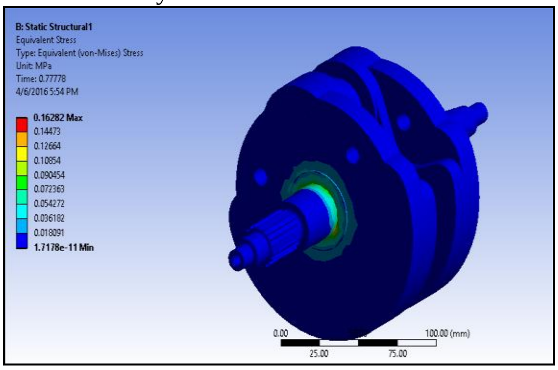

Fig. 8. Stress developed in 410cc

This indicates that the chance of failure is reduced to a greater extent than 350cc. The risk of failure is highly minimized by changing the design. The design modification not only reduces the stress developed over the region but also contributes to the reduction in the machining operation. The machining operation is carried on the 350cc part is very high. The 410cc component can be easily manufactured with less machining operation. Due to less machining operation, the machining time is reduced, and labor cost is also reduced. This creates a way for the easy production of the component and also the mass production can be done. The advantage of newly developed crankshaft assembly is that the material consumption is reduced, which leads to the reduction in the cost of the component.

VI. CONCLUSION

The design modification of the crankshaft assembly results in achieving the following benefits. The number of machining operation involved in manufacturing of flywheel is reduced which results in less human effort for operating. The crankshaft and flywheel is attached during casting, it leads to the material consumption. The risk of failure of crank shaft is minimized. The cost of manufacturing the component is minimized which results in the less cost of the component. The weight of the component is reduced which results in better performance and the efficiency of the vehicle is improved.

REFERENCES

1. Montazersadgh, Farzin H., and Ali Fatemi. Dynamic load and stress analysis of a crankshaft. No. 2007-01-0258. SAE Technical Paper, 2007.
2. Henry, Jean-Pierre, John Toplosky, and Marek Abramczuk. Crankshaft Durability Prediction-A New 3-D Approach. No. 920087. SAE Technical Paper, 1992.
3. Guagliano, Mario, Angelo Terranova, and L. A. U. R. A. Vergani. "Theoretical and experimental study of the stress concentration factor in diesel engine crankshafts." Journal of mechanical design 115, no. 1 (1993): 47-52.
4. Deshbhratar, R. J., and Y. R. Suple. "Analysis and optimization of Crankshaft using FEM." International Journal of Modern Engineering Reasearch 2, no. 5 (2012): 3086-3088.
5. Gopal, G., L. Suresh Kumar, K. Vijaya Bahskar Reddy, M. Uma Maheshwara Rao, and G. Srinivasulu. "Analysis of Piston, Connecting rod and Crank shaft assembly." Materials Today: Proceedings 4, no. 8 (2017): 7810-7819.
6. Borges, Adriana Camilo Costa, Luiz Claudio Oliveira, and Perrin Smith Neto. Stress distribution in a crankshaft crank using a geometrically restricted finite element model. No. 2002-01-2183. SAE Technical Paper, 2002.
7. Shenoy, Pravardhan S., and A. Fatemi. "Dynamic analysis of loads and stresses in connecting rods." Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science 220, no. 5 (2006): 615-624.
8. Zoroufi, Mehrdad, and Ali Fatemi. "A literature review on durability evaluation of crankshafts including comparisons of competing manufacturing processes and cost analysis." In 26th Forging Industry Technical Conference. 2005.
9. Dhinakaran, V., N. Siva Shanmugam, K. Sankaranarayanasamy, and R. Rahul. "Analytical and numerical investigations of weld bead shape in plasma arc welding of thin Ti-6al-4v sheets." Simulation 93, no. 12 (2017): 1123-1138.
10. Dineshkumar, S., Shrinidhy Sriram, R. Surendran, and V. Dhinakaran. "Experimental Investigation of Tensile Properties of Ti-6Al-4V alloy at Elevated Temperature." International Journal of Recent Technology and Engineering 8, no. 1 (2019): 103-107.
11. M. Swapna Sai, V. Dhinakaran, K. P. Manoj Kumar et al., A systematic review of effect of different welding process on mechanical properties of grade 5 titanium alloy, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2019.09.027
12. Varsha Shree M, Dhinakaran V, Rajkumar V, Bupathi Ram P M, Vijayakumar M D, T Sathish, Effect of 3D printing on supply chain management, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2019.09.060
13. Dhinakaran, V., Suraj Khope, N. Siva Shanmugam, and K. Sankaranarayanasamy. "Numerical prediction of weld bead geometry in plasma arc welding of titanium sheets using COMSOL." In Proceedings of the 2014 COMSOL Conference in Bangalore, Bangalore, India, pp. 13-14. 2014.
14. T. Sathish, 'Experimental Investigation Of Machined Hole And Optimization Of Machining Parameters Using Electrochemical Machining', Journal of Materials Research and Technology, Elsevier Publisher, Vol. 8, Issue 5, Oct 2019, pp. 4354-4363, 2019.
15. T. Sathish, 'Profit Maximization in Reverse Logistic based on Disassembly Scheduling using Hybrid Bee Colony Bat Optimization', Transactions of the Canadian Society for Mechanical Engineering, Vol. 43, Issue. 04, pp. 551-559, 2019.
16. T. Sathish, 'Equivalent stress prediction of Automobile structural member using FEA-ANN Technique', International Journal of Mechanical and Production Engineering Research and Development, Vol. 9, Issue 2, Apr 2019, pp. 757-768, 2019.
17. T. Sathish, 'Artificial Intelligence Based Green Manufacturability quantification of a unit production process', International Journal of Mechanical and Production Engineering Research and Development, Vol. 9, Issue 2, Apr 2019, pp. 841-852, 2019.
18. T. Sathish, 'Fluid Flow analysis of composite material based wind turbine blades using Ansys', International Journal of Ambient Energy, Taylor and Francis Publishers, Accepted, Ref.No: TAEN-2019-0001.R1, DOI: 10.1080/01430750.2019.1608861, 2019.
19. T. Sathish, 'GAC-ANN Technique for Prediction of Spring Back Effect in Wipe Bending Process of Sheet Metal', Materials Today Proceedings, Elsevier Publisher, Vol. 05, Issue 6, pp. 14448-14457, 2018.
20. T. Sathish, 'BONN Technique: Tribological Properties Predictor for Plasma Nitrided 316L Stainless Steel', Materials Today Proceedings, Elsevier Publisher, Vol. 05, Issue 6, pp. 14545-14552, 2018.
21. T. Sathish, 'Prediction of Springback Effect by the Hybridization of ANN with PSO in Wipe Bending process of sheet Metal', Progress in Industrial Ecology, An International Journal (PIE), Inderscience Publishers, Vol. 12, No. 1/2, pp. 112-119, 2018.

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