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Evaluation of motor oils and their effects on engine output and efficiency

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ABSTRACT

Several lubricant manufacturers make claims of substantial horsepower and torque improvements as a result of the use of their oils or oil additives. Possible explanations for these claims may possibly be attributed to the use of lighter viscosity oils or the addition of friction modifiers (FM). Although the selection of an oil based on its wear inhibiting properties is paramount, an evaluation of these same oils for their effect on horsepower and torque as well as the base specific fuel consumption of the engine with these lubricants is of interest on an air-cooled horizontally-opposed pushrod engine.

BACKGROUND

Our initial investigation of accelerated camshaft and follower/lifter wear leading to catastrophic failure started in 2003, leading to our introduction of ceramic composite sintered-silicon nitride lifters which virtually eliminated all wear and failures. Due to circumstances beyond our control, the manufacture and availability of these components ceased in 2006. In the process of investigating various processes and treatments of conventional camshafts and lifters in attempt to improve their performance, it was discovered that one possible cause of increased wear rates and instances of catastrophic failures were the oils these engines have been lubricated with. Aircooled Technology developed its own spintron to simulate run-in of camshaft and lifters to evaluate various lubricants as well as their effects on different brands of camshafts and lifters. It was determined that the oil Aircooled Technology had been using was indeed one cause of less than satisfactory results when using conventional lifters. Field testing of the poor performing oil along side various other semi-synthetic and fully-synthetic motor oils demonstrated the poor performing oil had several times the wear rate and viscosity loss compared to the more favorable lubricants, leading to recommendations for several lubricants based off of bench and real world testing of their superior wear performance in an air-cooled horizontally-opposed pushrod engine.

EXPERIEMENTAL
The work consisted of a series of dynamometer tests with three (3) production air-cooled horizontally-opposed pushrod engines using several motor oils.

PROCEDURE
The oil system was purged between each test and oil was captured back into pre-measured containers to ensure purging was complete. Complete weather and dyno cell conditions were recorded before and after each session and cell and intake air temperatures were maintained throughout the entire process for each test. Engines were allowed to warm up to an oil temperature of 180F at which time testing was started and all tests were completed as close to 220F. Allowing each oil a period of 10-15 minutes of run time allows for decomposition of oil additives into their better-performing byproducts and to allow anti-wear/anti-friction tribofilms to form.. Oil was promptly drained out and new oil was put in as soon as the old oil was collected and measured. Desired samples for oil analysis were collected to be sent out to Staveley Services North America to compare to previously sampled virgin oil. For sake of accuracy, every dyno pull was repeated to verify the observed and collected numbers. If there was any observed variation or unexpected deviation, each pull was redone until figures were repeatable. If observed cell or oil temperatures exceeded our allowed 10 degree F delta, tests were halted and temperatures were allowed to normalize before continuing with testing.

EXPERIMENTAL ERROR
Although every attempt to ensure the most accurate results were taken, there are subtle variations in weather and cell climate that can affect results and as such, there are correction factors to adjust for these changes. To try to limit this effect, the testing of each oil was performed as quickly as possible as to finish all tests within the time frame allotted where there would not be any drastic changes in weather or cell climate. As a result, we could only attempt limited number of tests with each oil in the time allotted. If more time had been permitted, each oil should have been run, drained, then a new batch of the same oil should have been tested again, to verify the previous results. Additionally, the engine should have been flushed between tests, to remove any deposited tribofilms left from the previous oil, like those deposited by moly-based friction modifiers. The process of allowing each oil to run for 10-15 minutes before any dyno testing was conducted was to allow each subsequent oil to clean and re-deposit its respective anti-wear/anti-friction films. Although some oils may have provided better figures, average horsepower, torque, and BSFC numbers from a full dyno sweep were computed and will be used for comparison. Lack of availability of some oils limited their test on all three (3) engines, but the majority of oil brands were represented between all three series of tests. Additionally, oils of different viscosities were tested in engine 3 ranging from 0W20 to 20W50 with no apparent effect on horsepower as best average numbers were achieved with a 15w40 and 20w50. As such, results posted in Matrix 1 and 2 are reported disregarding viscosity as an indicator for performance of the lubricant.

EQUIPMENT
Engine 1 was a VW Type 1 engine with dual valve springs and uncoated bearings with .0015” running clearance. Engine 2 was a 1971cc Volkswagen Type 4 engine with single

valve springs and uncoated bearings with .0015” running clearance. Engine 3 was a 2056cc Volkswagen Type 4 engine with dual valve springs and coated bearings with .002” running clearance. All engines had 30mm oil pumps, Mahle cast iron cylinders with cast hypereutectic pistons with conventional standard tension top, second, oil control rings, and similar sump capacities.

LUBRICANT TEST MATRICES

TEST MATRIX 1 AVERAGES

	Engine 1			Engine 3		
Oil	Torque	Horsepower	BSFC	Torque	Horsepower	BSFC
SS1	101.72	82.53	70.53	145.0	138.22	49.37
NS1	102.15	82.80	72.83	140.89	134.23	50.30
FS1	108.89	88.83	69.19	144.70	137.94	49.47
FS2	111.12	90.37	66.35	142.07	135.42	49.75

Matrix 1 evaluated two engines with different bearing clearances, engine 1 running .0015” clearance with an uncoated bearing and engine 3 running .002” clearance with a coated bearing. In engine 1, the semi-synthetic oil SS1, which contains no moly friction modifiers, performed notably worse than oils FS1 and FS2, both of which are friction modified oils. In engine 3 however, the effect of friction modifiers and the percentage of synthetic content had little effect on the perceived hydrodynamic friction losses recorded in engine 1.

TEST MATRIX 2 AVERAGES

	Engine 2			Engine 3		
Oil	Torque	Horsepower	BSFC	Torque	Horsepower	BSFC
SS1	125.05	83.82	52.89	145.0	138.22	49.37
NS2	127.74	85.76	51.64	145.07	138.26	49.99
FS3	125.84	84.19	51.86	143.86	137.03	49.75
FS3.2	125.58	84.07	52.25	142.60	135.89	50.10

Matrix 2 again evaluated two engines with different bearing clearances, engine 2 running .0015” clearance with an uncoated bearing and engine 3 running .002” clearance with a coated bearing, but in addition to this, engine 2 ran single valve springs with significantly less valve spring pressure directly affecting horsepower losses in the valve-train (including friction between cam and lifters). As in matrix 1, engine 2 experienced a similar improvement using oil NS2 containing a species of moly-based friction modifiers which in future tests has shown similar performance to oil FS1, but no where as drastic an improvement as seen in engine 1.

TEST MATRIX 3 AVERAGES

		Engine 3		
Oil	VIS	Torque	Horsepower	BSFC
FS7	0W20	142.56	135.70	52.71
FS6	0W20	143.43	136.50	49.45
FS5	10W40	142.49	135.82	48.88

SS2	15W40	142.90	136.29	49.99
NS2	15W40	145.07	138.26	45.37
FS4	15W40	143.26	136.50	49.34
SS1	20W50	145.06	138.22	49.37
FS1	20W50	144.70	137.94	49.47
FS2	20W50	142.07	135.45	49.75
FS3	20W50	143.86	137.03	49.75

In the previous matrices 1 and 2, oils SS1, NS2, and FS1 were identified as nearly indescribable from one another in engine 3 where in engines 1 and 2, oil SS1 was the poorest performer compared to the aforementioned oils NS2 and FS1. Matrix 3 was set up to evaluate the effect of viscosity as well as differences in oil formulations to see if improvements in horsepower, torque, and fuel consumption could be observed in engine 3. Observed horsepower and torque numbers were similar between the 15w40 NS2 oil and 20w50 FS1 oil, but base specific fuel consumption was clearly less with NS2. To rule out that neither the synthetic versus non-synthetic or viscosity difference was the cause, FS4, a 15w40 of the same brand and formulation as the thicker viscosity 20w50 FS1 was also tested without the same improvement of BSFC. Oil SS1 had similar horsepower and torque numbers as the best performing NS2 oil, but without the similar BSFC improvements.

TEST MATRIX 4 AVERAGES

	Engine 3		
Oil	Torque	Horsepower	BSFC
SS1	145.0	138.22	49.37
SS1.2	141.19	134.52	49.94
NS1	140.89	134.23	50.30
NS1.2	141.21	134.54	51.62
FS3	143.86	137.03	49.75
FS3.2	142.60	135.89	50.10

The purpose of matrix 4 was to evaluate the performance claims of an oil additive in non-synthetic, semi-synthetic, and full synthetic fully-formulated motor oils. The oil represented by XXX.2 the previously tested oil XXX plus the oil additive, manufactured by and of similar composition to FS3.

CONCLUSION

More testing is needed to validate these results and more thorough research needs to be done with the use of coatings or other surface treatments due to the sizeable reductions in BSFC and overall increase in output per liter as observed in engine 3, regardless of oil composition and viscosity. It is possible for a non-synthetic oil to have similar wear and better horsepower gains over even a thinner, full-synthetic oil, as we demonstrated, yielding further evidence that an oils' additive package is just as important, if not more so, than the oils' base stock as long as they are of equal quality. Similar improvements in BSFC were also observed with reductions in valve spring pressure and more attention needs to be directed towards use of lighter weight valve-train components. Gains from reductions in oil viscosity likely require engines to be built specifically with tighter clearances or it might be possible that a thoroughly blueprinted engine, as used in our test matrices, can yield similar horsepower gains which still retaining the wear benefits of using thicker motor oils with higher film strengths. The oil additive tested did not improve horsepower or improve fuel economy as claimed by the manufacturer, but did manage to reduce horsepower and torque output while increasing BSFC with oil SS1. As such, until further development and testing is done with oil additives, using such products is likely to have no positive effect over using a fully-formulated motor oil previously recognized for either its wear or performance gains.