"EXPERIMENTAL ANALYSIS OF CAM AND FOLLOWER OF VALVE TRAIN SYSTEM FOR PREDICTION OF WEAR-RATE"

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ABSTRACT

A particular type of contact condition, known as cam and follower contact, exists in the direct valve train system of an engine and is partly responsible for wear. In this thesis the wear analysis of cam and follower contact system are analyzed. Based upon the theoretical analyses, a theoretical model for evaluating the tribological performance of the valve train was developed. A multi-aspect comparison between theoretical and experimental results was made. A good agreement between theoretical and experimental results showed that the model provided a reliable prediction of the tribological characteristics of the cam/follower. To understand the wear behavior of different MMC materials, wear tests are often carried out with suitable wear testing techniques. There are different types of wear mechanisms involved, for example, adhesive wear, abrasive wear, or others. However, adhesive wear is by far the most dominant form of material loss among sliding components in machinery the pin-on-disc test is a classical method commonly used for adhesive wear experiments. During the experiment, the sliding between the pin and disc may result in wear on both contact surfaces of the pair.

Keywords: *cam and follower, wear, pin-on-disc, MMC materials, and tribological characteristics*

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1 INTRODUCTION

Camshaft is one component of the internal combustion engine that engineers are always concerned about how to predict and extend the service life. Variables like lift profile and material of the cam, valve trains configuration and manufacturing process are responsible for the fatigue performance of the camshaft. High values of stress in the peak of the cam are the main responsible of cam damage. Cams are commonly used in opening and closing of valves in internal combustion engines. Both the inlet and outlet valves are regulated using cam and follower. The study of cam and follower mechanism becomes important for desired and required performance of the engines [1]. Wear can be defined as the removal of material from solid surfaces as a result of mechanical action. The amount of material removed is often quite small for contact surfaces in high performance machines or machines with long life. Wear can appear in many ways depending on the material of the interacting contact surfaces, the environment and the running conditions. From an engineering point of view, wear is often classified as mild or severe. Mild wear is what the engineers strive for. That can be obtained by proper form and topography of the contact surfaces. Convenient materials and treatments of the surfaces are also necessary in order to get a mild wear condition. However, often the lubrication of the surfaces is the most important factor in order to secure that a mild wear condition is obtained. Sometimes, severe wear may occur, giving rough or failed surfaces. A severe wear situation is not acceptable in any machine and must therefore be avoided [3]. As part of the continuing effort to understand the tribological performance of the cam and follower, the present study will analyze surface wear analysis of cam and follower system. It also consisted of two methods; these are theoretical analyses and experimental analysis. Finally the comparison between the theoretical and experimental analysis results will be attained in this thesis. It is believed that the present work including both theoretical analyses and experimental analysis has improved the understanding of the tribological performance of the cam and follower.

2 SIGNIFICANCE AND USE

In order to estimate the cam wear intensity, the dynamic analysis of the valve gear system was made

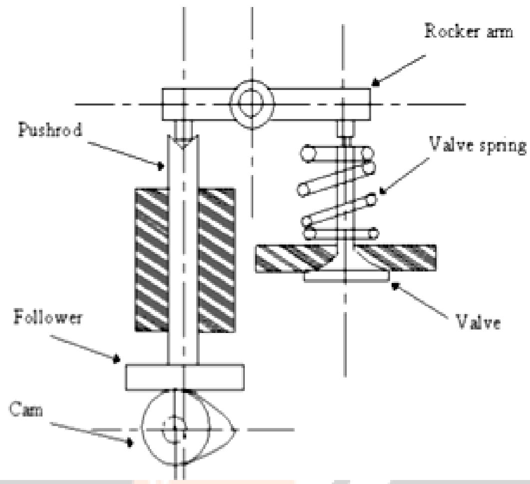

Fig- 1 Schematic diagram of pushrod type valve train system with flat-faced follower

The amount of wear in any system will, in general, depend upon the number of system factors such as the applied load, machine characteristics, sliding speed, sliding distance, the environment, and the material properties. The value of any wear test method lies in predicting the relative ranking of material combinations. Since the pin-on-disc test method does not attempt to duplicate all the conditions that may be experienced in service (for example; lubrication, load, pressure, contact geometry, removal of wear debris, and presence of corrosive environment), there is no ensurance that the test will predict the wear rate of a given material under conditions differing from those in the test.

3 CALCULATION

Wear measurements by pin on disk should be reported as the volume loss the wear measurements should be reported as the volume loss in cubic millimeters for the pin and disc, separately.
Use the following equations for calculating volume losses when the pin has initially a spherical end shape of radius R and the disc is initially flat, under the conditions that only one of the two members wears significantly:

$$\text{Pin (spherical end) volume loss, mm3} = \frac{\pi(\text{Wear Scar Diameter,mm})^4}{64(\text{Sphere Radius , mm})} \qquad \text{(I)}$$

Assuming that there is no significant discs wear. This is an approximate geometric relation that is correct to 1 % for (wear scar diameter/sphere radius) < 0.3, and is correct to 5 % for (wear scar diameter/sphere radius) < 0.7.

$$\text{Disk volume loss mm}^3 = \frac{\pi(\text{Wear Scar Diameter,mm})\ (\text{Track Width})^3}{6(\text{Sphere Radius , mm})} \qquad \text{(II)}$$

Assuming that there is no significant pin wears. This is an approximate geometric relation that is correct to 1 % for (wear track width/sphere radius) < 0.3, and is correct to 5 % for (wear track width/sphere radius) < 0.8. Calculation of wear volumes for pin shapes of other geometries use the appropriate geometric relations, recognizing that assumptions regarding wear of each member may be required to justify the assumed final geometry.

4 RESULT

The dry sliding wear test was performed with three parameters: applied load, sliding speed and sliding distance and varying them for three levels. The aim of the experimental plan is to find the important factors and the combination of factors influencing the wear process to achieve the minimum wear rate and COF. The experiments were developed based on an OA, with the aim of relating the influence of sliding speed, applied load and sliding distance. These design parameters are distinct and intrinsic feature of the process that influence and determine the composite performance.

4.1 Wear Rate and Friction Force at Different Speed without Coating

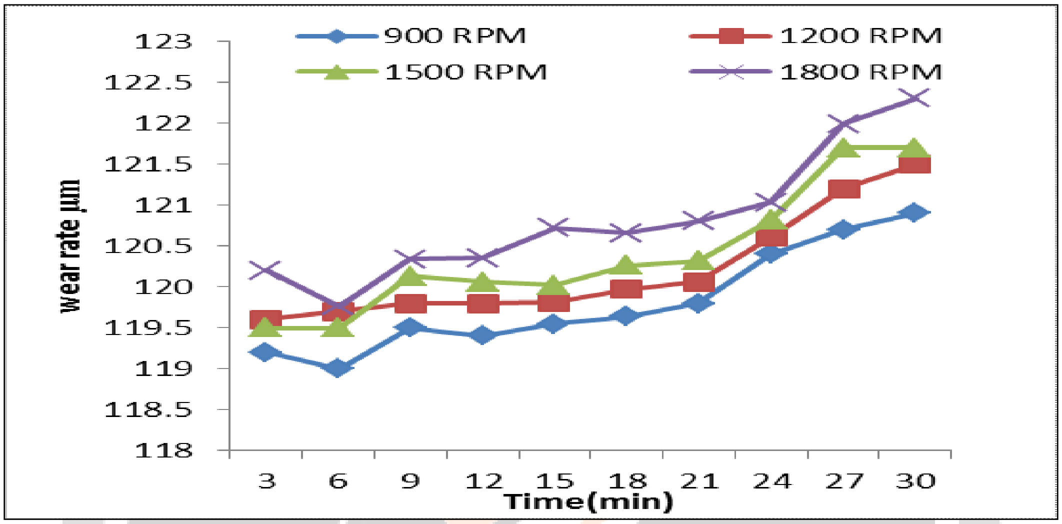

Fig- 2 wear rate for without coating

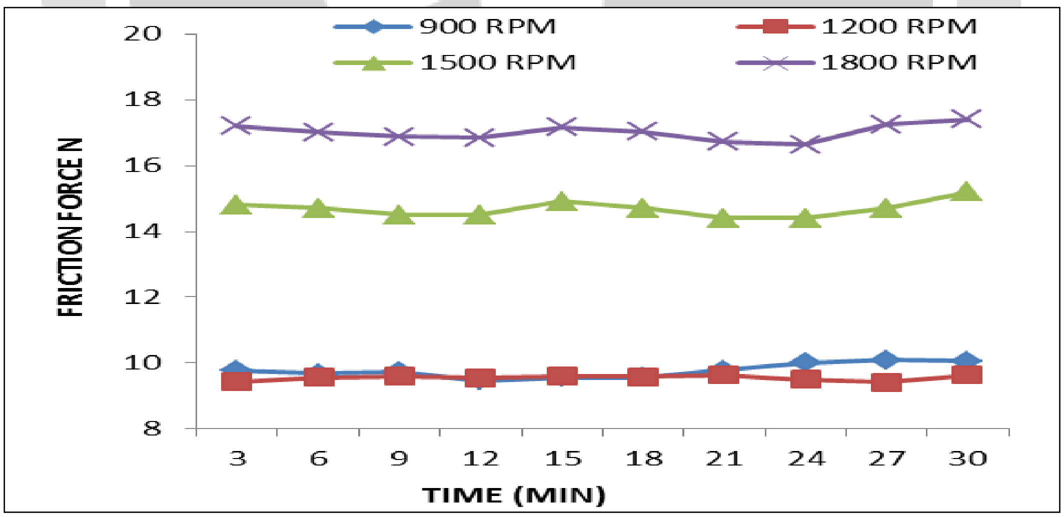

Fig- 3 Friction force for without coating

The wear rate vs. time diagram shown in fig.2. that wear rate is min for 900 rpm and max for 1800 rpm, as well as wear rate is increasing with increase in speed (rpm).Fig.3. illustrate the distribution of friction force along the disc min friction force occurs at 1200 rpm which is 9.55 N, and max friction force occurs at 1800 rpm, which is 17.54 N.

4.2 Wear Rate and Friction Force at Different Speed Chromium coating

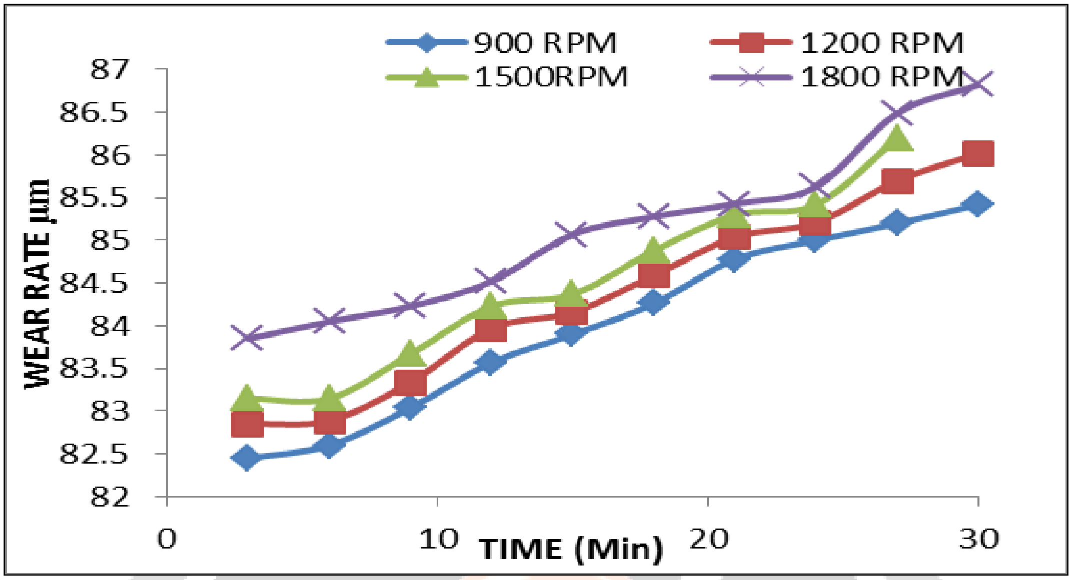

Fig- 4 wear rate for with Chromium coating

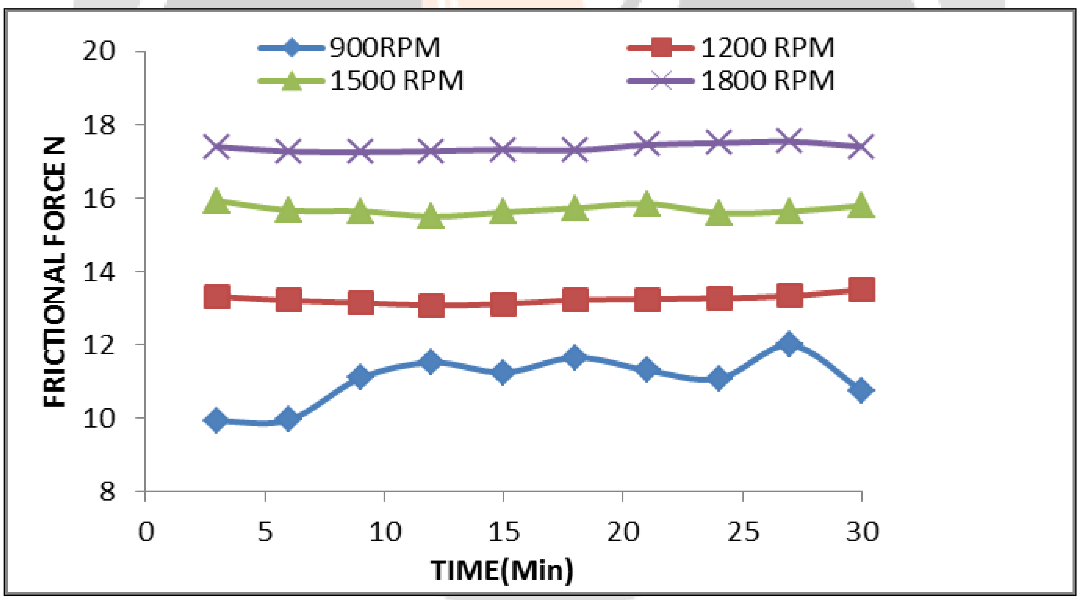

Fig- 5 Friction force for with Chromium coating

The wear rate vs. time diagram shown in fig 4. that wear rate is min for 900 rpm and max for 1800 rpm, as well as wear rate is increasing with increase in speed (rpm).Fig.5. illustrate the distribution of friction force along the disc min friction force occurs at 900 rpm which is 11.055 N, and max friction force occurs at 1800 rpm, which is 17.371 N.

4.3 Wear Rate and Friction Force at Different Speed manganese phosphate Coating

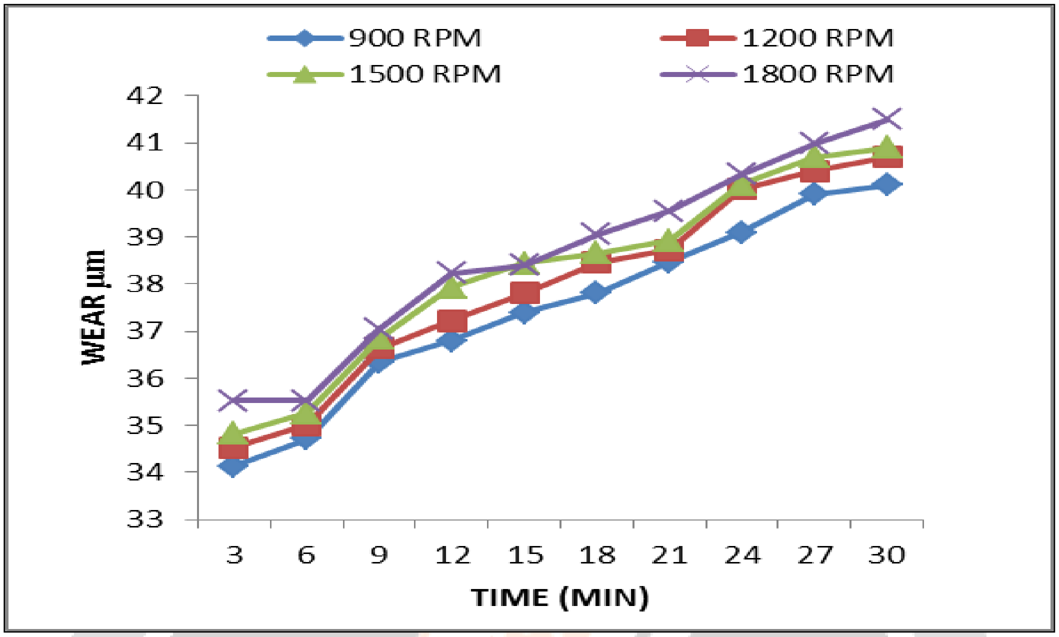

Fig- 6 wear rate for with manganese phosphate coating

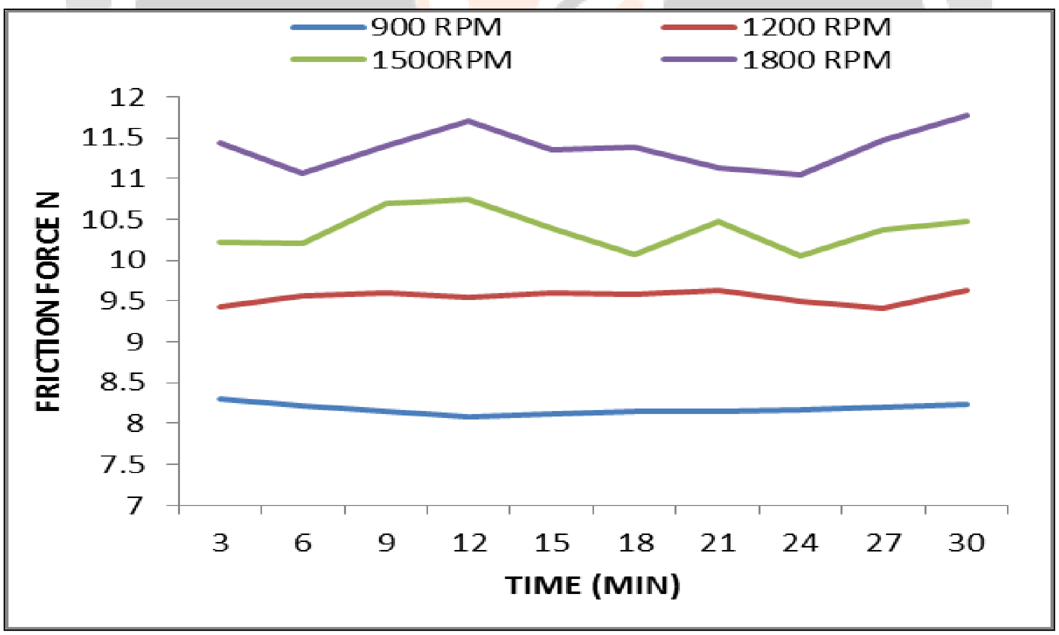

Fig- 7 Friction force for with manganese phosphate coating

The wear rate vs. time diagram shown in fig.6 that wear rate is min for 900 rpm and max for 1800 rpm, as well as wear rate is increasing with increase in speed (rpm).Fig.7. illustrate the distribution of friction force along the disc min friction force occurs at 900 rpm which is 8.179 N, and max friction force occurs at 1800 rpm, which is 11.376 N.

4.4 Wear Rate and Friction Force at Different Speed silicon nitrite Coating

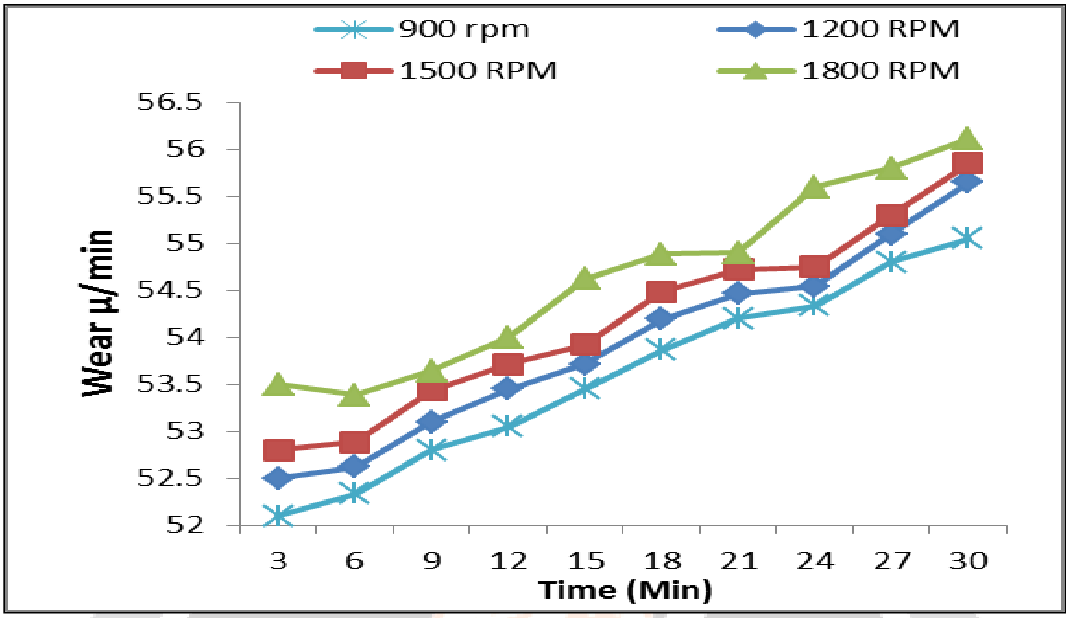

Fig- 8 wear rate for with manganese silicon nitrite coating

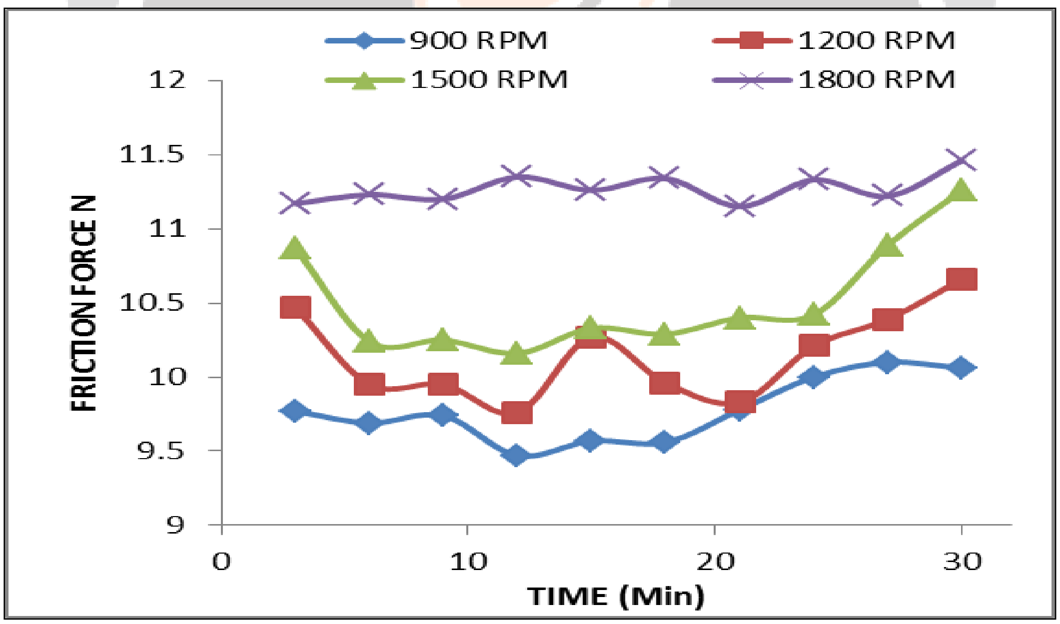

Fig- 9 Friction force for with manganese silicon nitrite coating

The wear rate vs. time diagram shown in fig 8.that wear rate is min for 900 rpm and max for 1800 rpm, as well as wear rate is increasing with increase in speed (rpm).Fig 9.illustrate the distribution of friction force along the disc min friction force occurs at 900 rpm which is 9.774 N, and max friction force occurs at 1800 rpm, which is 11.271 N.

If we analyze the comparison of wear calculated from the contact result of different metallic matrix and sliding speed both results of wear is in good agreement the wear increases with the increase of cam rotation speed, and the wear is also increases in without coating and lesser in the manganese phosphate relatively its speed which is shown in figure as below.

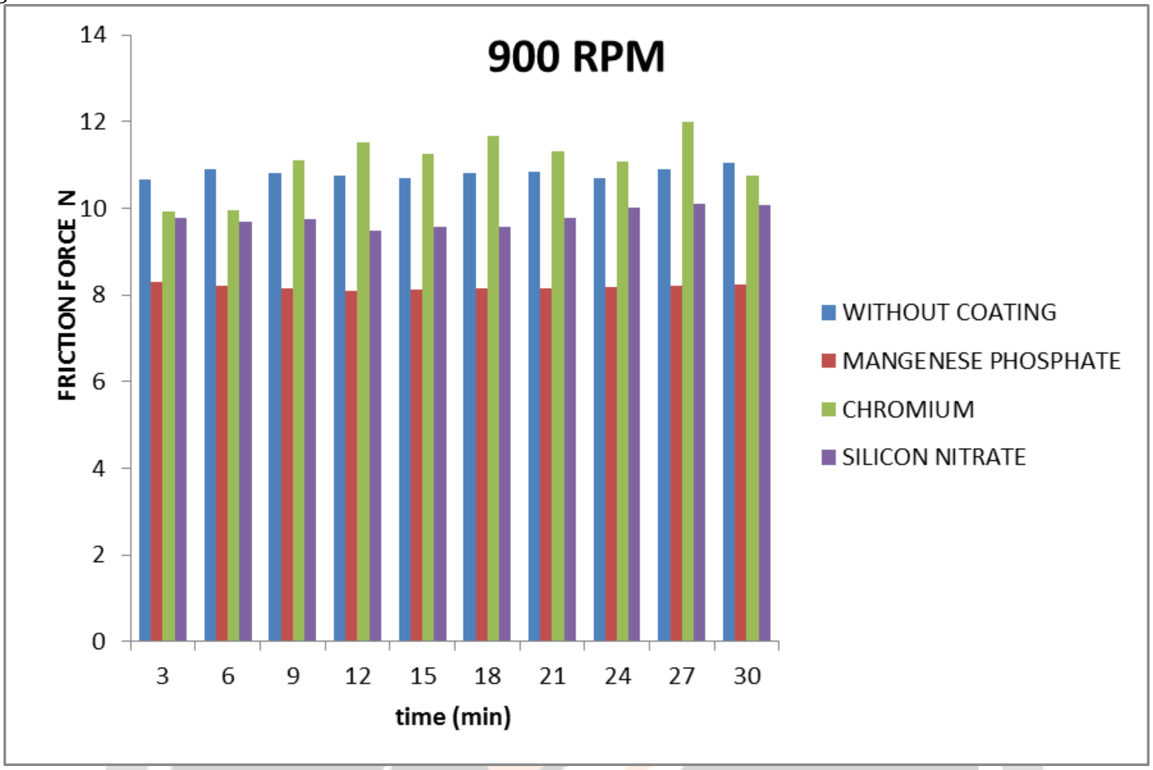

Fig- 10 friction force for different material at 900 rpm

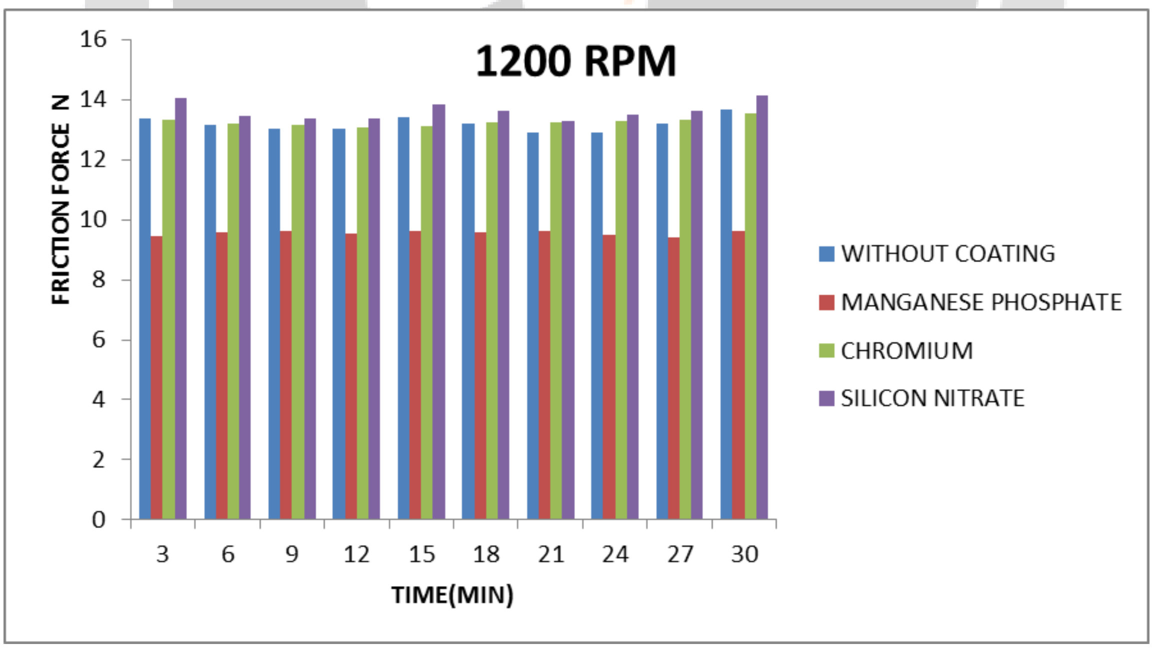

Fig- 11 friction force for different material at 1200 rpm

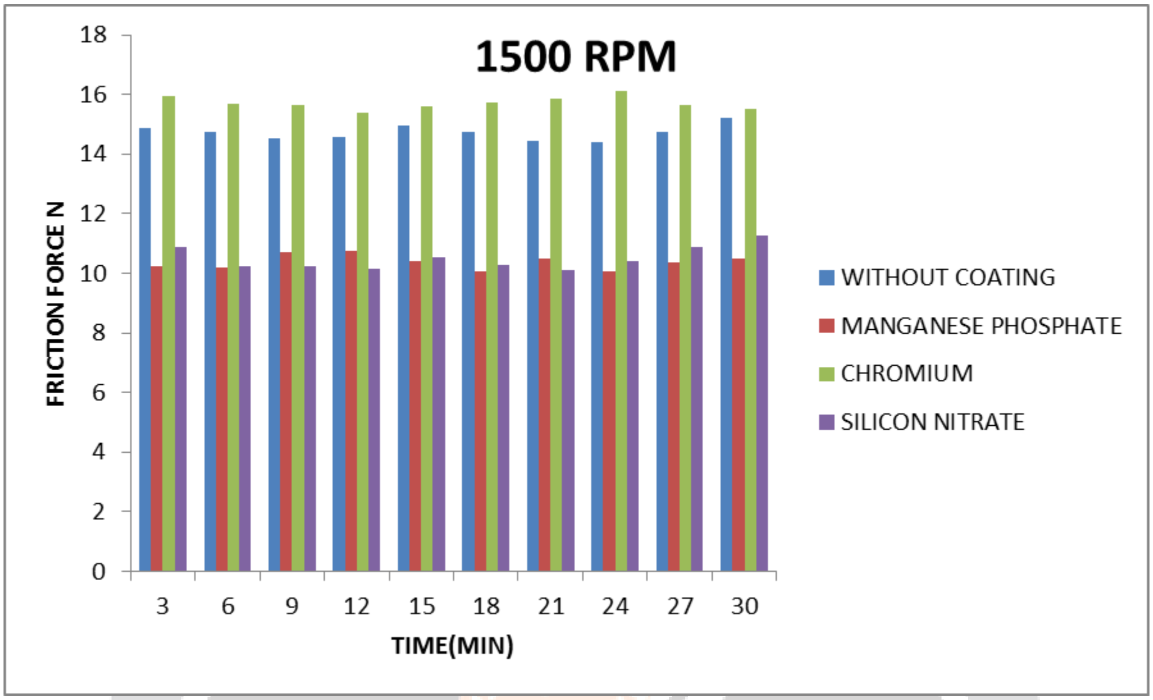

Fig- 12 friction force for different material at 1500 rpm

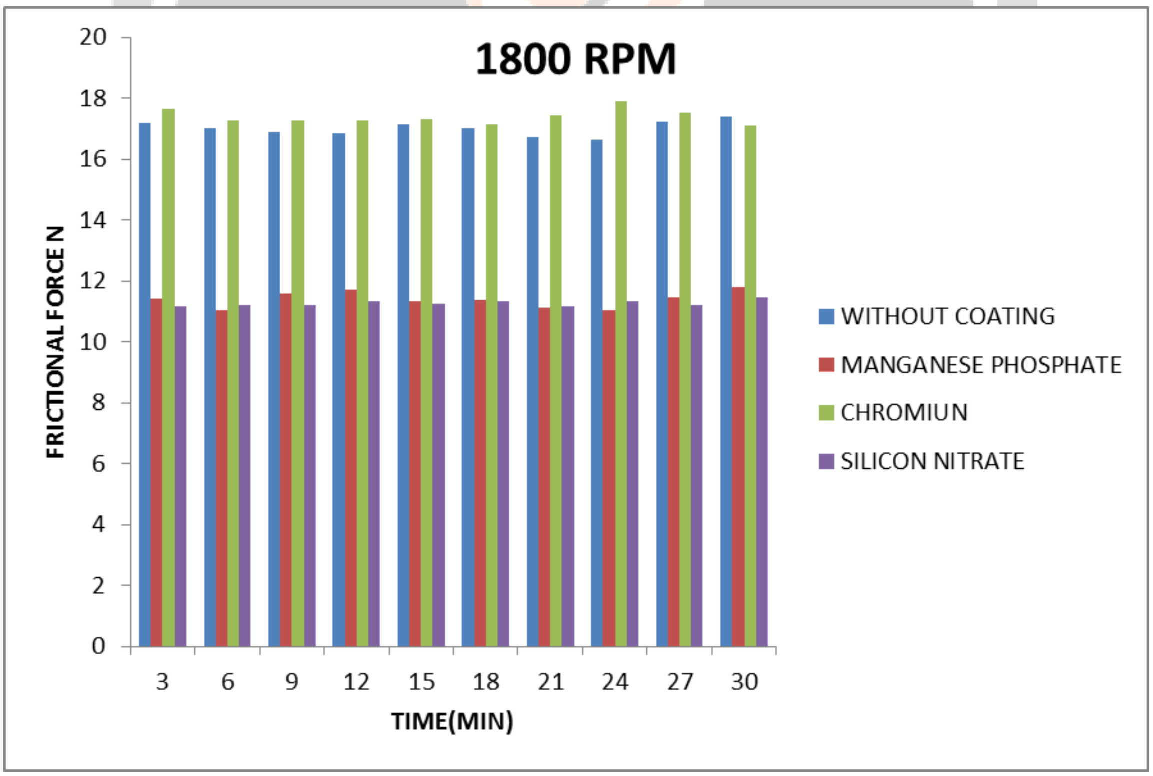

Fig- 13 friction force for different material at 1800 rpm

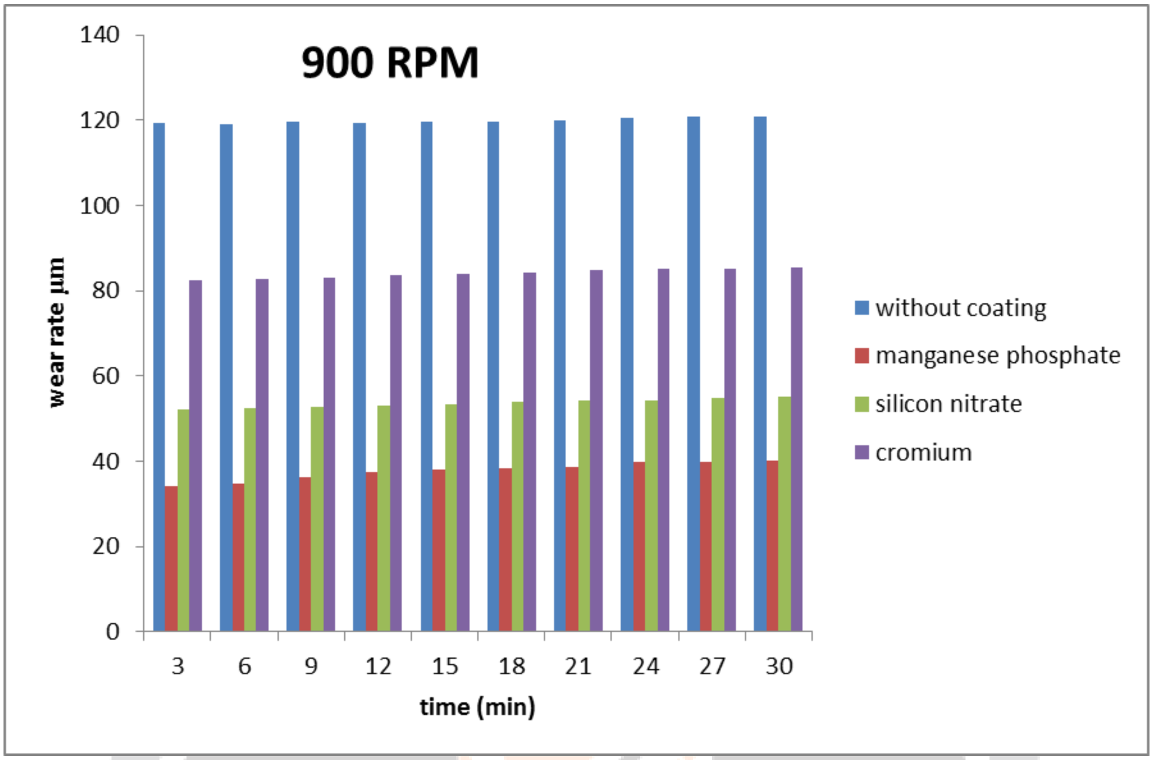

Fig- 14 wear rate for different material at 900 rpm

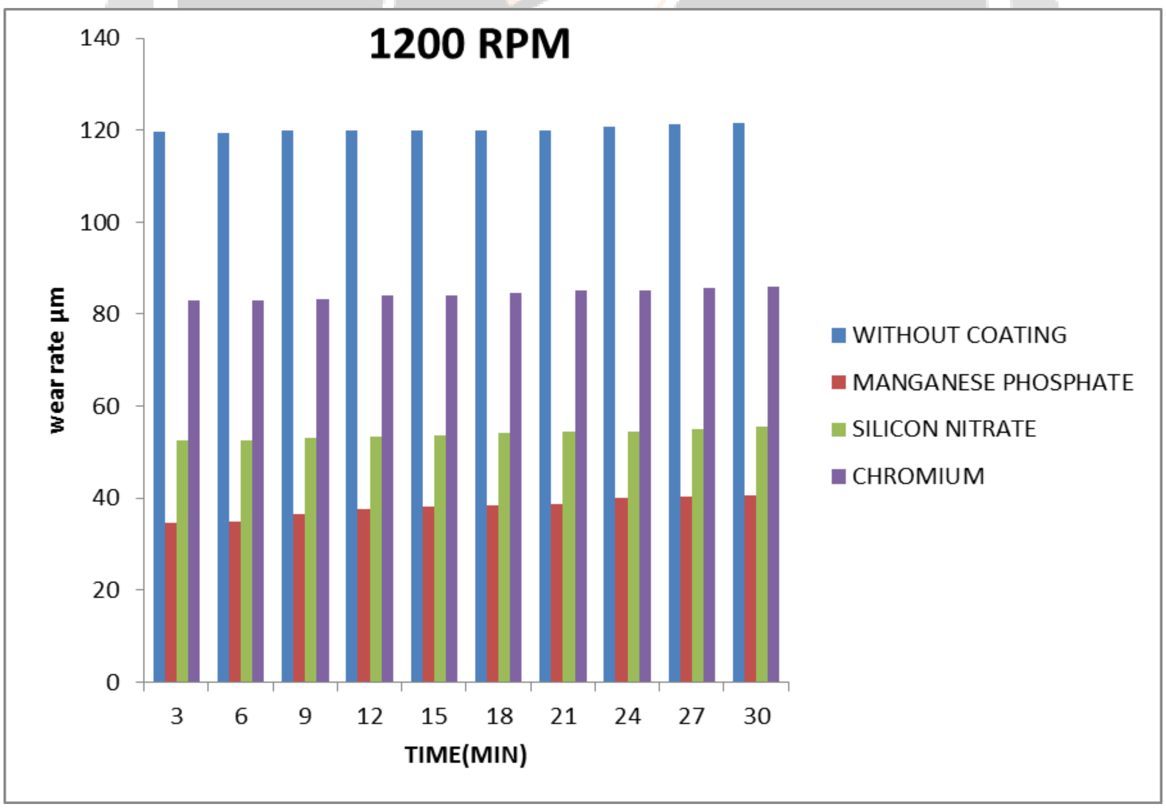

Fig- 15 wear rate for different material at 1200 rpm

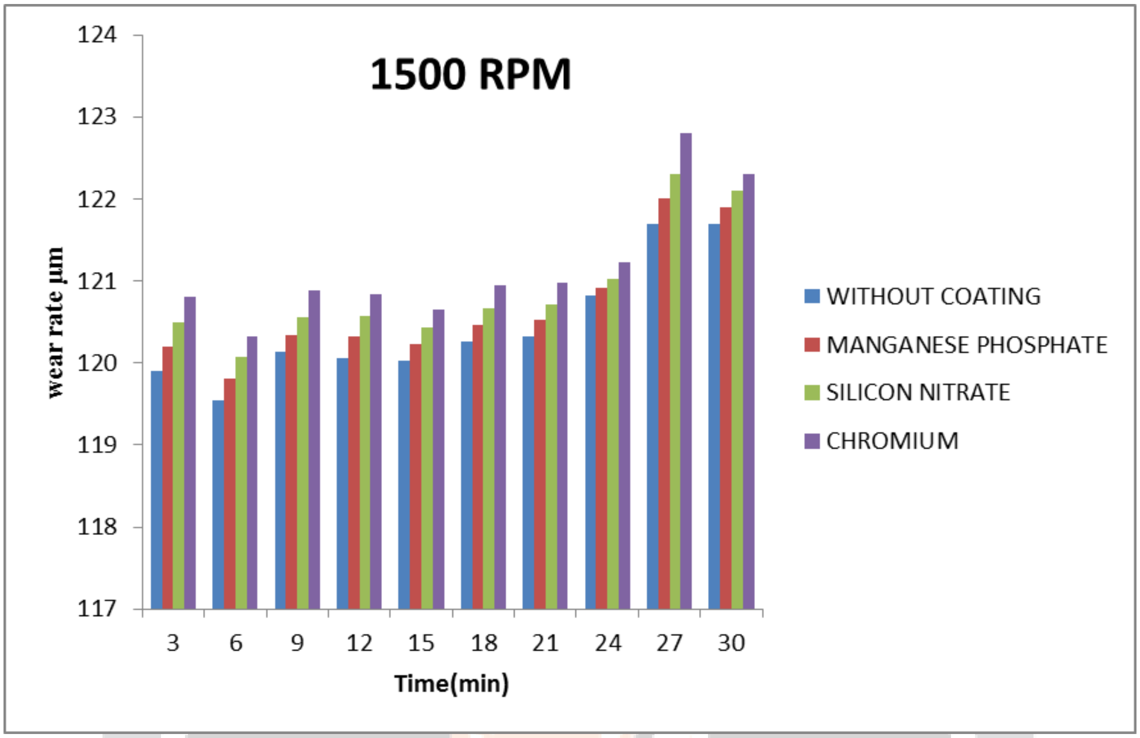

Fig- 16 wear rate for different material at 1500 rpm

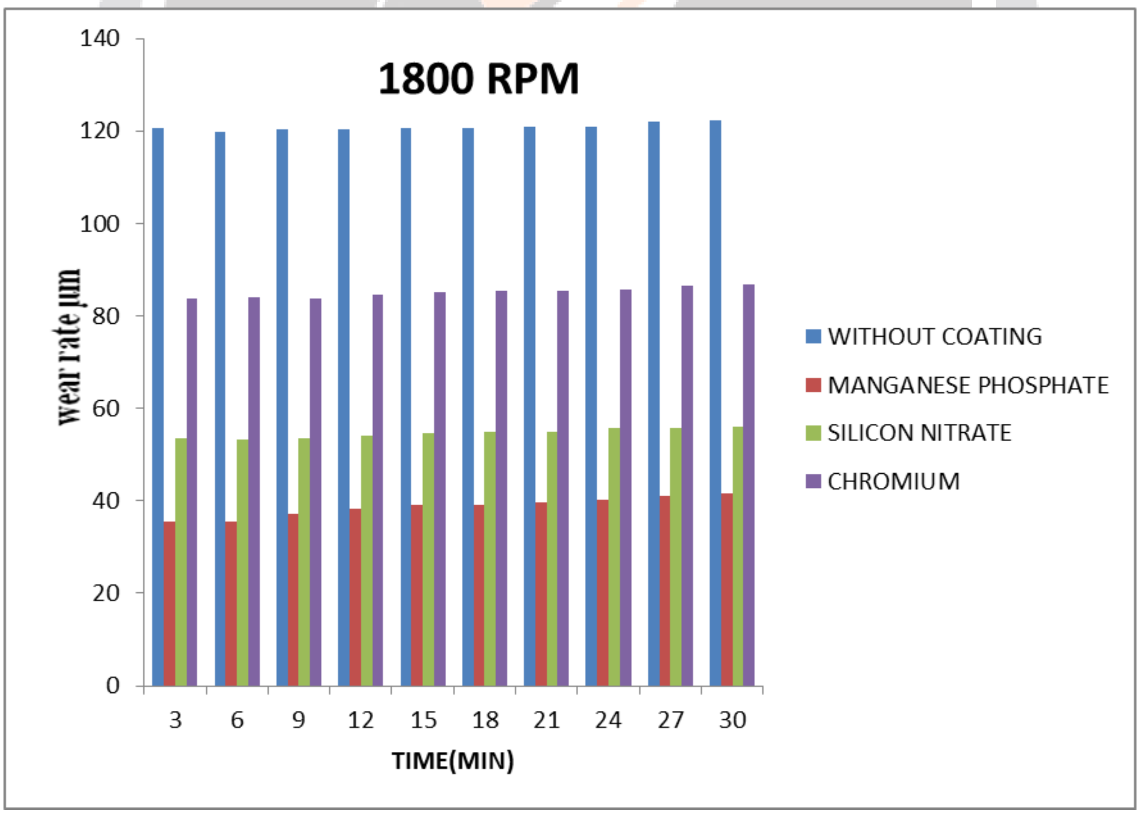

Fig- 17 wear rate for different material at 1800 rpm

From the comparative assessment of different coating material chromium, manganese phosphate and silicon nitride the best material according to wear rate and friction force is manganese phosphate. After that silicon nitride and chromium are best suitable in descending order for wear rate as well as friction force. Experimental observation predicts that the cam rotational speed has a significant influence not only on the actual load on the cam but also on the surface wear of the contacting element. The presence of sliding speed affects the friction force and wear rate considerably. The values of friction increase with the increase of sliding speed. Therefore maintaining appropriate level of sliding speed friction and wear may be kept to some lower value to improve mechanical processes.

5 CONCLUSIONS

An Experimental work has been done for predicting the valve train tribological performance of cam and follower which include the surface wear analysis on cam/follower contact. Furthermore, the experimental results has been undertaken. From the experimental work we can say all materials having less wear rate than without coating as well as friction force acting on contact surface is also less with coating surfaces. For manganese phosphate range of wear rate is 34µ/min to 40µ/min. Which one is the minimum from all other materials. While wear rate is maximum at 1800 rpm for without coating? So, it is advisable to coating the cam with manganese phosphate. Data obtained from experiment about friction force are very near to wear rate. Here also manganese phosphate is the best material with minimum force of 8.179 N at 900 rpm. For without coating 17.54 N forces measured at 1800 rpm which one is maximum from experiment.

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