A basic guide to borescopic inspection for gas engines

Background

ExxonMobil's Field Engineering Support team is dedicated to providing increased productivity and efficiency for the industry through application expertise. In a time, when "time equals money", monitoring inside of an engine without opening it pays off, as it will reduce downtime. An important method to get a valuable snapshot of equipment's condition is through borescopic inspection. It is important that we uncover the customer's real needs as opposed to offering borescope inspections as "nice to do's". Borescope can be a useful tool when used for troubleshooting, lube conversions, oil drain interval and overhaul extensions and demonstrating product capabilities. This document provides a summary for which components to inspect and what critical parameters to seek to come up with meaningful inspections on gas engines. We will focus our effort inside the combustion chamber and study:

- Liner
- Cylinder Head
- Piston
- Valves

1. Liner

Start with moving your lens toward the bottom surface of the liner. Here you will get good images of visible cross-hatching (honing marks). Then proceed to the upper surface of the liner where you can see the effects of combustion. In time, friction and wear will tend to erase the honing marks. Ideally, we would like to see obvious and well defined cross-hatchings on top of the liner as well as the bottom part.

Carbon particles polish the cylinder liner, leaving it with a smooth surface with honing marks no longer existing (bore polishing). Anti-polishing ring, fitted on top of the liner, is used to prevent bore polishing by collecting carbon particles that remain on upper parts of the piston. Move the lens toward the top dead center of the liner in order to inspect the thickness of blackish carbon deposits. Refer to OEM manual to check the thickness of deposit. If it exceeds limits, the liner may have to be renewed (Figure 1).

Finally, inspect the overall condition of liner surface. Ideally, we should not see horizontal scratches perpendicular to cylinder's line of motion. These are not acceptable. It is crucial to see the honing marks through the varnish or scratches. If you can see them, they should still be impactful (Figure 2).

Checking the above will enable you to evaluate the overall condition of the liner. Note that important bore polishing areas or varnishing fouling the honing marks tend to significantly increase oil consumption.

2. Cylinder Head

Position your lens to reflect the bottom surface of the cylinder head. Here, the first thing to inspect is presence of ash. Check out if the ash layer is evenly distributed. If not, this may indicate non-homogeneous thermal dissipation. Also check if there is excessive amount of ash, which has direct correlation with proper lubricant selection and its quality (Figure 3).

Observe if there are any cracks, especially around valve-deck vicinity. Coolant leaks may refer to cracks on cylinder head, which are not acceptable.

Figure 1
A defected anti-polishing area on liner

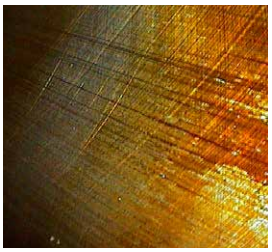

Figure 2
A varnished liner with honing marks visible

Figure 3
Valve deck ash layer

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3. Piston

Now you can proceed to the piston crown. Carbon deposit is the first thing to inspect in this area. It is normal to observe some deposit formation, which should be evenly distributed. Uneven deposit distribution is a sign for non-homogeneous thermal dissipation (Figure 4). Inspect signs of deformation on piston bowl as evidence of detonation, such as craters, pit marks and broken pieces on edges (Figure 5). Look for marks of water and oil to identify if there is any leakage from cooling galleries or lubrication system. Check the amount and source to understand the severity of leakage.

Figure 4
Piston crown carbon build-up

Figure 5
Piston detonation

4. Valves

First, move your camera towards exhaust valves. Observe carbon deposits on the valve plate to understand effects of combustion quality. Too much deposit and blackish residue means poor combustion.

A certain amount of ash is necessary on the valve surface to insulate the valve from combustion heat, but too much ash may carve out hot spots on the valve surface and result in eroded grooves or burnt valves (Figure 6).

Then, move to the intake valves. Monitor ash formation on the valve plate to understand lubrication quality and effects of product selection. If ash is unevenly distributed, this shows non-homogeneous heat distribution. Note that, too much ash can also be the result of excessive oil consumption due to oil control loss at the rings or through the valve guides. Inspect both valve groups for cracks. An engine with a cracked valve should not be started before renewing the valve.

Operating with a cracked valve may have catastrophic results, as broken pieces will damage other parts of the engine (Figure 7).

In natural gas engine operation, oil is permitted to travel down intake and exhaust valve guides to lubricate the valve stems and guides. Oil is also permitted to travel past scraper rings on the piston to lubricate cylinder walls. Oil is then consumed during combustion and produces ash, which protects the exhaust valve seats during operation. The amount of oil consumed is controlled by engine and scraper ring design and the selection of valve guide seals. Therefore, the amount of ash deposit is typically related to the amount of oil consumed.

Finally, check for the existence of valve recession. Recession is about losing valve lash. Seats wear out and valves shrink back into the head until there is no lash left and valve makes poor contact with its seat. Recessed valves should be reported and renewed (Figure 8).

Figure 6
A torched valve

Figure 7
A cracked valve

Figure 8
A recessed valve

Safety

Please ensure that you completed all required safety trainings (H_2S, Lock-out & Tag-out, 1st aid etc). You must be well trained and well equipped. That means you should have all required PPEs such as; hard hat, hearing protection, eye protection, nomex cover-all with reflective stripes, gloves, steel boots and for head gas monitor. Review the relevant Job Safety Analysis (JSA) and take proper mitigation to address risks. Don't forget to plan your work.

Conclusion

As a service of ExxonMobil's Field Engineering Support division, borescopic inspection may be widely used for all types of gas engines. Note that our main goal is to document the observations after monitoring combustion chamber's components. This can help us inform the customer about running condition of the gas engine and the effects of lubricant in operation.

This document summarizes the basics of conducting borescopic inspections on gas engines and serves as a simple guide on understanding the outcome.

Figure 9
Use personal protective equipments (PPE) during borescope inspections

Figure 10
Lock-out & Tag-out station