THE MEASUREMENT OF COMPONENT FRICTION LOSSES IN A FIRED ENGINE, PART 2 (EXPERIMENTAL RESULTS).

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ABSTRACT

Bench testing can provide rapid and cost effective information for developing new lubricants. But there is general agreement that the only satisfactory means of evaluating the behaviour of engine oil is by actual use in engine. Also for detailed analysis of the tribological interaction it is important to analyse the engine performance at the component level. With the help of advance data acquisition system and sensor technology, experimental measurement of friction losses at the component level have been measured at realistic engine operating conditions, using the technique explained in Part 1. This paper describes the outcome of the experimental results at a range of engine operating conditions using mainly SAE 0W20 lubricant and some results from a friction-modified SAE 5W30 lubricant. The results clearly show considerable changes in the percentage contribution of power loss between low and high lubricant temperatures. The change in mode of lubricating regime from boundary to fluid film lubrication can be seen at the component level with increase in engine speed and decrease in lubricant temperature. This system can be used as a powerful tool for screening engine oils, analysing component design, validating friction models and studying the effect of different additives on the performance of each component under realistic operating conditions.

1. INTRODUCTION

In this research project total engine and component friction measurement was carried out on a single cylinder Ricardo Hydra engine under fired conditions at crankcase lubricant inlet temperatures of 24°C, 40°C, 60°C and 80°C. The friction was measured at engine speeds of 800rpm (¼ load), 1500rpm (½ load) and 2000rpm (½ load) using an SAE 0W20 and a friction-modified SAE 5W30 lubricant.

The engine camshaft frictional loss has been measured using a specially designed cam pulley torque transducer [1]. The piston assembly friction is measured using the well known IMEP method with the help of an advanced data acquisition system [2] and the total engine friction loss is determined via a PV diagram. By measuring simultaneously the above mentioned parameters, engine bearing friction power loss is calculated as all the auxiliaries are independently and externally driven. The detail of the experimental method of measuring component and total friction loss is explained in Part 1.

2. RESULTS

While examining the engine component friction results for a single cylinder engine it is important to remember that the relative friction contribution from the engine bearings, especially main bearings, will be high compared to a multi-cylinder engine, as the ratio of cylinders to bearings for a single cylinder engine is higher than for a multi-cylinder engine. For a single cylinder engine the cylinder/main bearing ratio is 1:2 whereas for a four cylinder engine the ratio is 1:1¾. Similarly the cam and camshaft-bearing ratio for a single cylinder is greater than for a multi-cylinder engine.

The lubrication condition at the engine valve train is mostly in the boundary regime. Figure 1 shows instantaneous valve train torque measured experimentally at an engine speed of 800rpm. It can be seen that there is a sharp rise in friction torque exacerbated by rising temperature. During the experiments it was also observed that by increasing engine speed, the lubrication condition at the cam/follower interface improved greatly due to the increase in entraining velocity.

Figure 2 shows the piston assembly friction at an engine speed of 800rpm for the SAE 0W20 lubricant. At lubricant temperature of 80°C, at the start of the power stroke the piston assembly friction is high due to severe lubrication conditions resulting in boundary lubrication, but as the piston picks up velocity, at mid stroke, the friction decreases due to a high entraining velocity dragging more lubricant into the piston/liner interface. A similar picture can be seen for the other piston strokes. On the other hand at 24°C lubricant temperature the friction at the start and end of each stroke, except the start of power stroke, is low due to high viscosity reducing boundary lubrication. Whereas at mid stroke, due to high entraining velocity the friction increases as a result of high shear rate.
Figure 1. Camshaft drive torque, 800rpm, SAE 0W20

Figure 2. Piston assembly friction, 1500rpm, SAE 0W20

Figure 3. Engine bearing friction, SAE 0W20.

Figure 4. Total engine and component friction at an engine speed of 1500rpm, ½ load, lubricant SAE 0W20.

Figure 5. Contribution of engine component friction at an engine speed of 1500rpm, ½ Load, SAE 0W20.

mainly because of mixed to boundary friction loss becoming dominant and the presence of friction modifier that activates at higher temperatures (temperature sensitive), which helps in reducing friction.