Shell Lubricants

HYDRAULIC POWER EFFICIENCY
EVALUATING THE GAS-TO-LIQUIDS BASE-OIL ADVANTAGE

WHITE PAPER

Today's more compact mobile fluid power systems have smaller hydraulic fluid reservoirs and can be more susceptible to aeration. Because the fluid volumes are smaller, reservoir residence times can be as short as 30 seconds, which leaves little time for air release.

Fluid aeration reduces the efficiency and responsiveness, and increases the noise of hydraulic systems. Collapsing air bubbles on the high-pressure side can also cause erosion (Figure 1), which can cause pump failure and unplanned downtime. Aeration can also accelerate oil oxidation, thereby shortening oil life and contributing to poor precision in hydraulic operations.

EVALUATING EFFICIENCY AND NOISE

To tackle this problem, we evaluated four ISO viscosity grade 46 fluids formulated with different base oils:

- A: Group I mineral oil
- B: Group II mineral oil
- C: Group III gas-to-liquids (GTL) synthetic fluid
- D: polyalphaolefin (PAO) synthetic fluid.

We used the ASTM standard test method D3427 to measure the air release properties of each fluid. In this test, compressed air was blown through the test oil at 50°C. The time required for finely dispersed air in the oil to decrease to 0.2% by weight was then measured using a density balance.

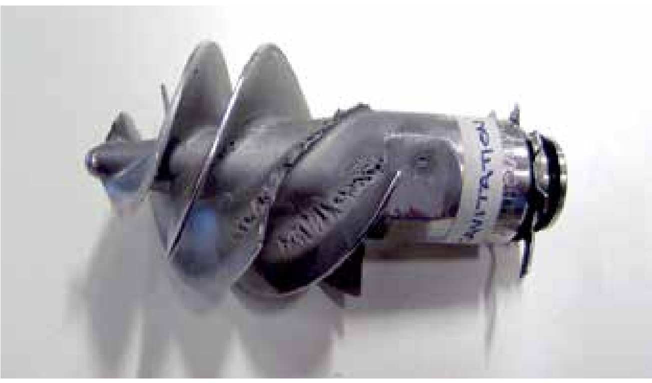

FIGURE 1: Erosion damage to a pump.

All the fluids evaluated were inside the 10-minute maximum air-release time allowed by the industry standard, but they did not all perform equally well (Table 1).

TABLE 1: Air release time.

	GROUP	AIR RELEASE TIME, MINUTES (ASTM D3427)
A	I (mineral)	5.03
B	II (mineral)	1.51
C	III (GTL)	0.17
D	IV (PAO)	0.17

We then evaluated the performance of these fluids in a dynamometer fitted with a reservoir with an inlet aerator and an outlet mass flowmeter using a modified ISO 4409:2007 procedure. The hydraulic circuit configuration, instrumentation and operating conditions were kept constant; only the fluids were changed.

Twelve different combinations of speed, pressure and aeration state were evaluated a minimum of three times, which generated more than 150,000 data points. This large dataset ensured that the air ingression and release rates had reached equilibrium and the pump performance was steady state.

RESULTS

The PAO and GTL-based oils had significantly faster air release compared with the mineral-based oils, which resulted in less entrained air and up to 8% greater volumetric efficiency. We also recorded a 50% perceived reduction in sound.

EFFICIENCY

Although the mechanical efficiency of the pump slightly improved when the fluid was aerated, this improvement was less than the concurrent decrease in volumetric efficiency. So, aeration reduced the overall pump efficiency. As volumetric efficiency affects hydraulic power transmission and productivity, fluids with a lower air content should improve machine performance.

The average volumetric efficiency of the pump was approximately 93% when the aerator was off. With the aerator on, this efficiency decreased by 9.4 and 4.5% for mineral-oil-based fluids A and B respectively. Synthetic-based fluids C and D reduced the efficiency by 2.0%. The synthetic fluids have up to 8% greater volumetric efficiency (Figure 2).

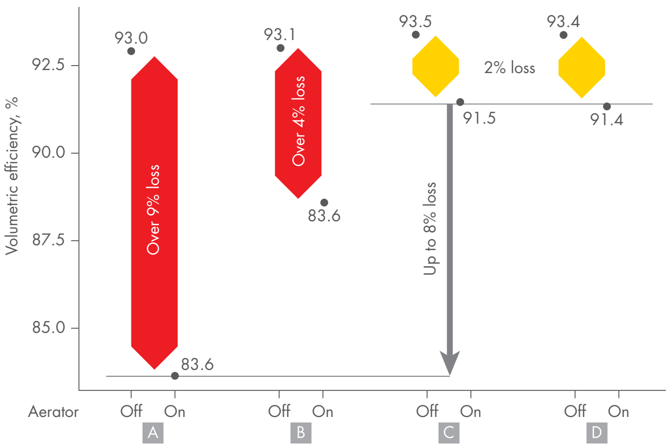

FIGURE 2: Volumetric efficiency.

SOUND

Fluid aeration causes cavitation and contributes to broadband noise generation by the pump.

Pump sound emissions were evaluated at several speeds, at 10 cm away, with the fluid in aerated and non-aerated states. Aeration increased the broadband high-frequency sound levels to between 2,500 and 4,000 Hz, which accounts for the harsh noise associated with pump cavitation.

Fluid A was the most susceptible to aeration and exhibited the largest sound increase relative to the baseline value. The mean sound level of the pump running with fluid A was about 6 dB(A) greater than that of the other fluids, which corresponds to a human perception of the noise being 50% louder.

GTL VERSUS PAO – WHICH IS BETTER?

Fluids C and D based on GTL (Group III) and PAO (Group IV) base oils respectively performed equally well, so which is better? The answer comes down to simple economics. PAO oils are expensive to produce, so our ability to manufacture lubricants, such as Shell Tellus S4 VE, formulated with GTL base oils on a global scale means that we can offer operators PAO benefits at a reduced cost.

KEY TAKEAWAYS

- Hydraulic fluids formulated with GTL (Group III) and PAO (Group IV) base oils display very fast air release times in the standard air release test and low levels of aeration in the dynamometer.
- Fluids formulated with Group I and Group II base oils met the standard requirements for air release time but exhibited high levels of aeration in the dynamometer.
- GTL-based fluids have significantly faster air release compared with the mineral-based oils, which means less entrained air and up to 8% greater volumetric efficiency.
- The mean sound level of the aerated Group I fluid was about 6 dB(A) greater than that of the three other fluids. This corresponds to a human perception of the noise being 50% louder.
- GTL-based fluids such as Shell Tellus S4 VE offer the performance advantages of PAO-based fluids but at a reduced cost.

SHELL TELLUS S4 VE

Shell Tellus S4 VE uses GTL technology, with the performance and cost advantages described above, to help improve the energy efficiency of mobile hydraulic systems. It is also designed to help extend equipment service life and lower maintenance costs through its outstanding wear protection and long oil life.

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