CAUSE AND EFFECT ANALYSIS OF HEAD COMPRESSION LEAK OF A TRACTOR ENGINE

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ABSTRACT

In today's world you cannot imagine life without automobiles and engine is the heart of any automobile. Defects in the engine while the production of any automobile lead to loss in every sense, be it monetary or loss of time. The head compression leak is one of the most severe and frequent defects one comes across while the production of an engine. Different methodologies can be adapted to minimize a defect in the manufacturing process of an engine. This paper represents a research on the manufacturing process and a trough follow up on the HCL defect of a tractor engine. This paper illustrates the whole methodology adopted for rectification and almost eradication of head compression leak in tractor engine. This paper will help industries to rectify and eradicate HCL which could further lead to less production time and high production efficiency.

Keywords: HCL, Defects, Production Time.

1. INTRODUCTION

A compression test measures how much pressure the piston creates in the cylinder when traveling from bottom dead center (BDC) to top dead center (TDC) with the valves closed. The reading is taken at the spark plug fitting in the cylinder head. Because we are trying to recreate normal operating conditions there are a few parameters that need to be met before performing the test.

- The engine must be at or near operating temperature.
- All the spark plugs must be removed. (It is advisable to loosen all the spark plugs ½ turn, and then start the engine for 15 seconds. Then completely remove the spark plugs from the cylinder head. This blows out any carbon that might get broken loose and caught between the valve and valve seat. If this were to happen, you could get a false, low compression reading.)
- The throttle must be all the way open (WOT)
- The ignition and/or fuel system should be disabled

While most compression leaks bleed into adjacent cylinders or across the fire deck to the atmosphere, it is possible for a leak path to open into the water jacket. The engine might seem healthy enough, but overheat within a few minutes of start-up. Coolant in the header tank might appear agitated and might spew violently with the cap removed. A cooling system pressure test will verify the existence of a leak, which can be localized with a cylinder leak-down test. However, the leak-down test cannot distinguish between cracks in the casting and a blown gasket. Fortunately, it is rare for an engine that has not suffered catastrophic overheating to leak coolant into the oil sump, where it can be detected visually or, in lesser amounts, by a spectrographic analysis. Likely sources are casting cracks, cracked (wet-type) cylinder liners, and liner-base gasket leaks. The cylinder head casting, like the fluid end of a high-pressure pump, will eventually fail. After a large, but finite, number of pressure cycles, the metal crystallizes and breaks. Owners of obsolete engines for which parts are no longer available would do well to keep a spare head casting on hand. Even so, most cylinder heads fail early, long before design life has been realized, because of abnormally high combustion pressure and temperature.

There are three major leak paths where cylinder pressure can escape: past the rings, the intake valve, or the exhaust valve. We'll ignore the head gasket for now. With each of these three leak sources, it's easy to tell where the leakage is originating with some sleuthing. If you can hear a hissing sound coming from the valve cover breather hole or from the dipstick tube, then the air is escaping past the rings. If you prop open the throttle blades and hear that same hissing sound, then the pressure is leaking past the intake valve. If the air is escaping past the exhaust valve, you will probably be able to hear the air even as far back as the tailpipe.

2. STRUCTURE OF CYLINDER HEAD

In an internal combustion engine, the cylinder head (often informally abbreviated to just head) sits above the cylinders on top of the cylinder block. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed with a head gasket. In most engines, the head also provides space for the passages that feed air and fuel in the cylinder, and that allow the exhaust gas to escape. Internally, the cylinder head has passages called ports or tracts for the fuel/air mixture to travel to the inlet valves from the intake manifold, and for exhaust gases to travel from the exhaust valves to the exhaust manifold. In a water-cooled engine, the cylinder head also contains integral ducts and passages for the engines coolant - usually a mixture of water and antifreeze - to facilitate the transfer of excess heat away from the head, and therefore the engine in general. In the overhead valve (OHV) design, the cylinder head contains the poppet valves and the spark plugs, along with tracts or 'ports' for the inlet and exhaust gases. The operation of the valves is initiated by the engine's camshaft, which is sited within the cylinder block, and its moment of operation is transmitted to the valves pushrods, and then rocker arms mounted on a rocker shaft - the rocker arms and shaft also being located within the cylinder head.

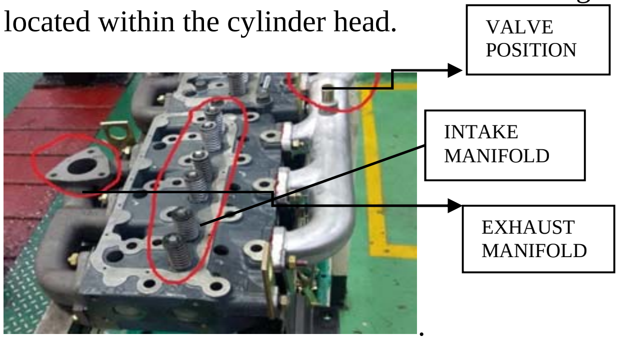

Figure 1: Cylinder Head Components

3. PROCEDURE FOR COMPRESSION LEAK TESTING

Compression Leakage in cylinder heads is one of the major problems being faced by the industry as it does have a considerable effect on the efficiency of the engine and the engine is not able to produce sufficient horsepower (HP).Broadly speaking, the piston moves from BDC to TDC compressing the cylinder air to certain pressure for combustion to occur. The resale of pressure at the cylinder head (due to leakage at valve seat) makes it impossible for the cylinder to attain the presided pressure for combustion this is known as Head compression Leakage (HCL). Head compression Leakage is of the major reason behind lowering of the engine efficiency.

Figure 2: water leaking at the valve cylinder interface

The steps involved in the compression leakage testing are as follows:

- The product is attached to the test port and the test sequence is initiated.
- The Fill step pressurizes the part with regulated air through [V2] and [V1].
- The valves are closed and the part is allowed to settle trapping air between [V1] and the product.
- During the Test step the decay of pressure is measured by the pressure sensor [S1].
- If a product exceeds the programmed reject value a reject indicator will be given along with the decay value.

- A part that does not decay past the reject value is a good part.
- The remaining pressure is vented for safety. [V1] opens to allow the pressure to vent.

3.1 PRESSURE DECAY TESTING

The pressure decay of a given control volume (the volume of the unit under test and Connecting tubes) can be used to calculate leak flow rate using the following equations:

- Mass leak flow rate:

$$m = \frac{\partial p}{\partial t} \times \frac{V}{Z \times R \times T}$$

- Volumetric leak flow rate:

$$Q = \frac{\partial p}{\partial t} \times \frac{V}{P}$$

In these equations, m is the mass leak flow rate in grams per minute; Q is the volumetric leak flow rate in cubic centimetres per minute; ($\partial p \div \partial t$) is the pressure decay rate in kilopascals per minute; V is the control volume in cubic centimetres; P is the average absolute gas pressure during the test in kilopascals-absolute; T is the average absolute temperature in degrees Rankin; R is the gas constant; and Z is gas compressibility, which is dimensionless. For most applications, Z can be assumed to be 1. These equations indicate that the pressure decay method is sensitive to the volume of the test part and the pressure decay rate. Any correlation between the leak flow rate and pressure decay must be performed with the same volume that was used during product testing. In addition, engineers must allow enough time for a steady decay to develop. The pressure decay rate is temperature-sensitive, because the gas density depends on pressure and temperature. Pressure decay instruments can detect leaks at sensitivity rates equivalent to their pressure decay measurement sensitivity. From the conversion equations, it's clear that the larger the product volume, the less sensitive the instrument will be. Engineers must use these equations to establish their measurement requirements. In general, the pressure decay method cannot detect very small leak rates. In the trace gas method, the product is pressurized with a trace gas, and the concentration of that gas leaking out around the product is measured. Helium is the most common gas used in this process. Helium is an excellent trace gas, because it exists in the environment at a concentration of 4 to 5 parts per million. Helium is also inert. It will not damage the product, the way that more active trace gases can. However, helium is expensive. In many cases, continuous test operations with helium can cost more than $100,000 per year.

3.2 VALVE LEAK TESTING

This is the process of testing leakage during compression stroke of engines. During compression when the charge is getting compressed then there is a chance of leakage occurring through the valves. Thus a pressure decay leak testing procedure is used to see the amount of leakage through the valves. This machine uses dry air, which is first supplied through the intake, then all the valves are closed and the amount of air pressure that gets leaked is calculated through the exhaust. If the leakage is more than the permissible limits, cylinder head fails the test. There is a light corresponding to each valve which is turned on if leakage occurs through that valve.

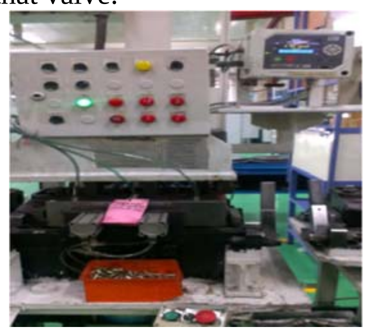

Figure 3: Valve leak Testing

4. RESULTS AND DISCUSSION

HCL is generally looped out (identified) during engine testing. The defect is accompanied by a hissing sound during testing that is the sound made by the air which is leaking from the valves. The data for the month of April May June is represented below:

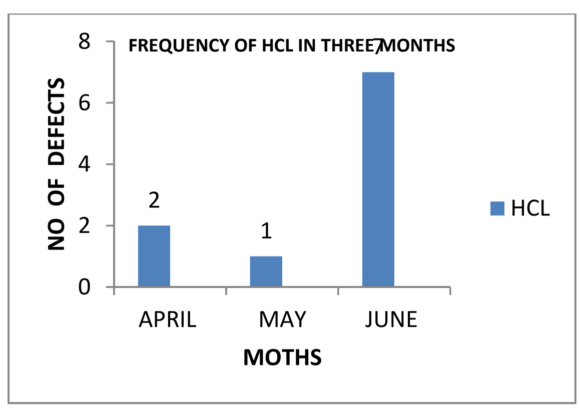

Figure 4: Frequency of HCL in months/No.of.defects

In combination with the cylinder-head gasket's quality, it is the surface finish of cylinder head and engine block as well as the gasket's installation that are decisive for good sealing results. Component unevennesses and distortions, reused head bolts, and the use of grease, oil or liquid sealing compounds will deteriorate the sealing effect of even the best cylinder head gasket.The cause and effect analysis observes the following issues, the improper handling of valves and the wrong valve fitted, cleaning of sealing pads not be done by the human force. From the prospect of machine effects is the improper machining of valve. By material, the dent from the supplier packing and anti rust not available. Finally by mechanism reuse of valves from rework head and improper removing of valves are the main causes for the head compression cylinder heads. so some of the necessary steps to be taken are the Leakage is due to pad not cleaned properly at Assembly Line. The Cleaning of Pads to be done after every 05 Jobs. Dent /unfinished Valves due to improper removing of valves of rework head due to untrained operator. The tool should be provided for opening the valve.

5. CONCLUSION

By applying these necessary actions of cause and effect analysis the company's practitioners will ensure that not only preventive measures, but also detective methods are being adopted simultaneously, and as a result their production process will improve. Moreover, this paper promotes all efforts by interested researchers to be seriously involved in case studies involving the upgrading of the manufacturing process especially for a developing country. Hopefully this work could be utilized as one of the reference points and for more studies on the manufacturing industry. To strengthen this knowledge and study detail aspects and ideas need to be incorporated comprehensively.

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