MODELLING AND ANALYSIS OF DI ENGINE OF TRACTOR

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ABSTRACT

This paper provides the solution of live problem occurred in the engine of DI model of tractor by using the Computer aided modeling and analysis techniques. The problem occurred in the connecting rod of engine which was fouling with the camshaft during operation. The main work is to model the components of engine with dimensions assemble those components and then simulate the whole assembly for each rotation of the crank. This will give the exact location of fouling and reason for fouling. The modeling software used is PRO-E wildfire 4.0 for modeling the engine components like camshaft, crankshaft, connecting rod, connecting rod bolt, nut, piston, etc. The analysis software ANSYS is used to analyze and simulate the whole assembly.

Keywords: Camshaft, Connecting Rod, Crank, Engine, Fouling.

I. INTRODUCTION

The tractor is a DI model of 39 H.P, three cylinder engines and 2049 cc. Speed is 1900 rpm. This particular model of tractor has problem in assembly of engine. While operation each connecting rod of the engine fouls with the camshaft. Due to which there is problem in performance of engine. The camshaft is driven with the help of gear drive with the pinion mounted on crank. The crankshaft, sometimes casually abbreviated to crank, is the part of an engine which 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 torsion 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. The crankshaft has a linear axis about which it rotates, typically with several bearing journals riding on replaceable bearing held in the engine block. As the crankshaft undergoes a great deal of sideways load from each cylinder in a multi- cylinder engine, it must be supported by several such bearings, not just one at each end. This was a factor in the rise of V8 engines, with their shorter crankshafts, in preference to straight-8 engines. The long crankshafts of the latter suffered from an unacceptable amount of flex when engine designers began using higher compression ratios and higher rotational speeds. High performance engines often have more main bearings than their lower performance cousins for this reason. 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 centre 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 connecting rod 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 pressure.

II. WORKING OF ENGINE

In a reciprocating piston engine, the connecting rod or connecting rod connects the piston to the crank or crankshaft. The connecting rod was invented sometime between 1174 and 1200 when a Muslim inventor, engineer and craftsman named Al-Jazari built five machines to pump water for the kings of the Turkish Artuqid dynasty — one of which incorporated the connecting rod. Transferring rotary motion to reciprocating motion was made possible by connecting the crankshaft to the connecting rod, which was described in the "Book of Knowledge of Ingenious Mechanical Devices". The double- acting reciprocating piston pump was the first machine to offer automatic motion, but its mechanisms and others such as the cam, would also help initiate the Industrial Revolution. In modern automotive internal combustion engines, the connecting rods are most usually made of steel for production engines, but can be made of aluminium (for lightness and the ability to absorb high impact at the expense of durability) or titanium (for a combination of strength and lightness at the expense of affordability) for high performance engines, or of cast iron for applications such as motor scooters. They are not rigidly fixed at either end, so that the angle between the connecting rod and the piston can change as the rod moves up and down and rotates around the crankshaft. The small end attaches to the piston pin, gudgeon pin or wrist pin, which is currently most often press fit into the con rod but can swivel in the piston, a "floating wrist pin" design. The big end connects to the bearing journal on the crank throw, running on replaceable bearing shells accessible via the con rod bolts which hold the bearing "cap" onto the big end; typically there is a pinhole bored through the bearing and the big end of the con rod so that pressurized lubricating motor oil squirts out onto the thrust side of the cylinder wall to lubricate the travel of the pistons and piston rings. The con rod is under tremendous stress from the reciprocating load represented by the piston, actually stretching and relaxing with every rotation, and the load increases rapidly with increasing engine speed. Failure of a connecting rod, usually called "throwing a rod" is one of the most common causes of catastrophic engine failure in cars, frequently putting the broken rod through the side of the crankcase and thereby rendering the engine irreparable; it can result from fatigue near a physical defect in the rod, lubrication failure in a bearing due to faulty maintenance, or from failure of the rod bolts from a defect, improper tightening, or re-use of already used (stressed) bolts where not recommended. Despite their frequent occurrence on televised competitive automobile events, such failures are quite rare on production cars during normal daily driving. This is because production auto parts have a much larger factor of safety, and often more systematic quality control. The camshaft is an apparatus often used in piston engines to operate poppet valves. It consists of a cylindrical rod running the length of the cylinder bank with a number of oblong lobes or cams protruding from it, one for each valve. The cams force the valves open by pressing on the valve, or on some intermediate mechanism, as they rotate. The relationship between the rotation of the camshaft and the rotation of the crankshaft is of critical importance. Since the valves control the flow of air/fuel mixture intake and exhaust gases, they must be opened and closed at the appropriate time during the stroke of the piston. For this reason, the camshaft is connected to the crankshaft either directly, via a gear mechanism, or indirectly via a belt or chain called a timing belt or timing chain. In some designs the camshaft also drives the distributor and the oil and fuel pumps. Also on early fuel injection systems, cams on the camshaft would operate the fuel injectors. In a two-stroke engine that uses a camshaft, each valve is opened once for each rotation of the crankshaft; in these engines, the camshaft rotates at the same rate as the crankshaft. In a four-stroke engine, the valves are opened only half as often; thus, two full rotations of the crankshaft occur for each rotation of the camshaft. The timing of the camshaft can be advanced to produce better low end torque or it can be retarded to produce better high end torque. Depending on the location of the camshaft, the cams operate the valves either directly or through a linkage of pushrods and rockers. Direct operation involves a simpler mechanism and leads to fewer failures, but requires the camshaft to be positioned at the top of the cylinders. In the past when engines were not as reliable as today this was seen as too much bother, but in modern gasoline engines the overhead cam system, where the camshaft is on top of the cylinder head, is quite common. Some engines use two camshafts each for the intake and exhaust valves; such an arrangement is known as a double or dual overhead cam (DOHC), thus, a V engine may have four camshafts. The rockers or cam followers sometimes incorporate a mechanism to adjust and set the valve play through manual adjustment, but most modern auto engines have hydraulic lifters, eliminating the need to adjust the valve lash at regular intervals as the valve train wears, and in particular the valves and valve seats in the combustion chamber.

III. REASON FOR SELECTING THE PROBLEM

This problem is live industrial problem which company is facing and they need the permanent solution, so if we can achieve the better solution the company can think over it. The company has already temporary solution of making groove on the collar of connecting rod but it will affect the life of the connecting rod and also it will create the problem of balancing. Also when the connecting rod will fail the customer will not get that grooved connecting rod in the market.

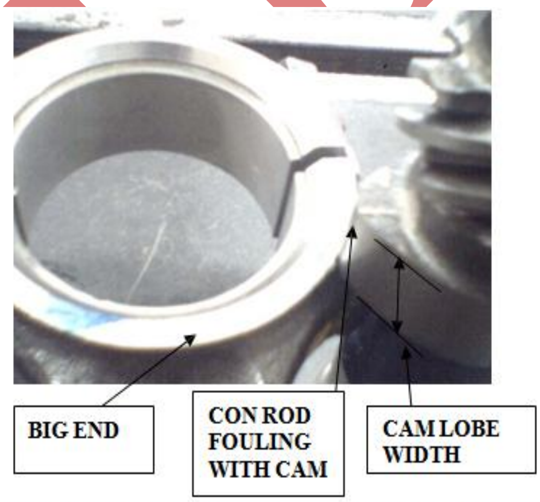

FIG. 1 FOULING OF CONNECTING ROD ON CAMSHAFT

FIG. 2 CONNECTING ROD SUB ASSEMBLY MADE IN PRO-E WILDFIRE

IV. AIM AND OBJECTIVE

Computer aided modeling and finite element analysis of connecting rod fouling on the camshaft of DI engine of a Tractor. The problem occurred in the engine of DI model of Tractor. The connecting rod of engine was fouling with the camshaft during operation. Our objective is to model the engine components with the help of drawings provided by company and assemble all the components of engine and make it run virtually on the computer modeling software to observe the problem of fouling and provide the solution/ solutions.

V. EXPERIMENTAL SET-UP

As it is the industrial problem the set-up physically will be in the assembly section company. But the model of the assembly will be made in the CAD software and we have to make the analysis with the help of analysis software tools. The model of connecting rod, connecting rod bolt, nut, camshaft and crankshaft are made in the PRO-E wildfire 4.0 software and then these components are assembled together to simulate it.

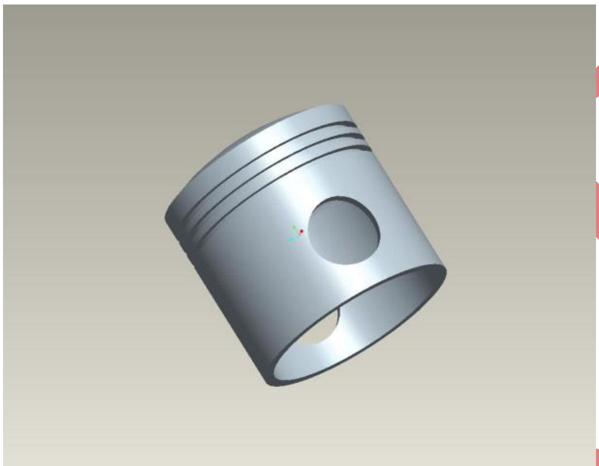

Fig. 3 Model of Piston Made In Pro-E Wildfire 4.0

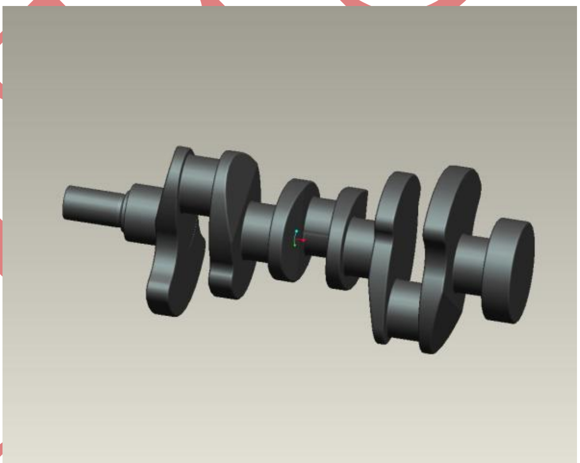

Fig. 4 Model of Crankshaft Made In Pro-E Wildfire 4.0

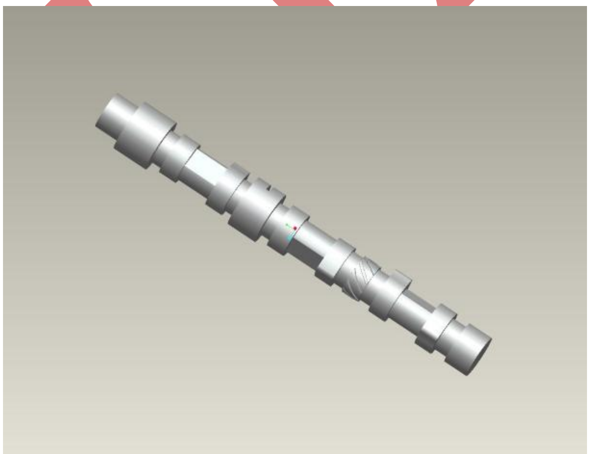

Fig. 5 Model of Camshaft Made In Pro-E Wildfire 4.0

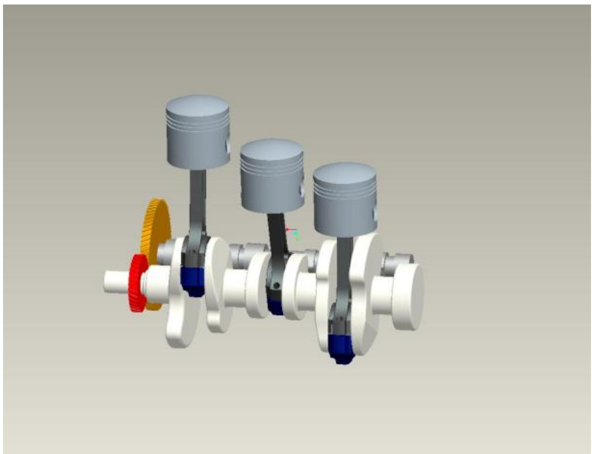

Fig. 6 Complete Assemblies Made In Pro-E Wildfire 4.0

VI. RESEARCH METHODOLOGY

This problem is live industrial problem and the research methodology followed will involve the practical and physical visualization of the fouling of connecting rod with camshaft in the assembly section of company. After practically visualizing the problem the next methodology to be adopted is to make the models of components with dimensions in the modeling software like Pro-E and also assemble all these components in the software and finally after the assembly is made, then that assembly is simulated in the simulation software for each degree rotation of the crank. Thus we can model and simulate the complete assembly and visualize the problem of fouling in the software and find the solution.

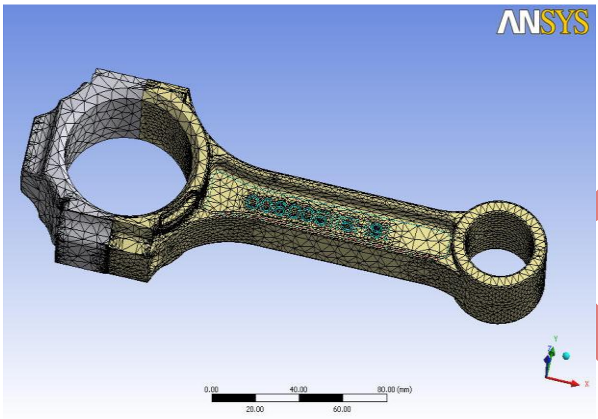

Fig. 7 Meshed Model of Existing Grooved Con Rod

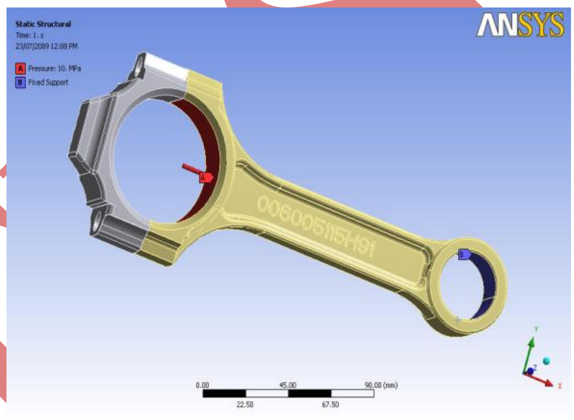

Fig. 8 Boundary Conditions on Existing Grooved Con Rod

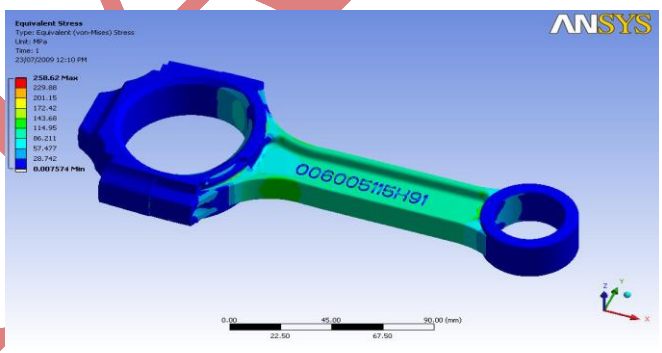

Fig. 9 Equivalent Stress in Existing Grooved Con Rod

VII. MEASUREMENT TECHNIQUES

We have made the research right from the drawings of camshaft, connecting rod, crankshaft, crank and piston. With the help of these drawings the model is made in the CAD software i.e. PRO-E wildfire 4.0 and also the complete assembly. The complete assembly is simulated and the analysis is made for each degree rotation of the crank and with the help of these results the conclusion is made whether there is any problem in the assembly or there is any fault in the drawings.

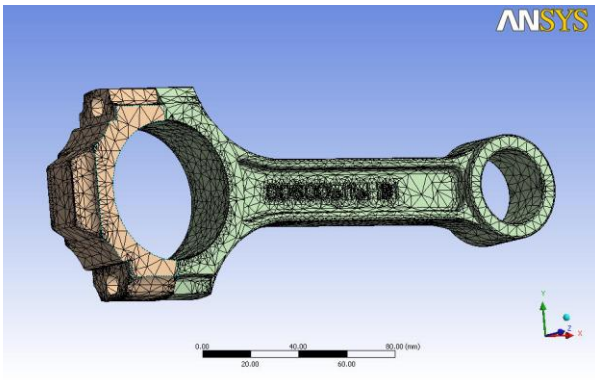

Fig.10 Meshed Model of Proposed New of Con Rod

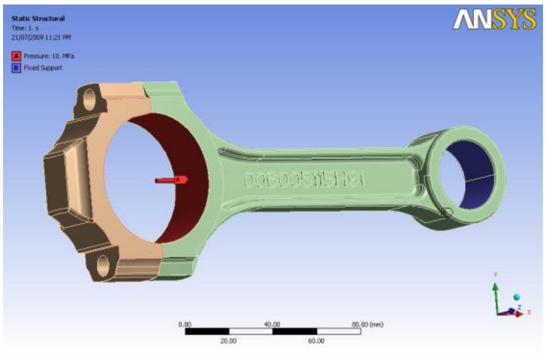

Fig. 11 Boundary Conditions on Design Proposed New Con Rod

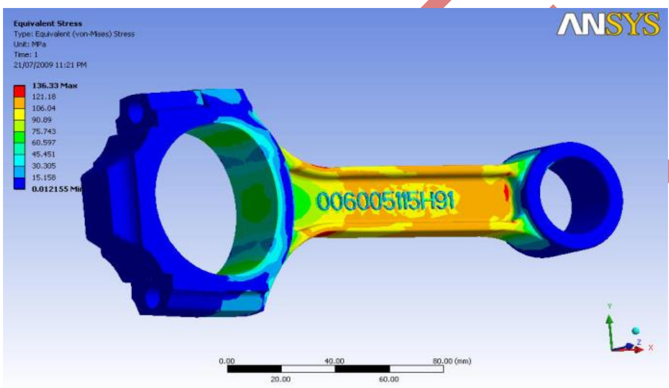

Fig. 12 Equivalent Stress in Proposed New Con Rod

VIII. RESULT AND OUTCOME

1. In this project all the engine components are modelled with dimensions and assembled to observe the problem of fouling in the Pro-E software by giving motion to the assembly.
2. In the Pro-E software after assembling of all components it has been observed that the middle connecting rod of engine was fouling with the cam lobe of camshaft.
3. Modal and Static Analysis of connecting rod without groove and with groove was performed on Ansys software and the deformation and stresses were compared.
4. The von-Mises stress in existing con rod with groove is 258 MPa and in new proposed design of con rod without groove is 136 MPa under same boundary conditions.
5. Modal and Static Analysis of other engine components i.e. piston, camshaft, crankshaft was also performed on Ansys software.
6. The von-Mises stress in piston is 317 MPa.
7. The von-Mises stress in camshaft is 0.0258 MPa.
8. The von-Mises stress in crank is 107 MPa.

9. A modal analysis determines the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component. It can also serve as a starting point for another, more detailed, dynamic analysis, such as a transient dynamic analysis, a harmonic response analysis, or a spectrum analysis. The natural frequencies and mode shapes are important parameters in the design of a structure for dynamic loading conditions.
10. A static structural 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.
11. By performing the analysis of connecting rod with groove and without groove it has been found that the stresses induced in the connecting rod with groove are more as compared to the conrod without groove.
12. Also when the grooved connecting rod will fail after some years of operation how one can get the new connecting rod from the market.
13. With the experience gained in this work a new design for the existing grooved connecting rod was proposed and analysis of same is done.

IX. RESULT VALIDATION

The results are validated by comparing the results obtained by Ansys software with the numerical method of FEM. The von-Mises stresses obtained by Ansys software are compared with the manual method. The small part of the connecting rod is considered and solved by considering the problem of plane stress and plane strain. The rectangular part considered is divided into two CST elements and solved by Principle of Minimum Potential Energy and Boundary conditions are applied to obtain von-Mises stress. The stress obtained by numerical method is 20.07 MPa and stress obtained by software is 25.321 MPa which are nearly equal. Thus the results are validated.

X. CONCLUSION

The possible solutions for fouling are:-

1. New design of connecting rod by reducing the collar width of connecting rod to 30 mm instead of 33.2 mm can solve the fouling problem. The analysis of new connecting rod is done and the von-Mises stress is 136 MPa while that of grooved connecting rod is 258 MPa. This proves that instead of making groove in the collar of connecting rod, the collar width can be reduced to 30 mm which will induce less stress than that of existing grooved con rod.
2. Axial movement of camshaft by 3 mm will solve the problem of fouling which requires further investigation.
3. Increasing the distance between camshaft and crankshaft by 5mm will solve the fouling problem which needs further study.

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