

Kerberos Solutions is pleased to provide the following test report as the final deliverable per KSQ-005, dated June 6, 2000.

Overview

The purpose of this project was to perform a series of simple, cost effective tests on three, 4-stroke gasoline fueled Engines in an attempt to partially substantiate claims made by the manufacturer of a product known as PBC-Technology (PBC).

Engine

The Ryobe Engine was chosen for the testing of the basic claims made by PBC. The Engine parameters from the manufacturer are as follows:

Engine Type	Air – cooled, 4 cycle
Displacement	1.6 cu.in. (26.2 cc)
Operating RPM at WOT	6,800 – 7,800 rpm
Idle RPM	2,800 rpm
Lubrication	SAE 30 Oil
Crankcase Oil Capacity	3.4 oz. (100 ml)
Fuel	Unleaded gasoline
Fuel Tank Capacity	20 oz.

Cylinder head temperatures were monitored using a hand held infrared thermometer, Omega O5520. The unit was calibrated on the A Engine via Method 3. Emissivity value was determined to be equal to .95.

Testing Conducted

Testing was conducted in accordance with the test plan as presented in Kerberos KSQ-005. The Engines were labeled A, B & C for recording test data.

- Engine A, the base line Engine with oil, is S/N 004230680.
- Engine B, the PCB treated Engine, is S/N 004230675.
- Engine C, the base line Engine without oil and the PCB “Repair Engine” is S/N 004240677.

To verify that all three Engines were functional, provide base line data and check the test set up, all three Engines ran the cycle of idle for 5 minutes then wide open throttle (WOT) for 5 minutes. This was repeated three times for a total of 30 minutes.

At this point Engine B had the oil drained. PCB was then added and mixed well with the oil. PBC – Lubricant & Compound Dosages were scaled to the test Engine size based on dosage information found on the PCB website. The oil was then returned to Engine B. Then all three Engines repeated the cycle as before (3 x 5 minutes at idle/5 minutes

at WOT), but with the addition of 5 more minutes of idle at the end for a total of 35 minutes.

At this point the oil was drained from the B and C Engines. To monitor closely, Engine C, the untreated Engine without oil, was run by itself. It was run for 10 minutes at idle and then for 5 minutes and 43 seconds at WOT before it seized. The Engine was allowed to cool and disassembled. The observed failure mode was an overheating of the piston, which in turn caused the Engine to seize. Minimal repair was affected to the Engine to allow freedom of movement of the piston with in the cylinder. All exposed "rubbing" surfaces were liberally treated with PBC Restore Compound. The Engine was then reassembled, oiled with SAE 30 oil and PCB lubricant and started. The Engine started with little difficulty, in spite of a broken compression ring. Initially, the Engine would not maintain idle speed and blue smoke (oil) was evident. The Engine speed was then advanced to WOT for 48 minutes. An occasional puff of blue smoke was noted, but the Engine appeared to run normally. At 48 minutes run time, the Engine was brought to idle and the Engine was able to maintain a normal idle, however, there was an excessive amount of smoke noted. The Engine was stopped and allowed to cool for 5 minutes and then restarted. After the restart, the before mentioned smoking at idle speed had cleared and the Engine continued to idle normally for a few more minutes until it was stopped due to the lateness of the hour. Subsequently, the Engine was disassembled, inspected and photographed.

Next Engine B, the treated Engine now without oil, was ran for 10 minutes at idle followed by 110 minutes at WOT. Due to the lateness of the day, the Engine test was stopped. The following day Engine B ran for additional 103 minutes at WOT before seizing. Engine B ran for a total of 3 hours and 43 minutes without oil after being treated with PCB.

Engine A accumulated the same amount of time as Engine B before stopping and resuming the next day. The following day Engine's A and B ran side by side. Engine A ran well through the entire test.

Detailed Engine Inspection

Engine A was not disassembled.

Engine B was visually inspected after running 3 hours and 43 minutes without oil. The following conditions were noted:

Piston

- Top compression ring free in the ring land
- No. 2 Compression Ring stuck in the ring land
- Oil Control Ring stuck in the ring land
- Piston galling was minimal
- Piston pin retainers had started to melt (designed to indicate over heating)

- Upper piston pin bearing appeared to be loose

Cylinder

- Cylinder was scored
- Aluminum material migrating on to the spark plug sidewall

Rocker Arm Assembly

- There was little evidence of oil on the rocker arm bearing surface or the rocker arm shaft

Engine C was visually inspected the first time after having run for 15 minutes and 43 seconds without oil. The inspection revealed the following damage: The Engine heat seized between the piston and cylinder. This was a predictable failure mode due to lack of proper lubrication and oil cooling effect.

Piston

- Piston was galled
- Compression and oil rings were stuck in their respective ring lands
- No. 2 compression ring was broken

Cylinder

- Cylinder was scratched and scoured but not excessively
- Aluminum material was stuck to the cylinder wall
- Rocker arm assembly appeared in tack
- Crankshaft and connecting rod bearings seemed in tack and no unusual binding during rotation was noted

Rocker Arm assembly

- Nothing unusual was noted in the inspection

Engine C was reassembled after the piston rings were freed and the top of the piston smoothed and the aluminum was removed from the cylinder wall. All parts received a liberal amount of the "Repair" compound, especially to the cylinder, crankshaft and connecting rod assembly. The Engine was then started and run for approximately 55 minutes and visually inspected after it's second run with the following observations:

- The piston was still galled, but the compression and oil rings were found to loose in the ring lands
- The cylinder wall remained scoured, however it was free of aluminum
- The piston did not exhibit any apparent additional wear
- The rocker arm assembly did not exhibit any wear

Conclusions

The test plan prepared for these Engines is best defined as grueling. To our knowledge, these Engines are designed by the manufacturer with an estimated life expectancy of about 50 hours of operation. The operating cycle of the Engine is normally cyclic with the majority of running at some other speed than Wide Open Throttle (WOT). The Engines are considered to be high-speed Engines because of the speeds they are able to obtain and sustain. During the testing the Engines were subjected to operating conditions that are considerably taxing.

Engine A ran well and demonstrated the high quality expected of Ryobe Engines.

Engine B after treatment with PCB-Technology Lubricant ran for 3 hours and 43 minutes without oil. This compared with C only lasting 15 minutes indicates that PBC claims of enabling an Engine to run without oil are in fact creditable. Based on the visual inspection of the parts at the time of failure and when compared to the C Engine failure mode, while the failure mode was the same, the damage to the B Engine was not nearly as extensive, especially when one considers the amount of time accumulated by the B Engine while running without lube oil.

Engine C initial failure was predictable; running an Engine at high speed with out lube oil is always disastrous. When the Engine was rerun without parts replacement, the PBC restore compound and PBC lubricant the Engine appeared to exhibit some repair in that the Engine did not overheat and re seize in spite of the fact the Engine was run with a broken ring. Also, when initially started, after the PBC was used, the Engine was unable to idle. However, this improved significantly after the Engine was run for a period of time. This observation is consistent with the claims made by PBC on their web page.

Attached to the end of this report are the temperature recordings taken on the cylinder heads. These temperatures were evaluated and were determined to be inconclusive in terms of reliable scientific data because of environmental instabilities (wind, shade, etc.), however, the results are indicative of the condition of the parts at failure and through out the testing.

Also provide are photographs showing the condition of the parts of the Engines, however, the failure mode may not be readily discernable to the untrained eye as none of the failures were truly catastrophic.

Recommendations

The testing conducted certainly indicates further more intensive and controlled testing is warranted. At a minimum, the following additional tests are recommended:

- Run a treated Engine and untreated Engine for a period of 4 hours while closely monitoring Engine temperature, speed and fuel consumption.
- A side by side comparison with products that make a similar claims
 1. fuel savings claims
 2. Engine able to run without oil
 3. lower emissions
- A test rig set up with a babbet type bearing driven by an electric motor. The bearing would be scored and measured and then compound added and run for a TBD amount of time and then evaluated.
- Establish testing on an automobile Engine in a controlled environment.

Prior to conducting any additional testing, communications need to be established with PBC (manufacturer) and definite instructions on the use and dosage of the PBC products needs to be made available to document the accuracy of the testing and the claims of PBC-Technology.