Issue 14 - Oil pressure mapping to measure bearing wear

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One of the current buzzwords being used in condition monitoring is oil pressure mapping. This technical bulletin explains oil pressure mapping, why this diagnostic technique was developed and how it is used to measure engine bearing wear.

Testing for bearing wear in the past

Traditionally, testing for abnormal wear or damage to the main or big end bearings was carried out by measuring engine oil pressure at idle and maximum engine speed. The thinking was that excessive bearing clearance would cause excessive oil leakage and a resulting drop in oil pressure.

This test is no longer reliable as modern diesel engines are fitted with high capacity oil pumps, which are needed to deliver sufficient oil to the spray jets used to cool the pistons. As a result the pumps can cope with higher oil leakage rates so there is little noticeable drop-off in oil pressure. Consequently, oil pressure mapping is used nowadays.

Before we discuss oil mapping in more detail, it would be worthwhile to take an in-depth look at bearings, their importance in maintaining healthy equipment, and why oil pressure affects bearing wear.

Bearings and oil

A bearing is often an inexpensive item in a machine, but the failure of a bearing will result in a considerable amount of consequential damage to other components. It is for this reason that maintenance personnel are concerned about the health of bearings.

Oil analysis is an important tool used to assess the soundness of a bearing. Once a problem is detected through oil analysis, it needs to be investigated to establish the cause and extent of the problem.

The following are a few of the common causes of bearing faults:

- Overloading or shock loading
- Contamination of lubricating oil
- Overheating of lubricating oil
- Overheating of the bearing
- Misalignment or incorrect assembly of the bearing
- Insufficient pressure and/or volume of the lubricating oil

The secret to long bearing life, after installation and operational problems have been seen to, is to ensure that the bearing is supplied with the correct grade of oil in sufficient quantities, and that the oil is clean and at the correct temperature.

Plain bearings, in particular, are sensitive to oil volume and pressure. Insufficient pressure will normally result in insufficient oil volume being delivered to the bearing. The decreased oil volume causes the bearing to wear out faster, due to increased operating temperatures and contact between the journal and bearing.

Although anti-friction (roller or ball type) bearings can normally run on relatively small volumes of oil, a drop-off in oil volume will cause wear on the cage due to the increased sliding contact in this area. The wear then allows the rollers or balls to move out of position and accelerate wear of the bearing races.

Oil mapping

An oil pump, like most other pumps, produces a rapid increase in output as speed increases until a critical point is reached, whereafter the output drops off again, as shown in Figure 1.

Figure 1 Typical output curve for oil pump without pressure relief valve

To prevent erosion damage to the bearing from the excessively high oil pressures that are now possible with the high capacity oil pumps fitted to modern diesel engines, a pressure relief valve is fitted to the engine oil pump. This vents excess oil back to the sump when the maximum allowable pressure is reached. The result is an oil pressure curve similar to Figure 2.

Figure 2 Typical pressure curve for oil pump with pressure relief valve.

Oil pressure mapping is simply a method of verifying that the oil pump pressure is following this curve. When the shape of the curve changes, it is an indication of a fault with the oil pump or excessive oil leakage in the engine, possibly due to bearing wear.

How to map oil pressure

To map the oil pressure you will need an accurate oil pressure gauge which can accommodate the range of pressures to be encountered. Dashboard mounted gauges are not normally accurate enough for mapping purposes. An accurate tachometer will be needed to measure engine speed while doing the test. Graph paper to plot the resultant pressure curve will also be useful.

Caption 1: A typical engine oil pressure gauge with protective rubber cover.

Caption 2: Johan van Dam of Barlows in New Germany monitors the engine oil pressure on an earthmoving machine with a 3-in-1 gauge set.

Pic 3: SA Gauge Test Kit pic (no caption)

Figure 4: Recommended gauge pressure ranges for general equipment

(to appear next to pic 3)

	SI Metric	Alternate Metric	Japanese	Imperial
Engines	0 - 1 000 kPa	O - 10 Bar	0 - 10 kg/cm²	0 - 160 psi
Transmissions	0 - 6 000 kPa	0 - 60 Bar	0 - 60 kg/cm²	0 - 1 000 psi
Hydraulics	0 - 2 500 kPa	0 - 25 Bar	0 - 25 kg/cm²	0 - 400 psi
	0 - 60 Mpa	0 - 600 Bar	0 - 600 kg/cm²	0 - 10 000 psi

Consult your equipment supplier for specific applications.

The first step is to make sure the engine has reached full operating temperature. Water temperature is not a reliable indicator of oil temperature. The water temperature stabilises quickly due to the action of the thermostat, but the oil temperature lags behind during warm-up. If possible the oil temperature should be recorded when the pressure readings are taken. The oil temperature is important, because the oil thins rapidly as the oil temperature increases and thickens again when it cools down. The thickness of the oil (viscosity) will affect the pressures obtained and may give inaccurately high readings if measured at too low a temperature.

The second step is to connect the oil pressure gauge to the main oil gallery before it enters the bearings - the oil pressure sender unit is normally a good point. Connect a tachometer if required.

Oil pressure should then be measured at ten or more equally spaced speed intervals between idle and maximum engine speed. The results, when plotted on a graph should look similar to Figure 2. A useful aid is to draw a straight line from the first reading taken at idle to the last reading taken at maximum engine speed. All the intermediate points on the curve should lie above this line.

If the pressure falls below the line or follows the line closely, there is probably a problem with the oil pump or the pressure relief valve, or excessive leakage is occurring within the engine itself. Even if the oil pressure is close to normal at full speed, it may be too low at peak torque where the bearings are subjected to maximum loading. Refer to Figure 3.

Figure 3: Comparison of normal and abnormal curves

There are many different designs of engines and pumps so, when a problem is suspected, it helps to have a reference graph against which to compare the results. It is therefore advisable to map an engine shortly after it has been run in and to use this baseline for comparison with later graphs.

Any change or drop-off in the graphs should be investigated, first checking the pump and pressure relief valve. If no fault is found with the pump, the engine itself should be inspected for excessive leakage.

Note: Engines fitted with scavenge pumps

Engines on some earthmoving equipment are designed for operating on slopes and are fitted with scavenge pumps. It is normally not possible to check the function of the scavenge pump, but it tends to wear out faster than the main pump, due to aeration of the oil in the scavenge pump when the engine is running level. An undetected scavenge pump failure will soon result in *bearing failure. Engines fitted with this type of pump need to have the pump stripped and checked for damage at planned intervals of at least every 10 000 hours of operation.*

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