MEASURING ENGINE WEAR WITH RADIO-ACTIVE TRACERS

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INTRODUCTION:

Extensive research has been devoted to the cause of engine wear and to minimizing its rate or extent through improvements in lubricants, fuels, metallurgy and operating conditions.

Engine wear may result from three basic causes: corrosion, abrasion and friction. The chief cause of engine wear is generally recognized as corrosion, or chemical attack by moisture and acidic components originating as by-products of combustion. (1). Other researchers, however, (2) (3), seem to disagree on the percentage of engine wear caused by corrosion.

Certain vegetable oils are known to have a low co-efficient of friction and a high oiliness factor. (4).

It was therefore asumed that friction would be reduced when rape seed oil was added to mineral oil. The extent of the reduction and the method of determining the reduction were investigated.

There are three methods used to determine engine wear, namely, physical, chemical and radio-active. The radio-active tracer technique was patented by S. W. Ferris (5) in 1943. Since then the use of nuclear reactor in place of the cyclatron has resulted in rapid and widespread progress (6).

In 1957, after intense examination of the research work done with the radio-active piston ring technique, the Agricultural Engineering Department of the University of Saskatchewan and the Saskatchewan Research Council decided to use this method to investigate the anti-wear properties of rape seed oil.

PROCEDLURE:

The engines used for this test were two Lauson 2⅝ in. x 2¾ in. single cylinder, 4 cycle, model H2. Each engine had a fan load of 1.86 h.p. at 1840 r.p.m. A gravity fuel system was used for both engines. The coolant temperature of each engine was held constant at 200°F. by controlling the flow of water through heat exchangers. A heating coil under the crankcase of each engine was used for maintaining oil temperatures of 145°F. Each engine had a gear type external oil pump driven by a V-belt from the engine pulley. Thermocouples were used to record oil and coolant temperatures during the test run. A pressure regulator was installed in the line to ensure constant pressure on the geiger tube. The equipment used is shown in Figure 1.

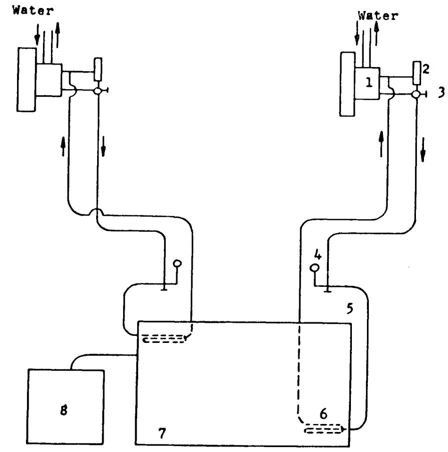

Figure 1. Test Equipment. 1. Lauson H-2 Engine; 2. External Oil Pump; 3. Pressure Regulator; 4. Oil Pressure Gauge; 5. Valve (usually open); 6. Radiation Counter Geiger Tube (lead shielded); 7. Tracerlab Ratemeter; 8. Esterline-Angus continuous Recorder.

The radiation entering the geiger tube caused the gas in it to ionize and generate a small electrical current. The Tracerlab Ratemeter accumulated the number of total counts over a short period of time (usually 40 seconds) and indicated their average as a continuous reading of counts per minute. The output of the ratemeter was connected to an Esterline-Angus Continuous recorder which recorded the counts per minute against time.

Engine wear was determined by continuously measuring the radio-activity of oil pumped from the pressure regulator to a lead shielded geiger tube connected to the Ratemeter. As the engine operated, a distinct rate increase in relation to the piston ring wear rate was dependent upon the geiger tube volume compared to the total oil volume, the oil consumption rate, and the specific activity of the piston ring. Two reasonable assumptions were made:

1. The oil sample in the geiger tube was representative of the oil in the system.

2. Oil which was lost or consumed contained an aliquot amount of radioactivity.

To relate the count rate increase to ring wear, a calibration standard was prepared by dissolving a measured amount of ring material filed from the compression ring used in the engine. This dissolved ring material was put into an identical geiger tube. By counting the relative calibrated standard daily in the same lead shield, and with the same counter, a direct conversion from count rate to ring weight was accomplished.

For a test run the oil system was drained, flushed and refilled. The electronic gear was zeroed and calibrated. The background and standard were counted. The engine was run up to control conditions and the activity increase recorded as the test progressed. At the conclusion of the run the engine was stopped, the oil drained and measured for consumption.

The first set of piston rings were irradiated at the Atomic Energy reactor at Chalk River, Canada. The two piston rings were subjected to a flux of 1×10^{13} neutrons per sq. cm. for a period of 19¾ hours, and when removed from the pile had an activity of approximately 1 millicurie each.

The piston rings were installed in the engines using special long handled tools. The radio-active rings were placed in the top ring grooves, compressed, and the pistons lowered in the cylinders in approximately 5 minutes. The engines were then reassembled in a very short time.

The second set of piston rings were irradiated at Brookhaven National Laboratories, Associated Universities Incorporated, Upton, Long Island, New York. Four piston rings were subjected to a flux of 3.5×10^{12} neutrons per sq. cm. for a period of 21 days and when removed from the pile, had an activity of 4 to 5 millicuries per gram of radio-active isotope Fe^{59}. Extra long tools were needed to install the second set of radio-active piston rings.

Results and Discussion

During the breaking in of the first set of piston rings, the wear rate and consequently the wear loss was very high. The wear rate decreased as the engine reached its operating temperature and as the piston rings became