High Performance Cylinder Sealing

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Cylinder sealing is affected by each component in the cylinder kit. The piston and rings are of course major players in achieving optimal cylinder sealing, along with cylinder bore geometry and honing finish.

For this discussion, we will be concentrating on the influence the piston and ring groove has to cylinder sealing in high performance applications.

Blow-by gas leakage past piston rings will follow the path of least resistance and without preference. It is often assumed that if an engine has excessive blow-by, the gas leakage is predominately occurring between the outside peripheral surface of the ring and the cylinder bore.

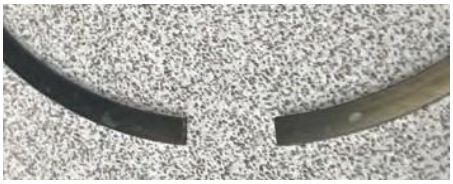
While this is true in many cases, there can be other less obvious reasons for the leakage that will contribute to blow-by as much or more than the interface between the outside peripheral surface of the ring and the cylinder bore itself.

Here are a few other examples of where blow-by can originate from and what can be done to address this leakage.

Piston ring microwelding can be defined as adherence of minute particles of aluminum from the piston ring groove side surface to the bottom of the piston ring surface. It can cause substantial blow-by gas leakage and can be easily missed during engine teardown inspection.

It can be caused by, among other things, a combination of high temperature, friction and inadequate lubrication. The result is significant damage to the bottom of the ring groove caused by the development of minute local welds between the bottom sealing surface of the ring and ring groove.

This often looks like very minute dots or smeared aluminum paint on the bottom sealing surface of the compression ring and is easy to overlook if not closely examined.



Microwelded lower sealing surface of top ring.

Because the lower flank of the ring groove and the lower surface of the piston ring play such an important role in sealing the blow-by gas, even a small amount of microwelding will immediately increase the entry of blow-by gas into the crankcase.

As aluminum from the bottom of the ring groove surface microwelds to the bottom of the piston ring surface, the ring moves in the ring groove due to primary and secondary piston motion. During this motion, the aluminum welded to the ring will be pulled off the lower ring groove surface leaving a crater in the surface of the ring groove that is a direct leakage path for blow-by gas.

As the microwelding progresses, another small piece of aluminum from the bottom of the ring groove will weld to the ring in yet another location and the ring continues to pull out more aluminum from the lower sealing surface of the ring groove and will create yet another leakage path for the blow-by gas.

As soon as the microwelding begins to happen, a notable increase in blow-by will occur that can be quantified with the use of a blow-by meter.

Piston ring blow-by is measured with the engine running with a blow-by meter, which is a special type of flow measuring device specifically designed for this task. It is used by piston and piston ring manufacturers in the development of their products and is also widely used in the racing industry. The blow-by data is acquired with the engine running on a dynamometer in real time and recorded continuously throughout the testing. This is a dynamic measurement that offers more in-depth information than a leak down test.

There are several methods of improving the durability of the ring groove surface to combat the microwelding issue.

One method is to hardcoat anodize the top ring groove. Anodizing is a metal conversion process used on aluminum alloys. In this process, the piston is masked and the top ring groove is left exposed during the anodizing procedure. The piston is submerged in a sulfuric acid solution and low voltage, high amperage current is applied. During this process, the aluminum in contact with the acid bath is converted to aluminum oxide, which is a very hard material that is resistant to microwelding.

Piston with autocatalytic plated ring grooves.

It also provides a wear resistant surface for the piston ring to run against.

Another solution is to apply an autocatalytic plating to the ring groove. A single chemical reaction is said to be autocatalytic if one of the reaction products is also a catalyst for the same or a coupled reaction. Such a reaction is called an autocatalytic reaction. Electricity is not used in this type of plating process.

The autocatalytic plating method has several advantages over the more common Electroplating method. The dimensional accuracy and coating thickness uniformity of this plating method is unsurpassed, which is why the process lends itself so well to the ultra precise geometry of a modern ring grooves. It is a proven method of eliminating microwelding of the top ring groove and adds to the overall durability of the ring groove.

Speaking of blow-by, how much is acceptable? It is known that large displacement engines do produce more piston ring blow-by volume than small displacement engines do, so is there a blow-by rating method that fairly compares different engines?

Combustion chamber erosion caused by detonation.

Second land damage from severe detonation.