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Effect of Ans Coating to Surface Mechanical Properties on Fuel Pump Shaft

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Abstract : Fuel pump shaft pumping fuel to motor in a heavy duty Diesel Engine. Fuel pump shaft pumping fuel to motor in a Heavy Duty Diesel Engine. This part is operating at very high pressure. Fuel pump shaft to examine the losses during the study, great for work efficiency. In this work the wear behaviors of the cam surfaces have been examined by the fuel pump shaft ANS Triboconditioning ® coating. The camshaft with two cams is used on the work. The cam shaft material is the AISI 4140 steel used in the work. Before coating, surface roughness value is measured to the cam surfaces on the camshaft. Then the cam surfaces are covered with a special coating method. Surface roughness values were measured after coating. The effects of surface properties of ANS Triboconditioning ® coating were investigated. At the end of the study The surface roughness values of the fuel pump shaft were improved by the ANS Triboconditioning ® coating. The resulting surface reduced the friction significantly and increase the part life.

Keywords:- Fuel pump shaft, ANS Coating, Friction, Wear, Roughness

I. INTRODUCTION

Friction and wear are inherent in operation of nearly all machines and mechanisms and often have detrimental effects on performance and lifetime. Lubricants and coatings are two well-known ways to solve friction and wear problems. Use of lubricants stems back to ancient times and use of coatings has been steadily gaining momentum over the past decades following the development and commercialization of magnetron sputtering, wire-arc thermal spraying and other physical and chemical deposition techniques [1-3]. Significant advances have also been made in the field of tribochemistry, improving the understanding of the role and function of various classes of friction modifiers and extreme pressure antiwear additives [4-8].

The ANS Triboconditioning® process combines mechanical burnishing with tribochemical deposition of a friction- and wear-reducing compound onto the component surface. A tool is pressed and sled against the component in the presence of a special process fluid. As the tool passes over the surface it triggers a tribochemical reaction within the process fluid which gradually deposits a low friction tribofilm on to the surface of the component [9]. The pressure applied on the tool also leads to a burnishing effect as some of the asperities on the surface will be leveled off and the valleys be gradually filled with the friction-reducing compound. As the process is technologically simple and in most cases can be done with regular surface finishing equipment, it is very cost efficient in mass production environment. The ANS Triboconditioning® process is therefore perfect for in-house manufacturing as a part of the component manufacturer’s production line [9].

The ANS triboconditioning process allows one to enjoy the same fuel efficiency gain without having to use friction modifiers in engine oil. As a matter of fact, without the ANS process, rubbing parts in an engine would be “triboconditioned” – or run in – during the engine operation under conditions which are far from optimal. As a result, the engine may incur significant wear during the initial breaking-in stage [10-12]. The major difference that the ANS process brings is that breaking-in of engine components becomes a part of the component manufacturing process [10-12]. The outstanding wear-resistance of ANS-triboconditioned parts allows one to switch to lower viscosity lubricants for improved energy efficiency without accruing risk of wear-related failures and having to compromise between the level of antiwear protection and the lifetime of exhaust catalyst.Fuel pump shaft was coated with ANS to investigate surface properties. Surface roughness values, Friction coefficient, Wear surface area were calculated of part.

II. EXPERIMENTAL STUDY

In the experimental works, fuel pump shaft manufactured from SAE 4140 steel was used. Camshaft is manufactured by machining method. Cam surfaces are hardened by adsorption of carbon on the cam surfaces during the sememetization process. The machined camshaft has been applied to the coating process at the ANS company.

Technical aspects of the ANS triboconditioning method are disclosed in Pat. Appl. PCT/SE2010/050850. Triboconditioning of camshafts has been carried out using an in-house built rig as shown in Fig.1.

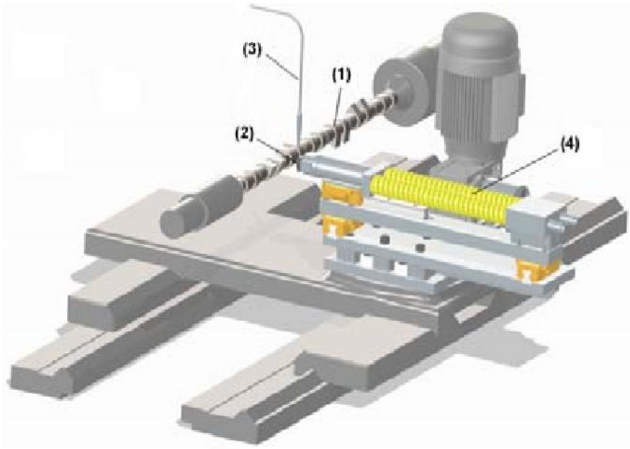

Figure1. The ANS triboconditioning rig used for treatment of camshafts: The camshaft (1) is rotated in a turning machine. A ceramic tool is pressed and slid against each lobe to induce the triboreaction between WS2 precursors contained in the process fluid, which is supplied through the nozzle (3). Contact pressure between the tool and the lobe is maintained by using the tension springs (4) [9]

Triboconditioning of fuel pump camshaft has been carried out using a standard lathe machine. The lathe head has been modified to accommodate a set of triboconditioning tools in place of the cutting tool and the cutting oil has been replaced by a special process fluid required for the triboconditioning. Schematıc vıew of triboconditioning system gives to fig.2.

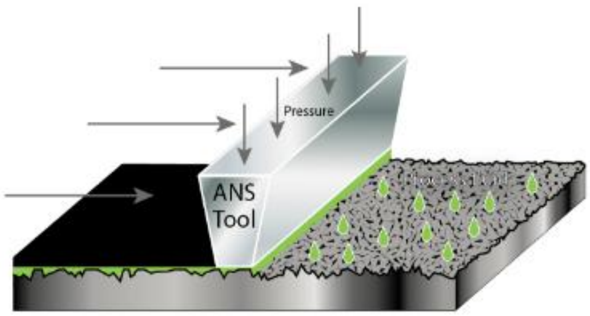

Figure 2. The ANS triboconditioning rig used for treatment of camshafts [9]

The ANS triboconditioning method uses a process fluid carrying a tungsten source and a sulfur source which can be surmised to undergo the following transformations in the tribocontact between the tool and the workpiece:

$RSnR' + Fe \rightarrow FeS + RR'$ (9)

$WO_3 + Fe \rightarrow FeWO_3$ (9)

$FeWO_3 + FeS \rightarrow WS_2 + FeO$ (9)

The above three reactions can be combined into

$RSnR' + Fe + WO_3 \rightarrow WS2 + FeO + RR$ (9)

In one or another way, the ANS triboconditioning results in the formation of a non-stoichiometric tribofilm, of 10 to 100 nm thickness, composed of tungsten, iron, oxygen, sulfur and carbon. ANS triboconditioning coated fuel pump shaft is shown in Fig.3.

Tribological testing of triboconditioned cylinder liners has been carried out using a reciprocating ring/bore friction and wear tester resembling the common high frequency reciprocating rig.

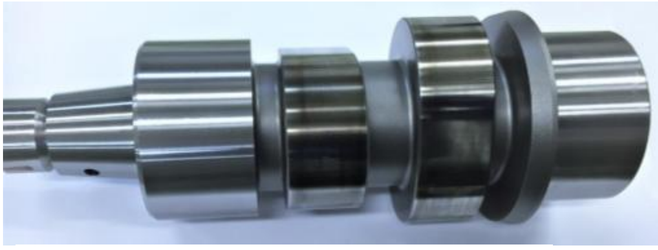

Figure 3. Fuel pump shaft coated on cam surfaces

Tribological testing of triboconditioned camshafts has been carried out using a specially engineered test rig. Surface roughness values were measured before and after the abrasion test. Surface roughness values were measured to examine the effects of quality on the surface of the coating. The roughness was measured with a Stylus. Friction was measured with the cam mounted in a lathe connected to a friction rig, see Fig.2.

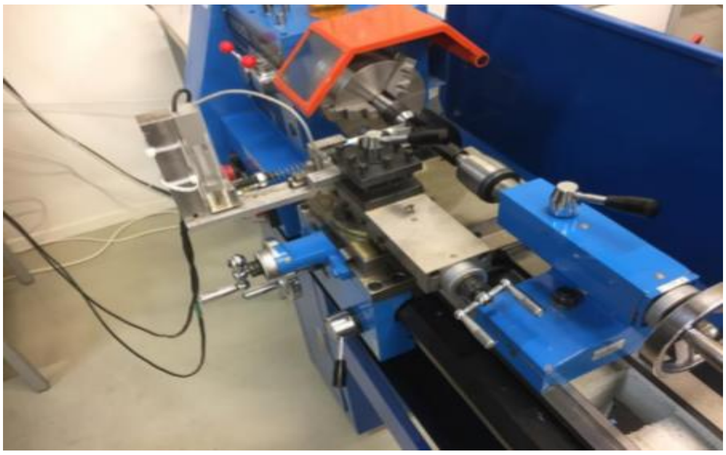

Figure 4. Friction rig used in test

The rig measures friction force and normal force. For the friction test the spindle speed was ramped two times up to 300 rpm, total time 8 min. For the wear test the spindle speed was set to 150 rpm for 1 hour. Wear marks was measured with a digital microscope.

III. RESULT AND DISCUSTION

As high-pressure mechanical treatment is involved, triboconditioning leads to smoothing of asperities by tool contact and partial coverage of valleys by generated WS_2. Treatment was successful even though the treatment looked uneven. Indicates that the quality of the coating surface is higher than the initial value. Treatment was successful even though the treatment looked uneven. Surface roughness was improved and chemical analysis showed high levels of chemistry. Friction analysis showed lowered friction coefficient and wear marks was reduced. Three camshafts were used in the studies and the average surface roughness values were given in the fig.5.

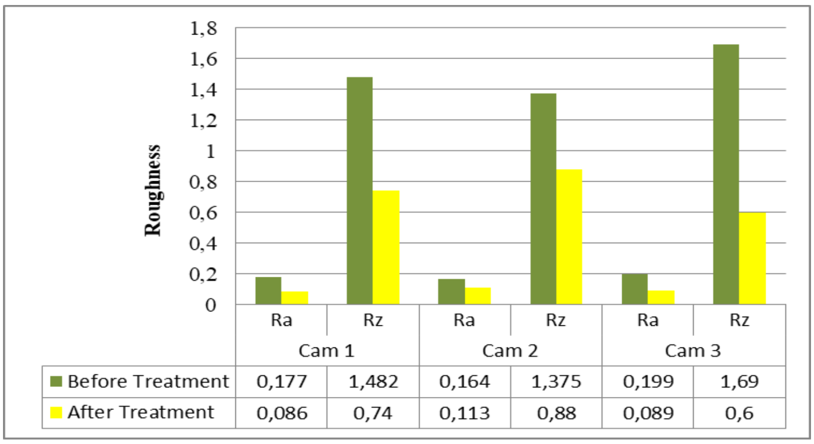

Figure 5. Effect of triboconditioning on cam surface roughness

The average surface roughness values before and after abrasion test are given in fig.5. After triboconditioning treatment the surface roughness value improved between %40-50.

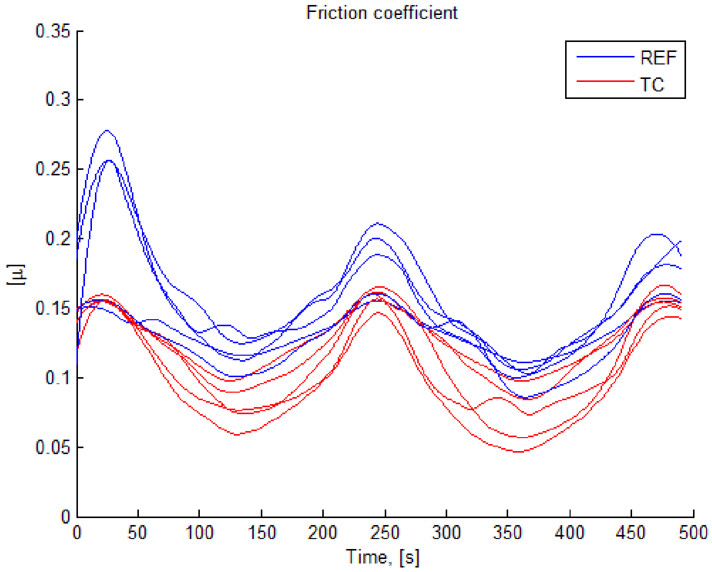

Figure 6. Wear test friction coefficient

For the friction test the spindle speed was ramped two times up to 300 rpm, total time 8 min. The coefficient of friction is 0,15-0,28µm on the untreated surface, 0,06-0,15 µm on the treated surface.

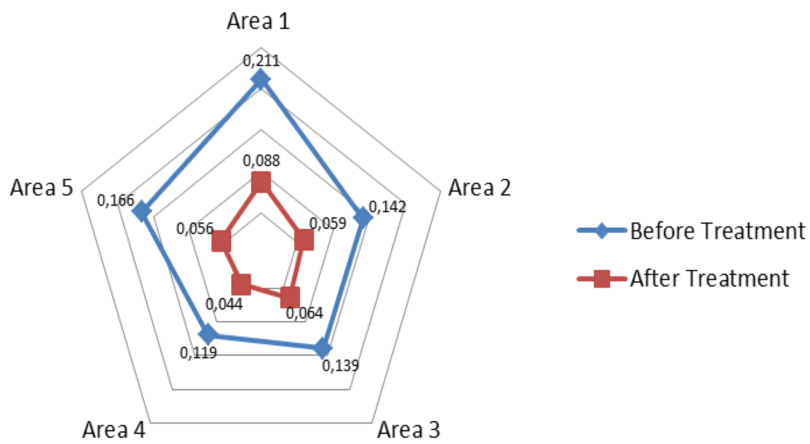

Fig 7. Wear marks on counter surface (mm^2)

When the wear marks of the surfaces are measured, It has been observed that there is a reduction of 50-60% in the area of wear. The ANS Triboconditioning® technology greatly improves the tribological performance of the component in terms of wear-resistance and lowered boundary friction. The surface properties also increase the lubricant film strength which makes it ideal for deployment in combination with modern energy-saving lubricants [9].

IV. CONCLUSION

The ANS triboconditioning process allows one to enjoy the same fuel efficiency gain without having to use friction modifiers in engine oil. The fuel pump is a part of the motor that operates under very high forces. The tribological properties of fuel pump shafts gained significant improvements due to ANS triboconditioning. Extremepressure mechanical treatment of the component surface in combination with a tribochemical deposition of a low-friction antiwear film based on tungsten disulfide allows one to produce, in a single finishing operation, a smoother surface with a significantly reduced coefficient of boundary friction and improved wear-resistance and load-carrying capacity. The treatment proved to be especially efficient for reducing friction and wear in lubricated contacts under high tribological stress.

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