Experimental Investigation on Effect of Plasma Nitriding on Wear of Chain-Sprocket Assembly Used In Motorcycle

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Abstract— Now a day's different materials are used to coat on parts of vehicles which have friction between them to reduce wear characteristic. The wear resistance after Nitriding Process applicable to the Chain-Sprocket assembly is investigated in this study. Among Nitriding methods, plasma Nitriding is most widely applied in the automotive industries, because it is been applied at low temperature and so that the original properties of sprocket will not be harmed. Wear Resistance of Plasma nitrided chain-sprocket assembly is very high as compared to ordinary assembly. The friction due to meshing between chain and sprocket is of major concern and some of the power of engine gets wasted as friction loss. Plasma Nitriding will give high wear resistance so that, wear will decrease and eventually life of chain and sprocket will increase compared to ordinary one. Friction loss will decrease which can improve transmission efficiency of motorcycle.

Keywords: Chain-sprocket, Plasma Nitriding, Wear Resistance.

I. INTRODUCTION

Motorcycle is widely used two wheeled vehicle worldwide. The motion transmission from one wheel to other in the motor cycle is a major concern. Chain drives are used on the vast majority of motorcycles because they are much more efficient than belt drives and prop shafts.

One of the key problems until now has been that there have been no equations for calculating the efficiency of a motorcycle chain. This makes it difficult to determine the optimum size of sprockets and chain. At present, designers use experience and rules-of-thumb for optimising the chain drive system.

II. PROBLEMS DUE TO WEAR

In motorcycle transmission there is a sliding motion between chain roller and sprocket tooth. This causes friction wear and wear occur in pin hole of chain rollers making the chain to elongate and so that chain becomes slack. Also there is a wear on sprocket tooth and outer surface becomes rough affecting the transmission of motion in motorcycle. According to survey after approx. 20000 km of motorcycle drive chain sprocket assembly needs to be replaced.

III. CHAIN

A chain is a reliable machine component, which transmits power by means of tensile forces, and is used primarily for power transmission. The function and uses of chain are similar to a belt. There are many kinds of chain. It is convenient to sort types of chain by either material of composition or method of construction. Figure shows the construction of a typical motorcycle chain. The roller chain consists of a series of links. There are two types of links: roller links (or inner links) and pin links (or outer links). The roller link consists of two bushes that are fixed to two plates with a loose roller assembled over each bush. The pin link consists of two pins that are fixed to two plates. Most chains are made from high-carbon steel which is case hardened for wear resistance.

Some motorcycle chains have o-rings around the pins between the side plates to help keep lubricant in the pin area.

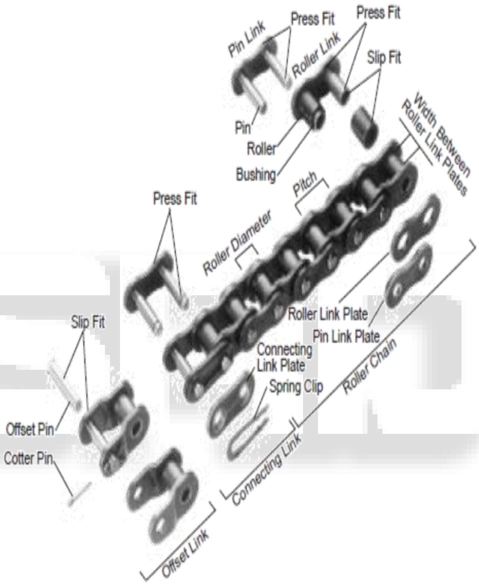

Fig. 1: Construction of Roller Chain

The effect of wear on a roller chain is to increase the pitch (spacing of the links), causing the chain to grow longer. Note that this is due to wear at the pivoting pins and bushes, not from actual stretching of the metal (as does happen to some flexible steel components such as the hand-brake cable of a motor vehicle).

IV. SPROCKET

The chain converts rotational power to pulling power, or pulling power to rotational power, by engaging with the sprocket.

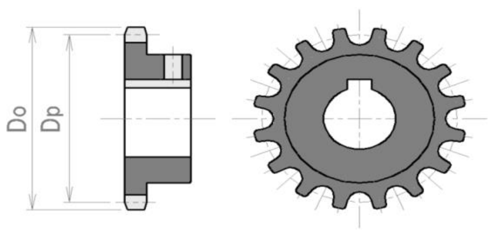

Fig. 2: Sprocket

Where, Do = Sprocket diameter, Dp = Pitch diameter

V. PLASMA NITRIDING PROCESS

Plasma Nitriding works by placing the component to be treated in a vacuum furnace so that it is electrically insulated from the furnace. The vacuum employed is relatively low, and normally, the DC voltage does not drop in a linear way. Almost the entire applied voltage drops directly in front of the cathode, producing the typical luminous purple glow seam in the cathode fall region around the component outline. The glow seam follows every contour of the component so that all surfaces receive uniform ion bombardment and therefore uniform surface hardness and case depth. Plasma Nitriding is successfully carried out at a lower temperature and at a greater rate than gas nitriding. Plasma Nitriding at low temperature enables components to be treated without the loss of base hardness and without distortion, provided that the components are in a stress-free condition before they are nitrided.

A. *Benefits of Plasma Nitriding*

(1) Improves Wear Resistance, Improves fatigue strength, improves basic strength, reduces friction, and reduces galling.
(2) Latest Technology – Most modern surface hardening process using Nitrogen.
(3) Cost effectiveness – No need for grinding after Plasma Nitriding, Prolongs component life, Saves on Plant down time, facilitates the use of smaller section for a given applied load.
(4) Quality – Approved to ISO9001-2000.
(5) Low Treatment temperature – No Distortion – Retains base hardness.

Main purpose of the research is to increase the wear resistance of the chain-sprocket assembly used in motorcycle. Plasma Nitriding is one of many processes which will improve surface hardness, which will increase Wear Resistance. Plasma Nitriding is selected because of its compatibility with Steel, low temperature operation and mainly because of its low cost. Plasma Nitriding was applied on rear and front sprockets. It is not suitable for very thin materials so it cannot be applied to chain as it have a very thin cross-section.

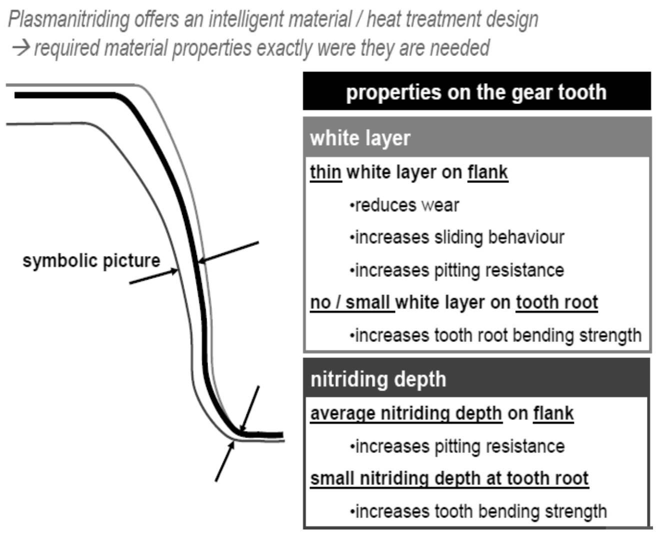

Fig. 3: Layers of Plasma Nitriding on Sprocket tooth

The Plasma Nitriding was applied on the sprocket at 550 degree Celsius for 4 hours. Layer of N_2 on sprocket has white color and has a great wear resistance. It also makes the sprocket a little bit lighter in weight.

Thickness of White Layer: 0.3 mm

Nitriding Depth: 0.27 mm

VI. METHODOLOGY

Two sets of chain-sprocket assemblies are placed on the test-rig that has been built and they are being operated simultaneously. The conditions of the experiment are kept similar for both the chain drives. The no. of cycles has been operated during the experiment. Each cycle was of 4 hours. The temperature of motor needed to check during summer because of the high ambient temperature, just for safety measures and to save motor coil from getting burned.

Thus, after establishing the experimental set-up, the experimental work towards chain-drive system evaluation for wear reduction has been carried out.

For the experiment, the speed of the driving shaft is kept constant. The RPM of engine can be at average of between 2500-3000. The RPM of the motor has constant value of 1425. So if we have the pulley diameter of around half the size of pulley diameter of motor, the required value can be obtained. The RPM of the driving and driven shaft is recorded by digital tachometer at the start so as to calculate total revolutions of the experiment can be known.

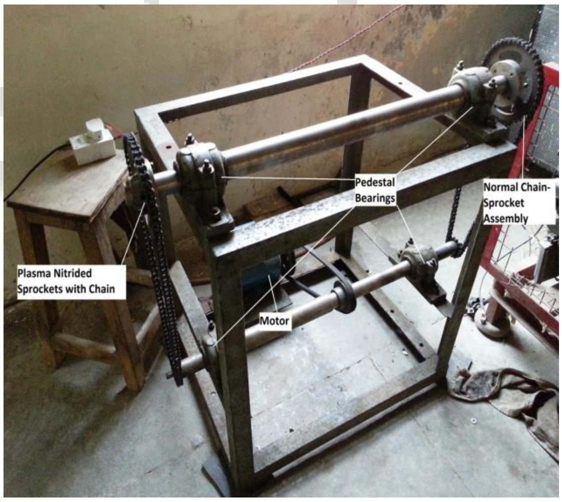

Fig. 4: Experimental set-up

In this phase, the evaluation of performance of experiment is carried out. The wear on plasma nitrided and normal sprocket has been recorded by different methods of readings. The operation cycles was been experimented regularly to complete the experiment in time and keep the record of the time for each cycle. So at the end total number of hours can be calculated of the experiment and the performance of the chain drive can be evaluated according to that. There were 60 cycles each of 9 hours has been performed, which gives the total of 540 hours of operation.

The analysis of the readings taken, are necessary to understand the compare wear rate of both the assemblies. The readings of tooth parameters were taken at 180, 360 & at the end of the operation. The instrument of surface roughness and profile projector wasn't available in our college and need to take permission of other college, so those readings couldn't be possible to be taken at regular intervals and will be taken at the end for the sake of comparison.

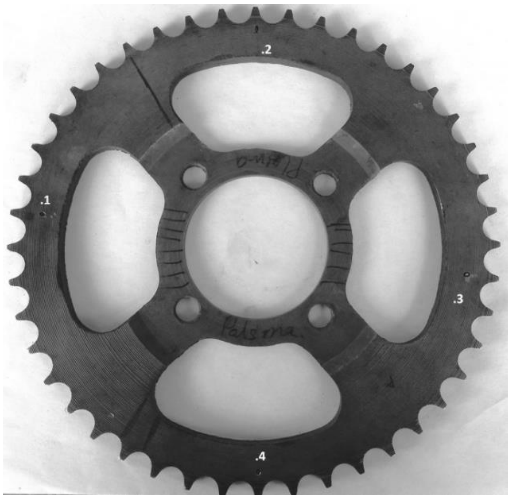

Fig. 5: Measuring Points

The parameters of sprocket tooth are measured on some different selected teeth of both the sprockets. They are punched to mark so as to take readings on the same teeth in future.

VII. RESULTS

The readings of weight for the driven sprockets were taken at 4 equal intervals. It can be seen form graph that the wear rate decreases with time. And it can be easily seen that wear in untreated sprocket is way much more than plasma nitrided sprocket.

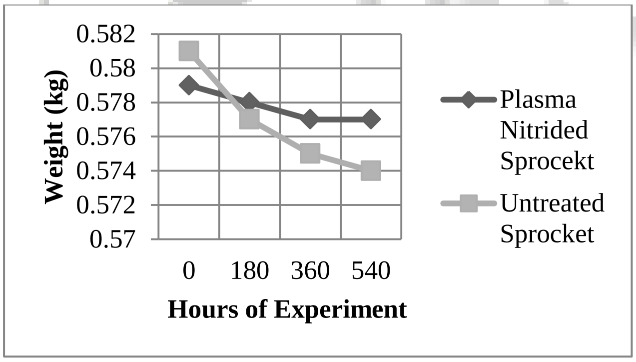

Fig. 6: Weight of driven sprockets v/s Time

Duration of Experiment	Large Sprocket (Plasma Nitrided Sprocket)	Small Sprocket (Plasma Nitrided Sprocket)	Chain (Operated with Plasma Nitrided Sprocket)	Large Sprocket (Normal Sprocket)	Small Sprocket (Normal Sprocket)	Chain (Operated with Normal Sprocket)
Weight At Start (kg)	0.579	0.105	0.922	0.581	0.106	0.922
Weight After 180h (kg)	0.578	0.105	0.919	0.577	0.105	0.917
Weight After 360h (kg)	0.577	0.104	0.918	0.575	0.104	0.915
Weight After 540h (kg)	0.577	0.104	0.917	0.574	0.104	0.914

Table. 1: Experimental Data of Weight reduction with time

The Figures were taken with a Profile Projector of Image scaling to 10X. We can observe more wear on Untreated Sprocket than Nitrided Sprocket. If the recording was more accurate than distance between tooth can be measured as parameter for the wear comparison of both the sprockets.

Profiles of sprockets at start and end of experiment for respective sprockets are compared:

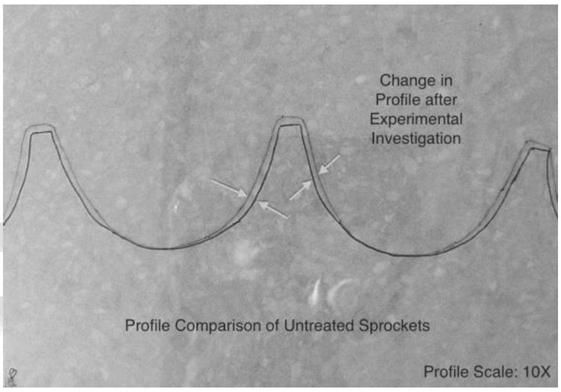

Fig. 7: Change in profile of untreated sprocket after 540h

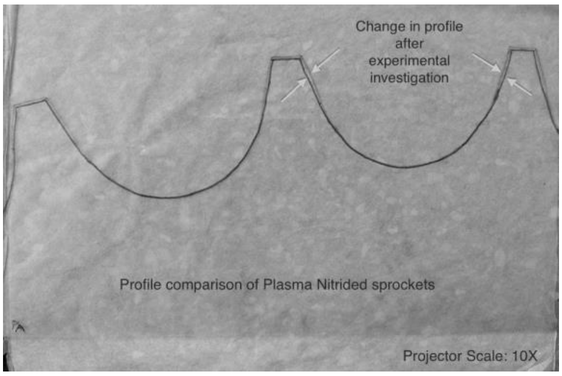

Fig. 8: Change in profile of plasma nitrided sprocket after 540h

The tooth parameters like face width and tooth thickness at addendum circle are measured with micrometer and the readings were taken.

From these graphs of tooth parameter change with time shows that wear rate is maximum during the first phase of the experiment. It gradually reduces in next interval. The wear rate for the Plasma Nitrided Sprocket was very less compared to the untreated sprocket. Also the wear rate after first phase is also more for untreated sprocket, and doesn't reduce much with time as what happens in plasma nitrided sprocket.

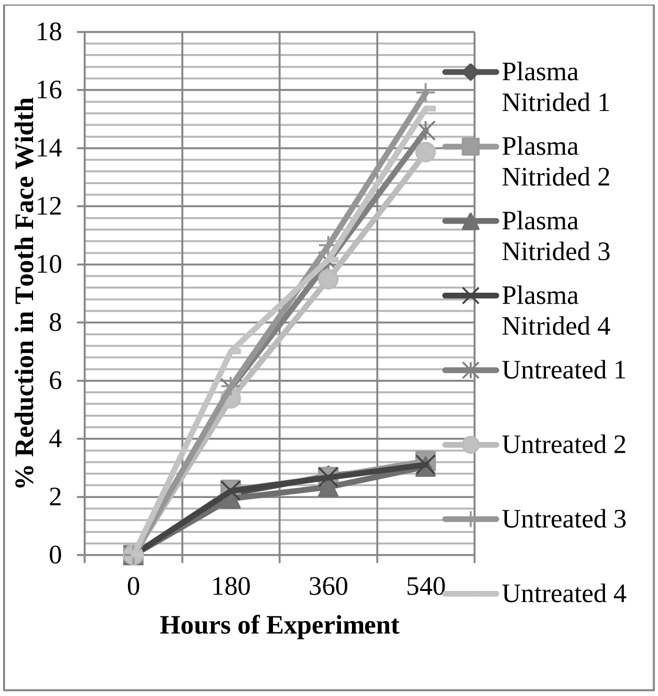

Fig. 9 Tooth Face Width v/s Time

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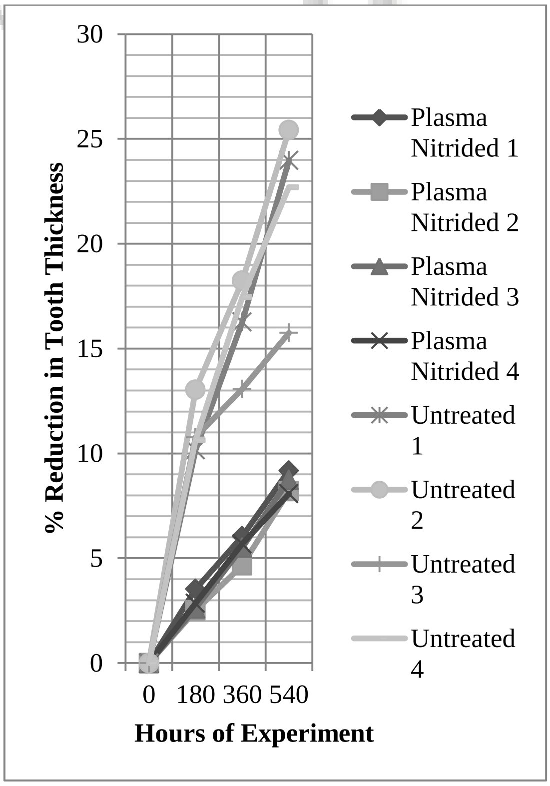

Fig. 10: Tooth Thickness v/s Time

The chain parameter of the spacing between two links has been measured by digital Vernier Caliper.

The reading at start: 4.30 mm

That was same for both of chains.

The readings after 540 h of experiment are taken and are:

Chain which is used with plasma nitrided sprockets: 4.35 - 4.38 mm

Chain which is used with untreated sprockets: 4.37- 4.41 mm

The above mentioned readings are taken on different links and all varies between these zones of values. It shows that the elongation in chain with normal assembly is more than in chain of plasma nitrided assembly.

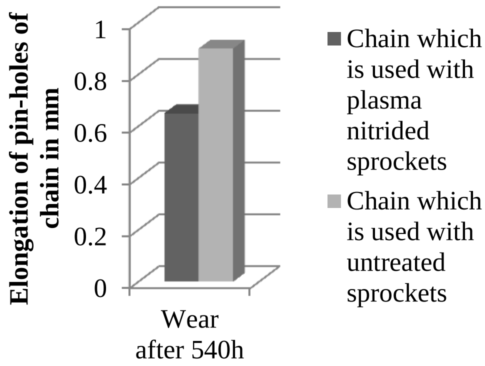

Fig. 11: Elongation of pin-hole v/s Time

VIII. CONCLUSION

The setup was run for 540 hours; which included both untreated and plasma nitrided sprockets. From the readings and condition of sprockets it can be concluded that plasma nitrided sprocket has greater wear resistance than the normal (untreated) sprocket.

Plasma nitriding is a cheap and easy way to harden the sprocket material. So plasma nitriding can be used to increase wear resistance which can deliver better performance in the chain sprocket assembly and plasma nitriding increases the life span of the sprocket. It also increases the time span of the chain-sprocket assembly before it should be replaced. It is also tendency of the motorcycle consumers to not replace the chain and sprockets when they should, so with plasma nitriding it will help them to keep using chain and sprocket without affecting the performance of motorcycle for longer than normal chain and sprocket.

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