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Effect of Friction on Piston Ring Assembly of 4-Stroke Four Cylinder Engine: A Review

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Abstract –In the internal combustion engine piston ring assembly (PRA) is very important component to calculate its efficiency and its performance. The performance of the piston ring assembly is adversely affected by the friction produced. Generally friction is produced in PRA due to relative motion between piston and cylinder, many authors and researcher have worked in different manner. In this paper we are focusing on the work done by different researcher to investigate the effect of friction on engine performance.

KEY WORDS: Internal Combustion Engine, PRA , Piston , Friction, Cylinder.

1.INTRODUCTION

The purpose of the I.C. engine is the production of the mechanical power from the chemical energy contained in the fuel. In the internal combustion engine, as distinct from external combustion engine, this energy is released by burning or oxidizing the fuel inside the engine. The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine, the expansion of the high-temperature and -pressure gases produced by combustion applies direct force to some component of the engine, such as pistons, turbine blades, or a nozzle[14]. This force moves the piston over a distance, generating useful mechanical energy. The friction is an important consideration taken into account in the internal combustion engine operation.

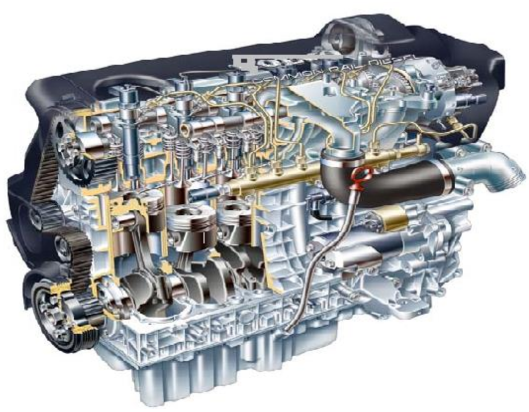

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Fig No. 1.1 A Diagram of the 4-Stroke 4- Cylinder Petrol Engine [14]

3 The main component of the I.C. engine and their function Piston: Piston is a reciprocating component of the I.C. engine which transmits the force of explosion to the crankshaft. It serves as a guide and a bearing for small end of connecting rod. The function of piston is also to form a seal so that the high pressure gases in the combustion chamber do not escape.
Piston ring: the function of the piston ring is to form a seal for the high pressure gasses from the combustion chamber against leak into the crank-case. (Details are given below insec.1.23)

Connecting rod: the function of the connecting rod is to convert the reciprocating motion of the piston into the rotary motion of the crankshaft.

Cylinder block: The basic frame of the engine is formed by the cylinder block. It houses engine cylinder, which serve as bearing and guides for the piston reciprocating in them.
Piston pin: The piston pin or wrist pin or gudgeon pin as it is so often called, connect the piston and the connecting rod. For lightness it is made in tubular form.

Crankshaft: Crankshaft is the engine component from which the power is obtained. It receives the power form the connecting rod in the designated sequence for onward transmission to the clutch and subsequently to the wheel.

Fig No. 1.3 Piston and Connecting Cod Assembly [14]

4. Source of friction in internal combustion

Mechanical losses due to friction account for between 4 to 15 % of the total energy consumed in modern internal combustion engine 40-50% of those total mechanical losses occur in the power cylinder and half of the power cylinder friction losses come from friction generated by the piston ring as a result, a reduction in piston ring friction has the potential to improve engine efficiency lower fuel consumption and reduce emissions. These are important objectives for today's engine manufacturers, who are striving to improve engine performance while trying to meet increasingly stringent emission standards [10]. Not all the work transferred to the piston from the gases contained inside the cylinder- the indicated work is available at the drive shaft for the actual use. That portion of the work transferred which is not available usually termed friction work; often the difference between a good engine design and an average engine is the difference in their friction losses[12].

Total friction work W_{tf} . the total friction work is the sum of the these three components, i.e.

$$W_{tf} = W_P + W_{rf} + Wa$$

5.LITERATURE REVIEW

Ankit Sonthalia, Chidambaram Ramesh Kumar [1] :In an internal combustion engine piston, piston ring and cylinder are the most important assembly for transmitting the forces produced by the combustion process. The friction , between piston ring pack and cylinder accounts for major portion of friction in an internal combustion engine and it also significantly affects the mechanical efficiency of the engine. In the piston ring pack, friction is mainly due to the compression ring, especially at the top dead centre and bottom dead centre where boundary lubrication exists. This paper provides a detailed study on the effect of ring profile on ring friction using MATLAB code. Three different ring profiles were selected and analysed for lubricant film thickness, ring twist angle, ring friction and friction coefficient. Out of these three, friction force and friction coefficient of one ring profile design was found minimum. The ring design with minimum friction force and friction coefficient was manufactured and assembled in a low speed SI engine. The engine liner was modified to float and friction of the ring was studied using motoring test method. The experimental results were compared with the simulation result, it was found that simulation result was in agreement with the experimental result.

Chenheng Yuan , Jing Xu, and Yituan He: In this work author describe that free-piston engine generator is a new alternative to traditional reciprocating engine, which moves without mechanical restriction of crankshaft system. This article investigated numerically the friction characteristics of piston rings in a free-piston diesel engine generator by adopting coupled models of dynamic and friction. The development of the dynamic model and friction model was described, and an iterative calculation method was presented, giving insight into the coupled parameters of these two models. The detailed effects of the dynamic on friction and lubrication were investigated compared with a corresponding traditional crank engine. The friction characteristics of the free-piston engine generator were found to differ clearly from those of the traditional engine due to its special piston motion. Compared with the traditional engine, the minimum lubricant film thickness of piston rings in the free-piston engine generator is thicker and lasts shorter at the dead center regions, but it is generally thinner at other positions. The average friction force, friction power, and friction work of the piston rings in the free-piston engine generator are less than the traditional engine due to the better lubrication in endpoints region. Meanwhile, the friction power of the free-piston engine generator increases with the increase in fuel mass or decrease in load. The friction efficiency varies in correlation with the generator load; the optimum friction efficiency can be obtained by either increasing or decreasing from a certain generator load.

H.D.Desai et al.: found the kinematic value of piston at the alter crank angle and calculate the thrust force, bearing load. The results are computed form the computer developed for complete dynamic analysis of the engine. The gas force acts on the piston due to the combustion of the fuel and these force varies during the cycle of operation. The complete force analysis of the engine is simplified by a summation of static force and inertia force ignoring the friction force which makes the analysis linear.

F. S. SILVA :in his work investigate that engine piston are one of the most important part among all automotive or other industry field components. He concern only with the analysis of fatigue-damaged piston. Pistons from SI and CI engine, from automobile, motorcycle and trains will be analyzed. An analysis of both thermal fatigue and mechanical fatigue damaged is presented and analyzed in this work. He concluded that fatigue is not the responsible for biggest slice of damaged and pistons, it remains a problem on engine pistons and its solution remains a goal for piston manufacturers.

Paweł Lisiak a, Izabela Rojek b, Paweł Twardowski: The article describes a method of evaluating the reliability of groove turning for piston rings in combustion engines. Parameters representing the roughness of a machined surface, Ra and Rz, were selected for use in evaluation. At present, evaluation of surface roughness is performed manually by operators and recorded on measurement sheets. The authors studied a method for evaluation of the surface roughness parameters Ra and Rz using multi-layered perceptron with error back-propagation (MLP) and Kohonen neural networks. Many neural network models were developed, and the best of them were chosen on the basis of the effectiveness of measurement evaluation. Experiments were carried out on real data from a production company, obtained from several machine tools. In this way it becomes possible to assess machines in terms of the reliability evaluation of turning.

John J. Truhan a b, Jun Qu b, Peter J. Blau b A test method has been developed to evaluate the friction and wear behavior of candidate piston ring and cylinder liner materials for heavy-duty diesel engine applications. Oil condition and its effects are important aspects of this test method and are the focus of this work. The test uses actual piston ring segments sliding on flat specimens of liner material to simplify alignment and to multiply the stress to the level normally seen in engine operation. Reciprocating tests were conducted at 10 Hz and 10 mm stroke at 100 °C. Test oils consisted of fully formulated lubricating oils that were conditioned in ASTM standard engine tests. The point contact between the ring segment and flat counter-face, the applied load and elevated temperature, all result in boundary lubrication, which simulates the environment near top-ring-reversal. The oil condition was defined by variables, such as spectroscopic elemental concentrations, soot level, oxidation, and contaminant particle concentration. Compared with engine-measured wear rates, ring wear was magnified by at least an order of magnitude and the liner by about 1.5–2 orders of magnitude as needed for an accelerated test. However, the basic wear mechanism, abrasive wear, was the same as in the engine. The soot concentration also had a strong effect on liner wear but no effect on ring wear. The oil viscosity has a mild effect on the friction at high load in boundary lubrication conditions. The viscosity of the conditioned oils tested here was related to the soot content rather than the oxidation levels.

Ewa Rostek a, Maciej Babiak b, Emil Wróblewski : The purpose of the internal combustion engine lubrication system is to provide optimal conditions for the oil film formation in all friction couples, such as a piston-cylinder, piston rings-cylinder, main bearings, etc. The oil film is designed to minimize the wear of the elements while ensuring the smallest possible friction losses. Lack of continuity of the oil film, and thus boundary or mixed friction conditions, obviously have a negative effect on the friction losses. However, the continuous oil film, depending on the conditions of its formation, may be characterized by different values of friction losses. One of the factors that may affect the conditions of formation of the oil film is the value of oil pressure in the lubrication system. In the paper the results of researches on friction losses carried out on an engine test bench are presented. The study consisted of measuring the driving torque of the internal combustion engine by an electric machine which is the source of power for the internal combustion engine. The oil temperature, the oil pressure, which was generated by independent from the engine oil pump, and the rotational speed of the crankshaft were the variables during test stand measurement. The article analyzes the results and conclusions are drawn.

M. Wozniak, D. Batory, K. Siczek & G. Ozuna : The main aim of the study was to evaluate changes in total friction in the engine, friction in its timing chain transmissions and engine emissions resulting from adding TiO2 nanoparticles to engine oil. The applicable engine oils and factors affecting their features were discussed. The drive from the crankshaft to the camshaft in an internal combustion engine is usually carried out by means of a cogged belt transmission or a chain transmission when high mileage is required without service operations. The engine performance of analyzed SI engine was obtained from the literature. The dependency of engine emission on engine operating speed was obtained using data from tests of a very similar engine under standard test conditions described in the literature. The changes in engine characteristics caused by varying internal friction conditions were estimated using the engine performance characteristic and engine friction losses, particularly in valve train chain transmission. The friction in such a chain transmission operating under oil lubrication conditions can be determined using its analytical model and measured friction torque occurring between the chain rollers and the pins. The smallest changes in engine were registered for the rotation speed of 2500 rpm. The oil consumption in the engine and its impact on the PM emission was estimated. The additional arrangements facilitating the extrapolation of the obtained friction results to the cases of using other oils and the method of measuring the PM emission on the test stand were proposed.

John J. Truhan a b, Jun Qu b, Peter J. Blau b :A test method has been developed to evaluate the friction and wear behavior of candidate piston ring and cylinder liner materials for heavy-duty diesel engine applications. Oil condition and its effects are important aspects of this test method and are the focus of this work. The test uses actual piston ring segments sliding on flat specimens of liner material to simplify alignment and to multiply the stress to the level normally seen in engine operation. Reciprocating tests were conducted at 10 Hz and 10 mm stroke at 100 °C. Test oils consisted of fully formulated lubricating oils that were conditioned in ASTM standard engine tests. The point contact between the ring segment and flat counter-face, the applied load and elevated temperature, all result in boundary lubrication, which simulates the environment near top-ring-reversal. The oil condition was defined by variables, such as spectroscopic elemental concentrations, soot level, oxidation, and contaminant particle concentration. Compared with engine-measured wear rates, ring wear was magnified by at least an order of magnitude and the liner by about 1.5–2 orders of magnitude as needed for an accelerated test. However, the basic wear mechanism, abrasive wear, was the same as in the engine.

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CONCLUSIONS

As it is clear from the above discussion that the friction is very important factor which adversely affect the performance of the piston ring assembly. And also affect the efficiency of the engine. Many researchers have worked on the same problem to solve these critical issues like piston ring design and geometry. Many authors also emphasized on the use of proper engine oil.

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