

Piston Diagnostics

These pictures and descriptions are by Eric Gorr and were taken from an Australian dirtbike website, which appears to no longer exist. I have had these "on file" for some time and I publish them, with thanks, unchanged.

The process of examining a used piston can tell a mechanic helpful information on the condition of an engine. When an engine failure occurs, the piston is likely to take the brunt of the damage. A careful examination of the piston can help a mechanic trace the source of a mechanical or tuning problem. This technical article serves as a guide for the most common mechanical problems that plague engines.

PERFECT BROWN CROWN

The crown of this piston shows an ideal carbon pattern. The transfer ports of this two-stroke engine are flowing equally and the colour of the carbon pattern is chocolate brown. That indicates that this engine's carb is jetted correctly.



BLACK SPOT HOT

The underside of this piston has a black spot. The black spot is a carbon deposit that resulted from pre-mix oil burning on to the piston because the piston's crown was too hot. The main reasons for this problem are overheating due to too lean carb jetting or coolant system failure.



ASH TRASH

This piston crown has an ash colour, which shows that the engine has run hot. The ash colour is actually piston material that has started to flash (melt) and turned to tiny flakes. If this engine was run any longer, it probably would've developed a hot spot and hole near the exhaust side and failed. The main causes of this problem are too lean carb jetting, too hot spark plug range, too far advanced ignition timing, too much compression for the fuel's octane, or a general overheating problem.



SMASHED DEBRIS

This piston crown has been damaged because debris entered the combustion chamber and was crushed between the piston and the cylinder head. This engine had a corresponding damage pattern on the head's squish band. The common causes of this problem are broken needle bearings from the small or big end bearings of the connecting rod, broken ring ends, or a dislodged ring centring pin. When a problem like this occurs, it's important to locate where the debris originated. Also the crankcases must be flushed out to remove any left over debris that could cause the same damage again. If the debris originated from the big end of the connecting rod, then the crankshaft should be replaced along with the main bearings and seals.



CHIPPED CROWN DROWNED

This piston crown chipped at the top ring groove because of a head gasket leak. The coolant is drawn into the combustion chamber on the down-stroke of the piston. When the coolant hits the piston crown it makes the aluminium brittle and it eventually cracks. In extreme cases the head gasket leak can cause erosion at the top edge of the cylinder and the corresponding area of the head. Minor leaks of the gasket or o-ring appear as black spots across the gasket surface. An engine that suffers from coolant being pressurized and forced out of the radiator cap's vent tube, is a strong indication of a head gasket leak. In most cases the top of the cylinder and the face of the cylinder head must be resurfaced when a leak occurs. Most mx bikes have head stays mounting the head to the frame. Over time the head can become warped near the head stay mounting tab, because of the forces transferred through the frame from the top shock mount. It's important to check for warpage of the head every time you rebuild the top end.



SHATTERED SKIRT

The skirts of this piston shattered because the piston to cylinder clearance was too great. When the piston is allowed to rattle in the cylinder bore, it develops stress cracks and eventually shatters.



SNAPPED ROD

The connecting rod of this engine snapped in half because the clearance between the rod and the thrust washers of the big end was too great. When the big end bearing wears out, the radial deflection of the rod becomes excessive and the rod suffers from torsion vibration. This leads to connecting rod breakage and catastrophic engine damage. The big end clearance should be checked every time you rebuild the top end. To check the side clearance of the connecting rod, insert a feeler gauge between the rod and a thrust washer. Check the maximum wear limits in your engine's factory service manual.



FOUR-CORNER SEIZURE

This piston has vertical seizure marks at four equally spaced points around the circumference. A four-corner seizure is caused when the piston expands faster than the cylinder and the clearance between the piston and cylinder is reduced. Another common problem of this type is a single point seizure on the centre of the exhaust side of the piston. However this occurs only on cylinders with bridged exhaust ports. The main causes for this problem are too quick warm-up, too lean carb jetting (main jet), or too hot of a spark plug range.



MULTI-POINT SEIZURE

This piston has many vertical seizure marks around the circumference. This cylinder was bored to a diameter that was too small for the piston. As soon as the engine started and the piston started its thermal expansion, the piston pressed up against the cylinder walls and seized. The optimum piston to cylinder wall clearances for different types of cylinders vary greatly. For example a 50cc composite plated cylinder can use a piston to cylinder wall clearance of .0015 inches, whereas a 1200cc steel-sleeved cylinder snowmobile set-up for grass drags will need between .0055 to .0075 inches. For the best recommendation on the optimum piston to cylinder clearance for your engine, look to the specs that come packaged with the piston or consult your factory service manual.



INTAKE SIDE SEIZURE

This piston was seized on the intake side. This is very uncommon and is caused by only

one thing, loss of lubrication. There are three possible causes for loss of lubrication, no pre-mix oil, separation of the fuel and pre-mix oil in the fuel tank, water passed through the air-filter and washed the oil film off the piston skirt.



COMPOSITE FLAKING

Most two-stroke cylinders used on motorcycles and snowmobiles, have composite plated cylinders. The composite material is made of tiny silicon carbide particles. The electro-plating process enables the silicon carbide particles to bond to the cylinder wall. The particles are very hard and sharp, they don't bond to the ports so the manufacturer or reconditioning specialist must thoroughly clean the cylinder. Sometimes the silicon carbide "flashing" breaks loose from the ports and becomes wedged between the cylinder and the piston. This causes tiny vertical scratches in the piston. This problem isn't necessarily dangerous and doesn't cause catastrophic piston failure, but it should be addressed by thoroughly flushing the cylinder and ball-honing the bore to redefine the cross-hatching marks. Normally you will need to replace the piston kit because the scratches will reduce the piston's diameter beyond the wear spec.



BURNT-OUT BLOW-HOLE

This piston was overheated so badly that a hole melted through the crown and collapsed the ring grooves on the exhaust side. Normally the piston temperature is higher on the exhaust side so catastrophic problems will appear there first. There are several reasons for a failure like this, here are the most common; air-leak at the magneto side crankshaft seal, too lean carb jetting, too far advanced ignition timing or faulty igniter box, too hot of a spark plug range, too high of a compression ratio, too low octane fuel.



BLOW-BY

This piston didn't fail in operation but it does show the most common problem, blow-by. The rings were worn past the maximum ring end gap spec, allowing combustion

pressure to seep past the rings and down the piston skirt causing a distinct carbon pattern. Its possible that the cylinder walls cross-hatched honing pattern is partly to blame. If the cylinder walls are glazed or worn too far, even new rings won't seal properly to prevent a blow-by problem. Flex-Hones is a product available at most auto parts stores. They can be used to remove oil glazing and restore cross-hatch honing marks that enable the rings to wear to the cylinder and form a good seal. If you purchase a Flex-Hone for your cylinder, the proper grit is 240 and the size should be 10% smaller than the bore diameter.



11 TIPS FOR REBUILDING A TWO-STROKE TOP END

1. Before you disassemble your engine, power-wash the engine and the rest of the vehicle. That will reduce the risk of dirt and debris falling into the engine. Once you remove the cylinder, stuff a clean rag down into the crankcases.
2. The cylinder and head use alignment pins to hold them straight in position from the crankcases on up. The pins make it difficult to remove the cylinder from the cases and the head from the cylinder. Sometimes the steel alignment pins corrode into the aluminium engine components. Try spraying penetrating-oil down the mounting studs before attempting to remove the cylinder and head. Never use a flat-blade screwdriver, chisel, or metal hammer to remove the cylinder. Instead use this technique; buy a lead-shot plastic mallet, swing it at a 45-degree angle upwards against the sides of the cylinder. Alternate from left to right, hitting the sides of the cylinder to separate it from the cases evenly. Clean the steel alignment pins with steel wool and penetrating-oil. Examine the pins closely. If they are deformed in shape, they won't allow the engine parts to bolt together tightly. This can cause a dangerous air leak or a coolant leak. The pins are cheap at about \$2 each. Replace them if they're rusty or deformed.
3. Never re-use old gaskets. Remove them with a razor blade or gasket scraper. Don't use a drill-driven steel wool type pad to remove old gaskets because they can remove aluminium from the cylinder and head. That will cause a gasket to leak.
4. Always check the ring end gap on a new ring by placing it in the cylinder between the head gasket surface and the exhaust port. The gap should be between .012 to .024 inches.
5. Always install the circlips with the opening facing straight up or down, that way inertia will hold it tight into the clip groove. Place one clip in the groove before installing the piston on the connecting rod. Its easier to install a clip with the piston in your hand rather than on the rod. There also less chance that you'll drop the circlip in the crankcases.
6. Always install the rings on the piston with the markings facing up. Coat the rings with pre-mix oil so they can slide in the groove when trying to install the piston in the cylinder.
7. Always install the piston on the connecting rod with the arrow on the piston crown facing towards the exhaust port.
8. The traditional way to assemble the top end is to install the piston assembly on the connecting rod, compress the rings, and slide the cylinder over the piston. That can be difficult with larger bore cylinders, or if you're working by yourself. Try this method instead. Install one circlip in the piston, install the piston into the cylinder with the pin hole exposed, install the piston pin through one side of the piston, position the cylinder over the connecting rod and push the piston pin through until it bottoms against the circlip, install the other circlip. It only takes two hands to install the top end using this manor and there is less chance that you'll damage the rings by twisting the cylinder upon installation.
9. On cylinders with reed valves and large oval intake ports, take care when installing the piston assembly in the cylinder because the rings are likely to squeeze out of the ring grooves. Use a flat-blade screwdriver to gently push the rings back in the grooves so the piston assembly can pass by the intake port.

10. For steel head gaskets, place the round side of the "bump" facing up. Don't use liquid gasket sealer, use aerosol spray adhesive types instead. For hybrid fibre/steel ring head gaskets, place the wide side of the steel rings facing down.
11. When you initially start the engine after a rebuild, manipulate the choke to keep the engine rpm relatively low. Once the engine is warm enough to take it off choke, drive the vehicle around on flat hard ground. Keep it under 2/3 throttle for the first 30 minutes. Two common myths for proper engine break-in are:
 1. Set the engine at a fast idle, stationary on a stand.
 2. Add extra pre-mix oil to the fuel.

When the engine is on a stand it doesn't have any air passing through the radiator and it is in danger of running too hot. When you add extra oil to the fuel you are effectively leaning the carb jetting. This can make the engine run hotter and seize.