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A Review on Valve Train Component Wear due to Soot Contaminated Lubricant

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Abstracts: A study has been carried out to investigate the effect of soot contamination in diesel engine lubrication and its effect on component wear in valve train components. The objective of the work was to develop a knowledge of wear data for lubricated in-contact valve train components. This will increase the understanding of the wear mechanisms that occur within a contaminated contact zone. The study is focused at developing methods to eliminate or reduce the observed wear.

Keywords — Valve train, Lubricating Oil, Soot, TAN, TBN, Viscosity, Viscosity Index.

I. INTRODUCTION

Modern diesel engines are required to meet better performance capabilities such as power output, specific fuel consumption and reduced exhaust emissions to meet certain regulatory norms, thus components are put under greater demands. Thus the lubrication system and the lubrication oil are of great importance to account for such high demands. Even with the development of lubricating oil with higher contamination retention abilities, there is still soot generation in lubricants which could lead to abnormal wear in contact parts of the engine.

There is currently a lack of wear models for lubricated engine components, leaving the understanding of the problem at an insufficient level that cannot be applied by engine designers. As part of a long term approach, wear

models and design tools for engine components are required to increase understanding and reduce wear.

One major problem in the wear of engine components is due to soot that contaminates the lubricant. Soot is a microscopic carbonaceous particle, which is a product of incomplete combustion of hydrocarbons (in this case diesel fuel). Soot particles are more prevalent in diesel engines than gasoline engines due to the differences in the combustion mechanisms.

Soot particles are considered harmful, and as such emissions to the atmosphere are undesirable. A number of strategies are being employed to reduce these emissions such as; improving control over the in-cylinder charge condition, the fuel injection system and exhaust gas recirculation (EGR). EGR involves returning a proportion of the exhaust gas to the air intake. This results in a reduction in harmful NOx emissions by reducing the peak cylinder temperature.

EGR, however, leads to a marked increase in particulate matter remaining within the engine. If higher level of EGR is introduced in the combat emission, there is an even greater need to understand wear affecting high soot levels.

II. VALVE TRAIN COMPONENTS

The main function of the whole valve train is to make perfect movement of valves (lift or returning of valves) at appropriate strokes. A standard valve train consists of following parts: Camshaft, Tappets, Push rod, VR lever, valves. Sometimes, in engines consisting of cylinders having two inlet and two exhaust valves, there is a device present to operate both the inlet or exhaust valves simultaneously called ‘valve bridge’. This device helps in reducing the number of cam lobes, tappets and rocker arms used in engine.

1. Camshaft: The material of camshaft is plain carbon steel. Surface hardening of camshaft is done by the process of Induction Hardening. The function of camshaft is to control the valve timing.

Fig. 2.1

2. Tappet: Tappet is made of Gray cast iron. Tappets are rested on cam lobes. They move along with the motion of camshaft and cause the movement of push rod.

Fig. 2.2

3. Push Rod: Push rod consists of low carbon steel. The ball of push rod is case carburized. Push rod moves up and down with tappet and presses the VR lever upwards.

Fig. 2.3

4. VR Lever (Rocker arm): Material is Plain carbon steel. It is made by forging. It has push rod at one end and spigot & bridge at the other end. When push rod pushes the respective end of VR lever, the lever spigot presses the bridge down.

Fig. 2.4

5. Bridge: It consists of 42CrMo4. The bridge undergoes through hardening. It is used when there are more than one inlet and exhaust valves. It controls the movement of all the valves of same type at the same time.

Fig. 2.5

6. Valve cup: Material is 34Cr4. It also undergoes through hardening. It holds the valve in its place with the help of collet.

Fig. 2.6

7. Inlet valve: It is made of EN52. The fresh air is taken inside the combustion chamber by inlet valve.

Fig. 2.7

8. Exhaust valve: In exhaust valve, valve head is exposed to very high temperature. So, the valve head is made up of 214N. The valve stem is made of EN52. The head and stem are joined by Friction Welding.

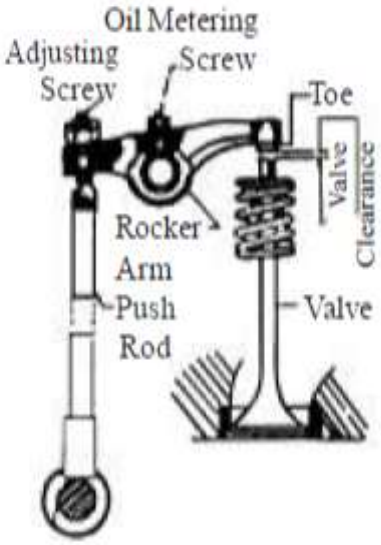

Fig. 2.8

Each and every component of a valve train is important for proper functioning of valves and hence the proper function of the engine. So, the abnormal wear on any of the component can cause disturbance in proper engine working.

III. TAPPET CLEARANCE

Tappet clearance is the space between top of the Valve Bridge and rocker arm adjusting screw. Tappet clearance is necessary to allow for thermal expansion of valve train components at working temperature. It also ensures the positive closing of the valve as it wears down. Clearance should be set when the engine is cold and the cam follower is off the cam peak. Amount of clearance should be monitored as excessive and minimal clearance as both have adverse effect on normal functioning of engine. Tappet clearance is measured with the help of Filler Guages.

Excessive clearance leads to:

1. Valve opens late
2. Closes early leading to decrement in scavenge efficiency.

3. Mechanical constraints like damage, noise and impact on working surface.

Minimal clearance leads to:
1. Open early and closes late.
2. Leaking of valve leading to burning of valve seat and other constraints.
3. Compression pressure will also decrease due to leakage

Clearance should be monitored regularly using filler gauge for excessive or insufficient clearance.

IV. VALVE TRAIN COMPONENT WEAR DUE TO SOOT CONTAMINATION

There are many things that can cause the wear on the different valve train components. But, most of the times, the reason can be excessive soot in lubricating oil of engine. When such oil repeatedly circulate through the valve train components, due to friction between components and soot, abnormal wear can be observed on the components.

Such wear changes the tappet clearance required for proper valve functioning. This ultimately results into valve timing changes and disturbs the engine working.

Sometimes, the wear on valve train components can do severe damages inside the engine such as **valve breakage**.

To avoid these consequences, periodic oil inspection becomes an important factor in engine servicing. Some of the important oil properties inspected in oil inspection are as follow:

Viscosity Index (VI): It is an arbitrary, unit less measure of the change of viscosity with temperature, mostly used to characterize the viscosity-temperature behavior of lubricating oils. The lower the VI, the more the viscosity is affected by changes in temperature. The VI was originally measured on a scale from 0 to 100; however, advancements in lubrication science have led to the development of oils with much higher VI.

The viscosity of a lubricant is closely related to its ability to reduce friction in solid body contacts. Generally, the least viscous lubricant which still forces the two moving surfaces apart to achieve "fluid bearing" conditions is desired. If the lubricant is too viscous, it will require a large amount of energy to move (as in honey); if it is too thin, the surfaces will come in contact and friction will increase.

Total acid number (TAN): Total Acid Number measures the acidity which is determined by the amount of KOH (Potassium Hydroxide) in milligrams that is enough for neutralizing the acids in one gram of oil. It is the measure of acidic concentrations in oil. This is an important quality measurement of lubricating oil.

Total base number (TBN): Total Base Number denotes the quantity of acid, expressed by the amount of the KOH in milligrams that is required to neutralize all basic constituents present in 1 gram of sample. It is the measure of basic concentrations in oil.

Apart from these properties, high boiling point and low freezing point, Thermal stability, Hydraulic stability, Corrosion resistance, High resistance to oxidation etc. also play important role in working of lubricating oil.

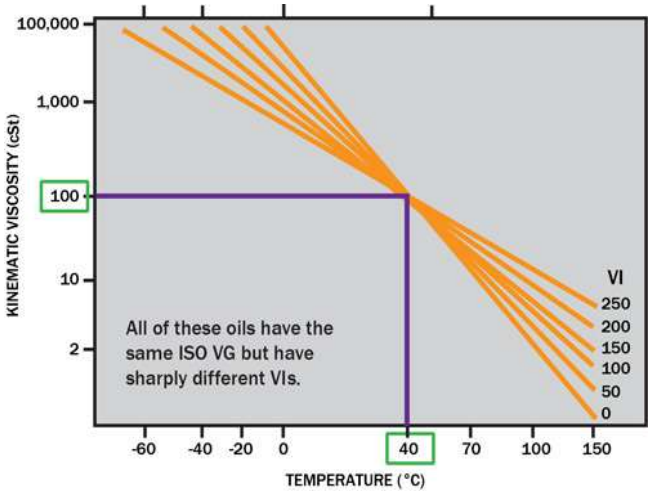

Fig. 4.1

When any of these properties of lubricating oil are not as per the requirements, it may harm the valve train components.

V. PROBABLE REMEDIES

To avoid valve train component wear, some remedies are available. For example, changes in EGR system, change in injection pressure of cylinder etc. can be done. But, all such solutions include design changes which will ultimately increase the overall cost and are not at all economically practical.

So, we have to imply some temporary solutions to avoid or reduce the problem. Some of such solutions are as follow:

1. **To increase the oil sump capacity of engine**: It will dilute the concentration of soot in oil.
2. **To add appropriate additives in lubricating oil**: Now a days, there are some additives available in market which help in maintaining VI of oil as well as increasing the resistance of oil to corrosion and oxidation.
3. **To replace the lubricating oil with the oil of desired oil properties:** It includes using the oil of improved oil properties.
4. **To change the oil filter cartridge:** It includes replacing the cartridge of lube. oil filter with the

cartridge of more filtering capacity. It helps to filter the soot particles of smaller size also which further prevents the circulation of soot along with the oil.

VI. CONCLUSION

Oil inspection plays an important role in proper working of valve train and ultimately of engine, as most of the times, contaminated oil is the main reason of wear on valve train components.

Every time it is not possible to make changes in the design or manufacturing process to avoid this wear. So, generally some easy and economical solutions are implemented to reduce the concerned wear.

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