Experimental Stand to Investigate the Sealing Properties of Piston Rings Used in Automotive Industry

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Abstract. The internal combustion engine has been used for many transportation applications but his efficiency is low mainly to his mechanical and thermal losses. The combustion chamber is designed to be perfectly sealed; however a small part of air and fuel mixture leaks toward the crankcase especially due to the imperfect contact between rings and and cylinder liner. These losses of pressure depends on many factors such as engine speed, load and wear of rings. The piston group is responsible for ~ 50% of the frictional losses of the engine. An experimental stand was designed and realized in the laboratory to study the pressure losses and sealling properties of rings. A piston for Raba engine (MAN D2356) and cylinder was chosen to verify pressure losses function of various loads. The results shows the pressure losses of the piston ring assembly function of different pressures.

Keywords: Internal Combustion Engine · Compression Rings · Pressure · Sealling Properties

1 Introduction

Despite the growing usage of new electrical propulsion systems the majority of vehicles are still powered by an internal combustion engines and the prediction are that in the near future they will be used especially in truks and transport applications where a solution must be found. The power obtained by burning fuel in the combustion chamber is transferred to wheels by piston and connecting rod [1]. The friction between piston rings and cylinder is significant and due to his proportion affects the mechanical efficiency of the engine. This friction is due to the compression ring in the area of top dead centre and bottom dead centre [2]. In Fig. 1 is presented all mechanical energy losses in IC Engine. The main purpose of piston rings is to assure a sealing between the gap of the piston and the cylinder wall, to controll and distribute the oil and to transfer the heat to piston and cylinder walls [3]. The choice of the dimensions for the piston rings and the determination the optimal size of the clearance between cylinder, ring and piston is crucial to the functionality of IC engine. The dimensions that determine a lower

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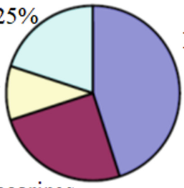

Fig. 1. Mechanical losses of IC Engine [2]

exhaust gas flow rate are not suitable and advantageous in terms of engine durability, oil consumption and resistance to motion [4]. The phenomenon of blow-by gas is when the tighness of piston rings and combustion chamber is not perfect and a part of intake gas mixture is lost toward the crankcase. Several studies investigated this phenomenon of blowby. Tamminen et al. [5] found in their experiments that blow-by and the inter-ring pressures at higher load of engine. Tomanik et al. in [6] studied the impact of the top ring end-gap reduction on blow-by and saw thet the decrease of the top ring gap cand reduce the gas flow. Arnault et al. [7] made some experiments on a diesel engine and that the blow-by is higher at higher speed and load with a maximum value at full load and medium speed condition. Curtis in [8] in his experiments found that the engine speed is a factor that affects the ring dynamics and gas flow. In this paper is studied the pressure losses between the combustion chamber and crankase by and experimental setup to find the sealing characteristics of piston rings.

2 Methods and Materials

Figure 2 shows our experimental stand designed and realized at laboratory of Engines at Faculty of Mechanics of Craiova. The stand is composed by an air compressor (1) which has the role of introducing different air pressures by a hose (6) in to the cylinder of the engine. The cylinder of the engine is pressure sealed by using 2 clingherit sheets (9) on both ends and then thigtened with 2 metal plates with (8) 4 tightening screws (7). A gas valve (6) is mounted at the entrance to the cylinder to vary the air flow and a digital manometer (2) to measure the pressure at the top of the piston. The stand simulate the process of combustion and the rapid inscrease of pressure in the combustion chamber. The rings (3) seal the combustion chamber. The pressure losses are measured with digital manometer (5) and the air is released in to athmosphere by using gas valve (10). In Fig. 3 is presented the front view of the stand.

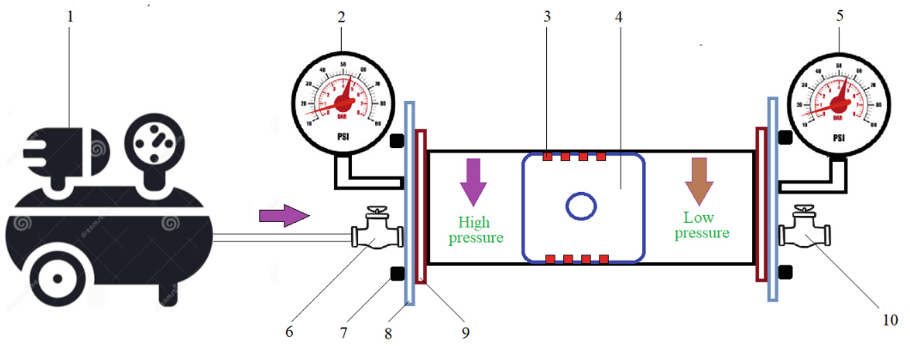

Fig. 2. Scheme of principle of the stand: 1-air compressor; 2-digital manometer; 3-rings; 4-piston; 5-digital manometer; 6-gas valve; 7-tighten rods; 8-metal plate; 9-clingherit sheet; 10-gas valve;

Fig. 3. Front view of the xperimental stand to investigate the sealing properties of piston rings

3 Results and Discussion

The ring pack is composed of four rings; a top ring (fire ring), a second ring (compression purpose), a third ring (for oil) and a four spring-loaded oil ring. The compressor generate a variable pressure to the piston head simulation the combustion processes; the pressure is recorded by two digital manometers located at the piston head and bottom. From Fig. 4 is seen the pressure losses between the combustion chamber and crankcase with a polynomial of second order expression. At higher values of pressure the rings losses their capacity to seal the combustion chamber and the force of the combustion gases is not transmitted to the crankcase. All the measurements were taken three times and the average value is taken in consideration.

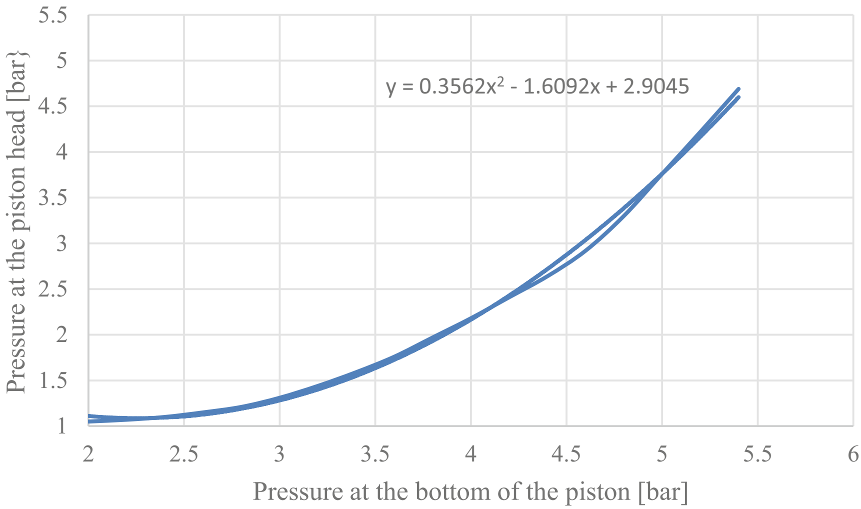

Fig. 4. Pressure losses variation

4 Conclusion

The present paper is focused on the investigation of the pressure losses between the combustion chamber and the crankcase. The piston ring assembly play an important role with to tasks; to restrict the excess oil from the cylinder liner walls and to prevent the blow of gases. Mechanical losses due to the piston ring and the pressure loses decrease the efficiency of internal combustion engines by increasing fuel consumption, loss of power and higher emissions. An experimental stand was designed and realized to study the pressure losses and a polynomial of second order expression was found. At higher pressure generated by the compressor the rings losses their capacity to seal the combustion chamber. The obtained results are in very good correlation with the literature.

References

1. Delprete C., Selmani E., Bisha A.: Gas escape to crankcase: impact of system parameters on sealing behavior of a piston cylinder ring pack. International Journal of Energy and Environmental Engineering, 10:207–220 (2019).
2. Raval T., Wadhwani D., Bhatt A., Raval N.: A review paper on redesigned piston rings to improve engine performance. 5th National Conference on Innovations in Mechanical Engineering, (2017).
3. Rozario A., Baumann C., Shah R.: The influence of a piston ring coating on thewear and friction generated during linear oscillation. Lubricants, 7(1):8, (2019).
4. Koszalka G. and Suchecki A., Analysis of design parameters of pistons and piston rings of a combustion engine. MATEC Web of Conferences 118, 00013 (2017).
5. Jaana T., Sandström C.E., and Nurmi Hannu: Influence of the piston inter-ring pressure on the ring pack behoviour in a medium speed diesel engine. No. 2005–01–3847, SAE Technical Paper, (2005).

6. Tomanik E., Sobrinho R.M.S., Zecchinelli R.: Influence of top ring end gap types at blow-by of internal combustion engines. No. 931669, SAE Technical Paper (1993).
7. Nicolas A. and Bonne S.: Engine lube-oil consumption stakes and benefits from significant blow-by oil mist reduction. No. 2012–01–1617, SAE Technical Paper, (2012).
8. Curtis, J.M.: Piston ring dynamics and its influence on the power cylinder performance. No. 810935, SAE Technical Paper, (1981).