ISSN (online): 2349-784X

A Technical Research on Piston Ring Coating of Single Cylinder Four Stroke SI Engine Fuelled with Compressed Natural Gas

Bhavik B. Hirapara
P.G. Student
Department of MechanicalEngineering
L D College of Engineering, Ahmedabad

Vijay C. Patel
P.G. Student
Department of MechanicalEngineering
L D College of Engineering, Ahmedabad

Hardik R Sharma
P.G. Student
Department of MechanicalEngineering
L D College of Engineering, Ahmedabad

Ritesh Kumar Ranjan
P.G. Student
Department of MechanicalEngineering
L D College of Engineering, Ahmedabad

Prof. P. D. Patel
Assistant Professor
Department of Automobile Engineering
L D College of Engineering, Ahmedabad

Abstract

Now a day's various methods are in use on cylinder piston group for improving service life of IC Engine for reducing exhaust emission and improving engine performance. The wear resistance of thermal sprayed molybdenum applicable to the piston ring is studied in this research. Wear resistance of molybdenum coated piston ring is high as compared to ordinary cast iron piston rings. Experiments on life cycle is performed on the compressed natural gas engine as per IS Standard for specified operating parameters. Oil lubricity test done on oil sample would gives measure of debris of wear. And wear effect on piston ring was investigated based on performance parameters like Brake Specific Fuel Consumption, Exhaust Gas Temperature, Brake Thermal Efficiency, Brake Specific Energy Consumption and Exhaust Emissions product like NOx, CO, CO2, HC, and O2. Result was compared for both coating and non coating condition. This research gives effect of piston ring coating on the performance and exhaust parameter by using Compressed Natural Gas in the four stroke SI Engine.
Keywords: Piston Ring Coating, SI Engine, Compressed Natural Gas, Oil lubricity test, Performance of SI Engine

I. INTRODUCTION

Internal Combustion Engine is a device in which heat is generated as a result of combustion process .This heat of combustion product is used to produce the work. To produce the work, the combustion is carried out in such a way that high pressure combustion product would be expanded through the piston. So engine life depends mainly on the part of the engine. So consequently service life of the engine can be increased by considering the part which dominates its major role in the working condition of the engine.

The split piston ring was invented by John Ramsbottom who reported the benefits to the Institution of Mechanical Engineers in 1854. It soon replaced the hemp packing hitherto used in steam engines. The use of piston rings at once dramatically reduced the frictional resistance, the leakage of stream, and the mass of the piston, leading to significant increase in power and efficiency and longer maintenance intervals.

Most automotive pistons have three rings: The top two while also controlling oil are primarily for compression sealing (compression rings); the lower ring is for controlling the supply of oil to the liner which lubricates the piston skirt and the compression rings (oil control rings). At least two piston rings are found on most piston and cylinder combination. Typical compression ring designs will have an essentially rectangular cross section or a keystone (right angled trapezoidal) cross section. The periphery will then have either a barrel profile (top compression rings) or a taper napier form (second compression rings or scraper rings). There are some taper faced top rings and on some old engines simple plain faced rings were used.

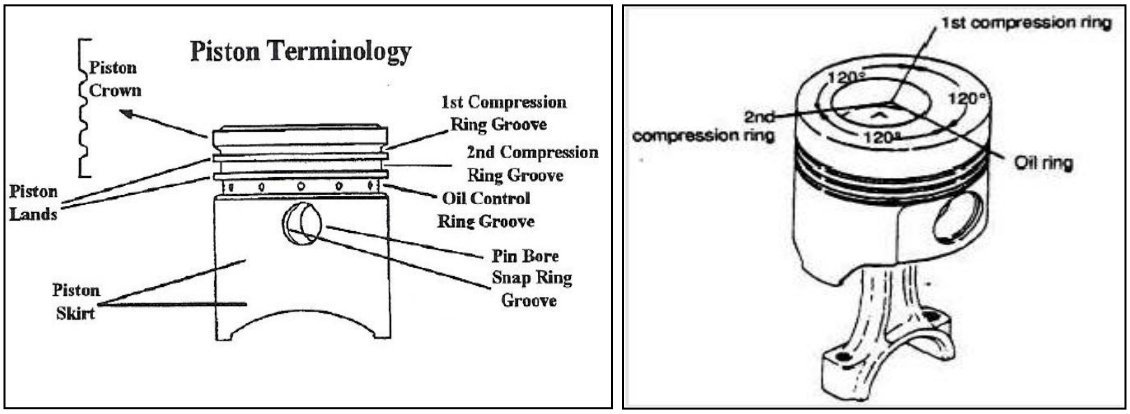

Fig. 1: Piston Ring Terminology (Left) and Facing of Piston Ring (Right)

The piston might be a fairly loose fit in the cylinder. If it were a tight fit, it would expand as it got hot and might stick tight in the cylinder. If a piston sticks (seizes) it could cause serious damage to the engine. On the other hand, if there is too much clearance between the piston and cylinder walls, much of the pressure from the burning gasoline vapour will leak past the piston (a condition known as blow-by) and into the crankcase, and the push on the piston from combustion will be much less effective in delivering power.[3]

Piston rings for current internal combustion engines is meeting all the requirements of a dynamic seal for linear motion that operates under demanding thermal and chemical conditions. In short, the following requirements for piston rings can be identified:

- It has to offer Low friction for supporting the high power efficiency rate.
- Its wear should be lower for ensuring a long operational lifetime.
- It provides good sealing capability and low blow-by for supporting the power efficiency rate.
- Low wear of the piston ring radial wall leads to retaining the desired surface texture of the cylinder liner.
- It reduces exhaust emission by suppressing and limiting the flow of engine oil to the combustion chamber.
- It provides good resistance against mechano- thermal fatigue, chemical attacks and hot erosion.
- It should give reliable operation and cost effectiveness for a significantly long time.

II. EXPERIMENTAL SETUP AND PHYSICAL VISUALIZATION

Experiment is done on the GL400, Air Cooled , four stroke SI (converted into CNG) Engine For the life cycle testing of the piston ring without coating and then same is investigated with that of moly-coated piston ring. As per IS Standard part V piston ring wear for the 100 hr was carried out for the performance and exhaust parameters. Fig. Shows the actual experimental set-up prepared for life cycle test and physical visualization for the same during the experiment.


Fig. 2: Physical Visualization of Experimental Performance

First GL400 Engine was converted into the Compressed Natural Gas and based on that experimental setup was prepared. Engine was fitted with the new purchased piston ring namely first compression ring, second compression ring, third compression ring and the oil control ring. Also measurement of wear of piston ring can be analysed by any of three methods: 1.) Dimensional measurement 2.) Oil sample sediments (debris) result. 3). Weight measurement method. In this research first two technique were followed. Piston rings were coated with molybdenum by thermal spray coating method. Oil sample result have been taken at each 50 hr cycle. Concentration was given at the kinematic viscosity of oil, sulphated ash content in the oil sample ,and metal stripe corrosion particle(Co, Cu, Mn, Mg) in the oil debris. For the dimension of piston ring wear of the axial wall thickness, radial wall thickness, piston ring end gap is measured.

III. RESULT OF EXPERIMENT

Observation of experiment includes measurement of performance parameter and Exhaust parameter. Continuous observation during the life cycle included manometer reading, fuel consumption time reading confirmed with digital weight scale, applied load ,exhaust gas composition reading (by AVL gas analyser), Exhaust gas temperature measurement by radiation pyrometer and output brake power was measured with Ammeter and Voltmeter connected to the load penal.
Following is the result and effect of piston ring coating on the life cycle of compressed natural gas engine.

A. NOx Vs Load

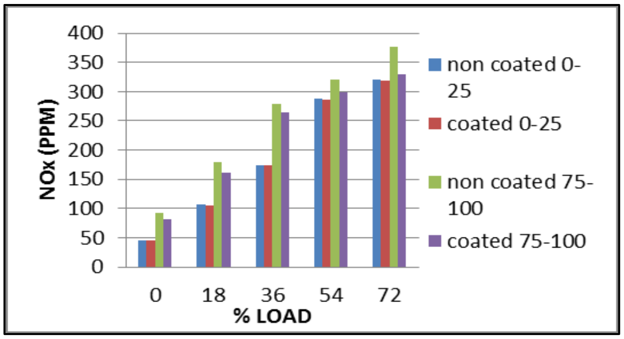

Fig. 3: NOx Vs Load

B. HC Vs Load:

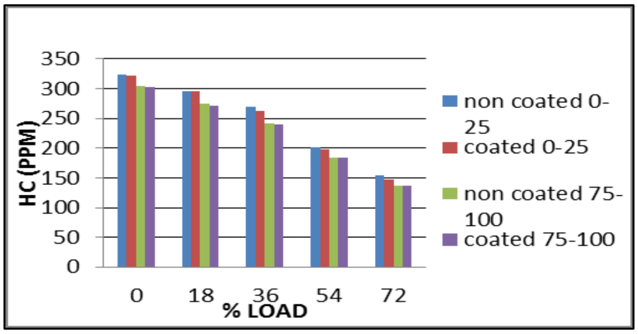

Fig. 4: HC Vs Load

C. Brake Thermal Efficiency Vs Load:

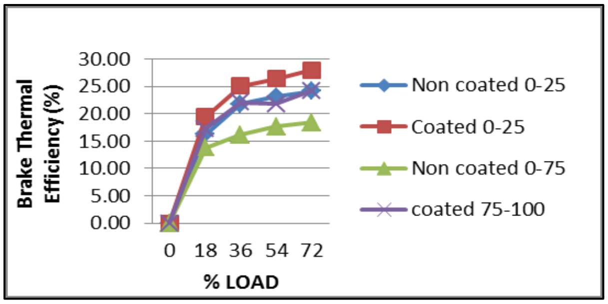

Fig. 5: Brake Thermal Efficiency Vs Load

D. Fuel Consumption Vs Load:

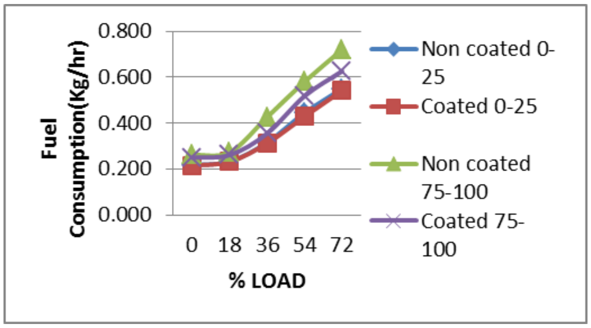

Fig. 6: Fuel Consumption Vs Load

E. Brake Specific Energy Consumption Vs Load:

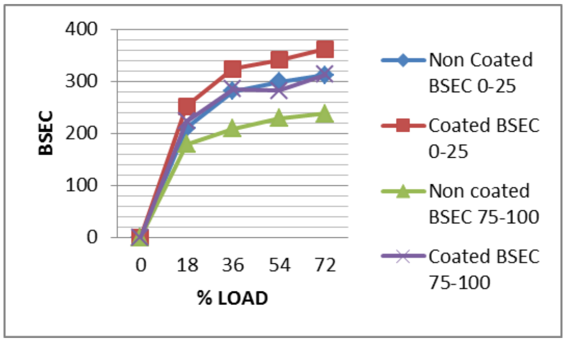

Fig. 7: Brake Specific Energy Consumption Vs Load

F. Exhaust Gas Temperature Vs Load:

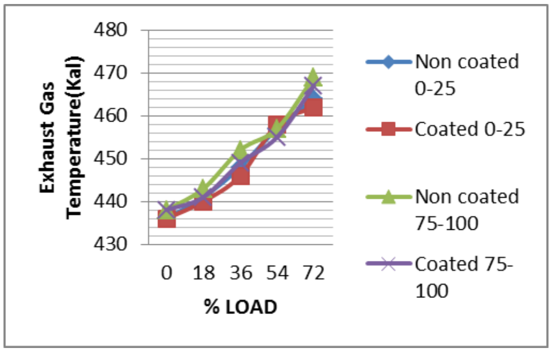

Fig. 8: Exhaust Gas Temperature Vs Load

G. Radial wall thickness Vs Cycle Time:

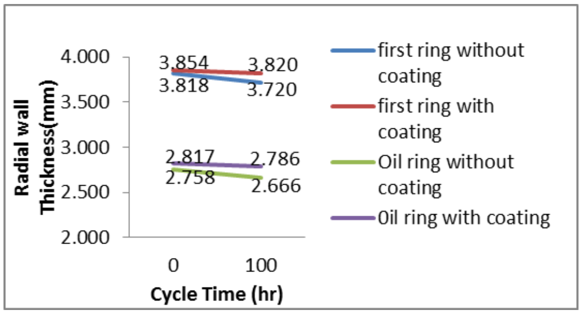

Fig. 9: Radial Wall Thickness Vs Cycle Time

H. Ring End Gap Vs Cycle Time:

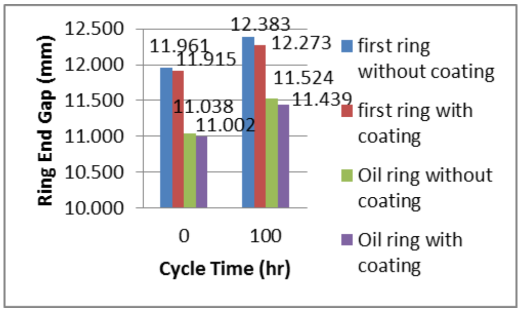

Fig. 10: Ring End Gap Vs Cycle Time

I. Metal Debris Vs Cycle Time:

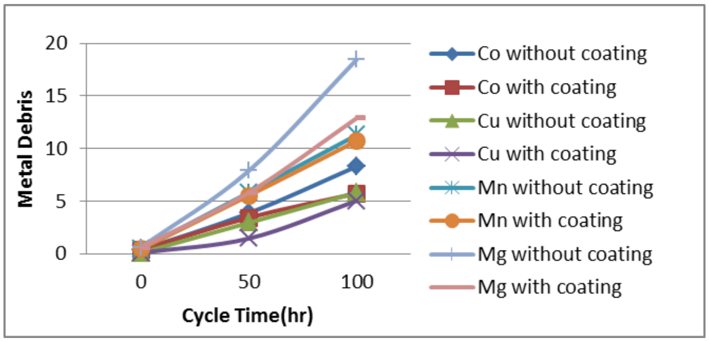

Fig. 11: Metal Debris Vs Cycle Time

J. Sulphated Ash Particle Vs Cycle Time:

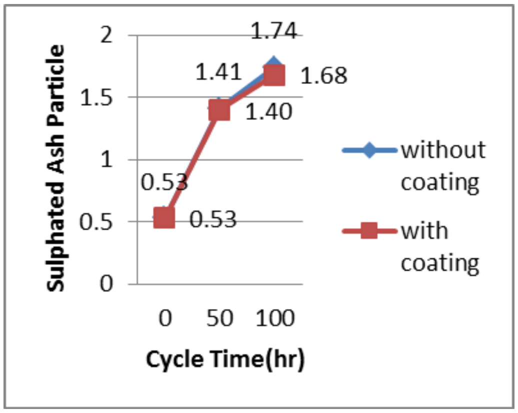

Fig. 12: Sulphated Ash Particle Vs Cycle Time

IV. Result and Discussion

From the above graph, the NOx showed the increase with increase in the load in the Engine. Coating of the piston ring it showed decrease in the Exhaust gas pollutant like NOx, HC , CO etc. HC and O_2 emission reduced with load. Brake Thermal Efficiency increased with increase in the load. But in the 75-100 hr range it was less than that of 0-25 hr cycle. In the same way fuel consumption increased with the increase in the load. Brake Specific energy consumption and Exhaust gas temperature increased with the load.

Result of dimension and oil debris showed that the wear in the piston ring with coating is less in amount than non-coated condition. Also oil sample at the end of 50 hr and 100 hr cycle with coating showed improvement in the Molybdenum coated piston ring. Sulphated Ash particle was found to be decreased in the oil sample of Molybdenum coated piston-ring. Kinematic viscosity of tested oil sample report showed increase with the cycle but was found less in coating condition.

V. CONCLUSION

Plasma spray method is best method for coating hard metal to increase the wear resistance of the material.
Brake Specific Energy consumption and Brake thermal efficiency increases by 31.73%. and Brake Specific fuel consumption increases by the 24.1586%.
Exhaust Gas Temperature shows reduction with coating condition.
Exhaust gas shows reduction in the component particle like Nitrogen Oxide, Carbon moxide, Carbon dioxide, and hydrocarbon
Brake power increases by 14.18 % in the piston ring coating than that of without coating.

ACKNOWLEDGEMENT

The author, Bhavik B. Hirapara would like to express their thanks to prof. P. D. Patel of automobile department and all the staff members of mechanical and automobile engineering department of L.D. College of engineering for motivation, valuable guidance and warm support.

REFERENCE

[1] P.M.Patel, Experimental Investigation on Life Cycle Analysis of The Moly (Mo) Coated Piston Ring In C.I.Engine, (2012)
[2] Kevin C. Radil, Test Method to Evaluate Cylinder Liner-Piston Ring Coatings for Advanced Heat Engines (1996) 14, pp:114
[3] Dr. Marcus Kennedy, Dr. Steffen Hoppe, Johannes Esser, studied, Piston ring coating reduces the gasoline engine friction (2012)
[4] Friedrich a, G. Berg a, E. Broszeit a, F. Rick b, J. Holland, PVD CrxN coatings for tribological application on piston rings (1997) 8, pp:661 – 668
[5] Yucong Wang, Simon C. Tung, Scuffing and wear behavior of aluminum piston skirt coatings against aluminum cylinder bore (1999) 9, pp: 1101 – 110
[6] P.N. Bindumadhavan , S. Makesh, N. Gowrishankar , Heng Keng Wah, O. Prabhakar , Aluminizing and subsequent nitriding of plain carbon low alloy steels for piston ring applications (2000) 8, pp:252 – 259
[7] Yucong Wang,∗, Kevin Brogan , Simon C. Tung , Wear and scuffing characteristics of composite polymer and nickel/ceramic composite coated piston skirts against aluminum and cast iron cylinder bores (2001) 12, pp:706 – 717
[8] B. Bryskin, galvanic chrome plating of piston rings is the most common way to improve engine performance(2002)
[9] T. Yoshimitsu, et al., SAE No 840431 5) A. Levy, et al., Wear, 101 (1985) P127
[10] Shan-Ping, Oh-Yang, Wear behavior of brazed WC/NiCrBSi(Co) composite coatings (2003) 8, pp:421 – 42
[11] Jeehoon Ahn, Byoungchul Hwang, and Sunghak Lee, Improvement of Wear Resistance of Plasma-Sprayed Molybdenum Blend Coatings (2004) 7, pp: 251-257
[12] M.B. Karamis, K. Yıldızlı, H. C¸akırer, An evaluation of surface properties and frictional forces generated from Al–Mo–Ni coating on piston ring (2004) 10, pp:191 – 201
[13] J.A. Picas, A. Forn , G. Matthaaus, HVOF coatings as an alternative to hard chrome for pistons and valves (2006) 8, pp:477 – 484
[14] NG Ka Jun, Farhad B. Bahaaideen ,Dr. Horizon GITANO-BRIGGS, Dr. Zaidi Mohd. RIPIN, Friction and Wear Characteristics of TiC Surface Coatings in a Small Two-Stroke Utility Engine (2008) 7, pp:1-7
[15] Dae-Hyun CHO, Evaluation of ring surfaces with several coatings for friction, wear and scuffing life(2009), 8
[16] Mr. Shailesh Dhomne, Dr. A. M. Mahalle, Mr. Mohammad Ayaz Afsar, Experimental and Computational Investigations on Piston Coated Externally Scavenged S.I. Engine(2014) pp:81-85
[17] Michael Anderson Marr, Study on An investigation of metal and ceramic thermal barrier coatings in a spark-ignition Engine (2009)
[18] J.Rajasekaran, B.M.Gnanasekaran, T.Senthilkumar, B.Kumaragurubaran, M.chandrasekar, Effect of thermal barrier coating for the improvement of S. I. Engine performance & emission characteristics (2013)
[19] Sarka Houdkova, Michaela Kasparova, Frantisek Zahalka, the friction properties of HVOF sprayed hardmetal coatings (2010)pp:1-6