LECTURE 4

MEASUREMENT AND MEASURING INSTRUMENTS & ENGINE DIAGNOSTICS

4.0 MEASUREMENT AND MEASURING INSTRUMENTS

Automobiles comprise of an assembly of parts which have specified dimensions. Some of these parts while in operation are subjected to wear and tear which necessitates the replacement or refurbishment when they have worn beyond a set limit. In most cases the decision on if a part is replaced is dependent on the extent of wear which is determined by using a measuring system.

The two measuring systems used by engine repair and servicing technicians are the Imperial and the Metric (S.I.) systems.

4.1 METRIC AND IMPERIAL MEASUREMENTS

4.1.1 Engine Size Measurement

In automobiles, volume measurement is in litres. A litre is equivalent 100cc. A 5700cc engine is referred to as a 5.7-litre engine. 1 litre is equivalent to 61.02 cubic inches.

4.1.2 Weight Measurement

The metric is kilogram (kg). A kilogram equals roughly 2.2 pounds.

4.1.3 Pressure Measurement

The metric system of measurement which equals the imperial, pounds per square inch (PSI) is expressed as kilograms per square centimetre. For the measurement of gauge pressure, both measurements are used.

4.1.4 Temperature Measurement

The two widely used temperature scales are the Centigrade and Fahrenheit scales. For the centigrade scale water freezes at 0 ˚C and boils at 100 ˚C. For the Fahrenheit scale, water freezes at 32 ˚C and boils at 212 ˚F.

4.2 MEASURING TOOLS

One of the common measuring tools is the steel rule used in metric and imperial measurement. There are several common types of rules: the meter rule, tape rule, the steel rule etc. Rulers could be used with a calliper or divider to transfer measurement.

Figure 4.1: A divider with a steel rule

Other measuring tools are the **thickness gauges** which are commonly known as **feeler gauges**. They are either flat or wire shaped. These **thickness gauges** are used to measure valve clearance, piston rings side clearance, the spark gap of spark plug, ignition points, piston rings and crank shaft end play. **Plastigage** is a product used to measure oil clearance in bearings and oil pumps. It is a strip of plastic that deforms when crushed. The deformed plastic gives an idea of the amount of clearance available between mating parts.

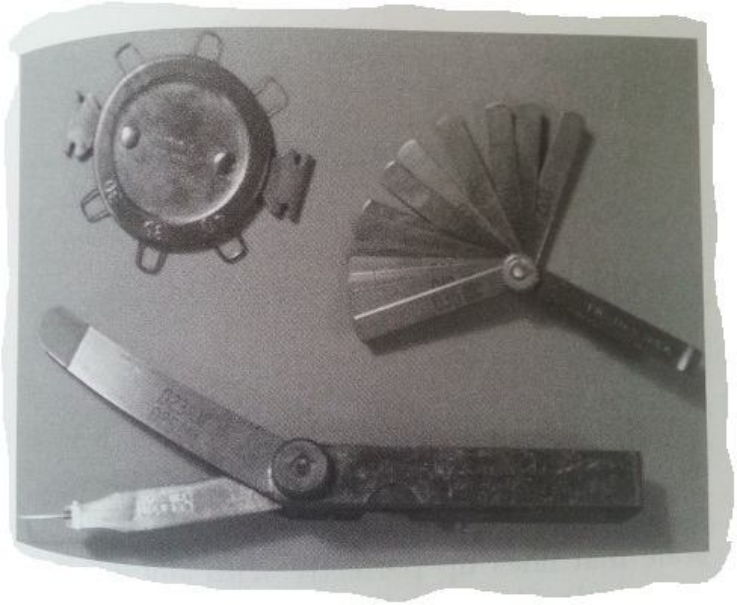

Figure 4.2: Flat and Wire types of Feeler Gauges

4.3 PRECISION MEASURING TOOLS

The following are precision tools used in measurement in an automobile workshop:

4.3.1 The Vernier Caliper

This is a measuring instrument that has a moveable calibrated scale that runs in parallel to a calibrated fixed measuring scale. The vernier caliper is a precision measuring instrument used by automotive technicians for inside and outside diameter measurements. It is used for both inside and outside diameters ranging from 1 to 180 millimetres (from 0 to 7 inches in thousandth of inches). It also measures inside and outer lengths and depths which is limited to the length of its jaw opening. The vernier calliper is one of the most multi-purpose measuring instruments used by automotive technicians. The digital vernier callipers exist too.

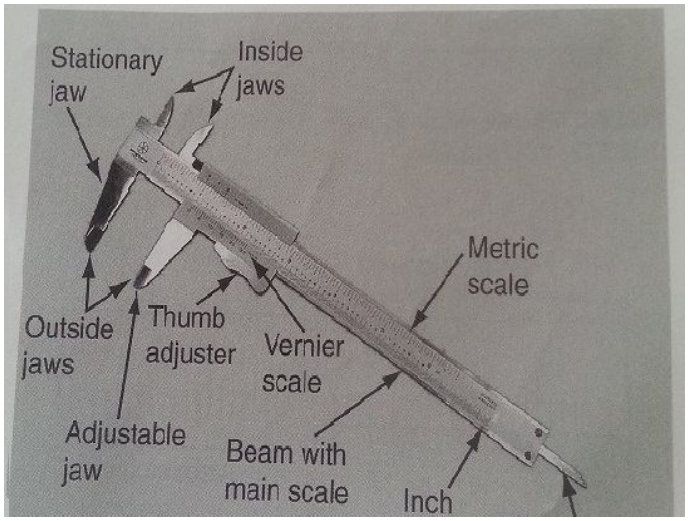

Figure 4.3a: A Vernier Caliper

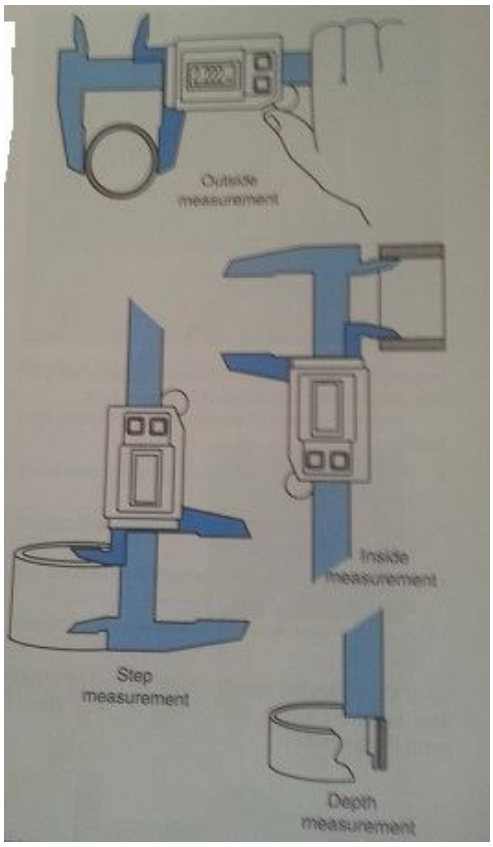

Figure 4.3b: A Digital Vernier Caliper

4.3.2 The Micrometer Screw Gauge

Micrometer screw gauge comes in different sizes and has several advantages over the other types of measuring instruments. Some of the advantages are:-

- They give consistent and accurate measurements
- The results of their measurement are clear and easy to read.
- They have in-built adjusters to compensate for wears

The digital micrometer screw gauge is also in use.

4.3.3 The Telescoping and Split Ball Gauge

An inside micrometer cannot take readings in cylinders smaller than 2", in cases like this measurement are taken either by **telescoping** or **small holes (split ball) gauges**. They are known as **transfer gauges** because the measurement they take are read with an outside micrometer. As shown in Figures 4.4 (a), (b) & (c).

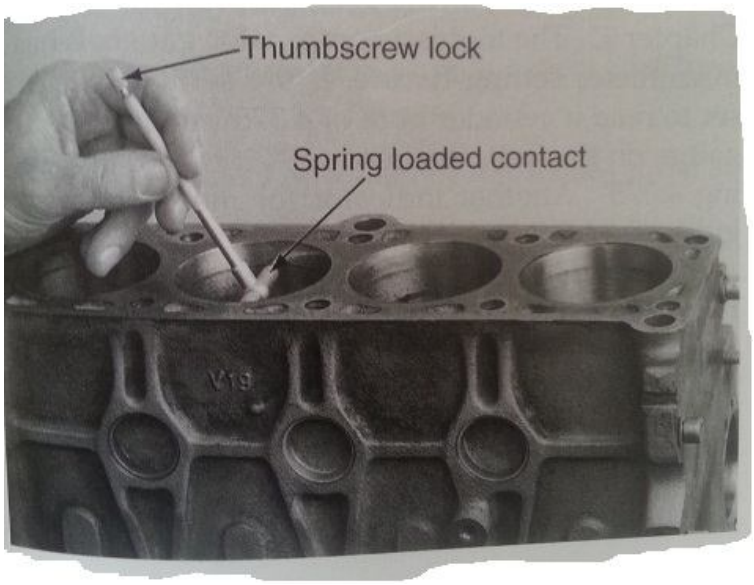

Figure 4.4a: Measuring the cylinder bore with a telescoping gauge

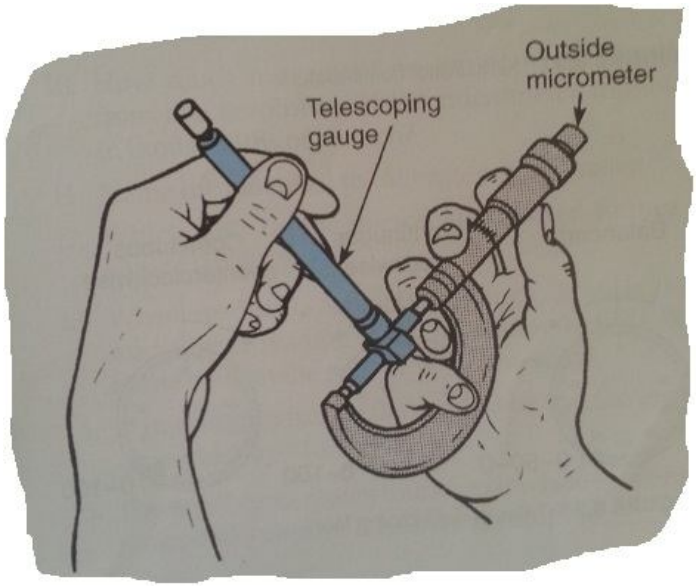

Figure 4.4b: Measuring with a micrometer screw gauge readings taken with a telescoping gauge

Small-hole gauge is used on small holes such as valve guides.

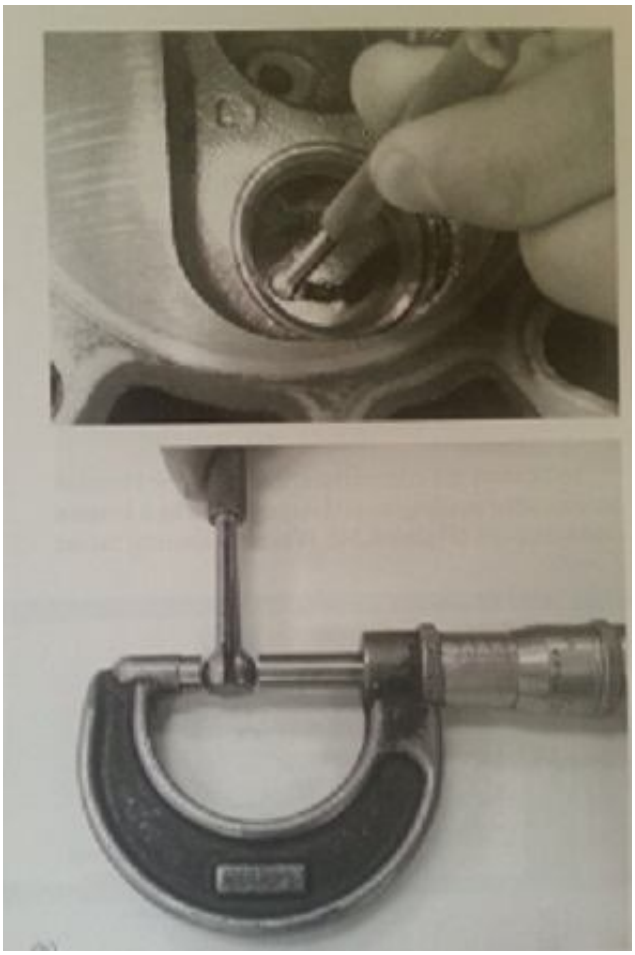

Figure 4.4c: Reading the small hole gauge size after setting it and taking measurement

Telescoping gauges come in different sizes. They can be used with a micrometer to measure cylinders, bearing bores, etc.

4.3.4 Dial Indicators

The dial indicator is a type of precision measuring instrument that measures movement. It can be applied / deployed to measure the main bearing and cylinder bores, valve guide and crankshaft wear and the valve in-head bore.

5.0 ENGINE DIAGNOSTICS

Before repairs can be carried out in an engine, the problem is meant to be first correctly diagnosed. Some few area of major diagnosis in automobiles will be discussed here. The areas that will be treated are:

- Problems associated with cooling systems
- Engine Oil shortage as a result of consumption or leakage
- Engine smoke types
- Problems associated with oil pressure
- Engine compression loss
- Engine noise
- Misfiring and engine loss of power

5.1 PROBLEMS ASSOCIATED WITH COOLING SYSTEMS

For the proper operation of an engine and its optimum performance, the cooling system of an engine is meant to function efficiently. The primary cooling system in a water cooled engine is a radiator and when it can't conduct / dissipate the heat conducted from the engine through the working fluid (coolant) to the surrounding air effectively, the engine overheats. Overheating leads to overheating of engine component parts which leads to seizure and eventual failure.

Overtime mineral and scale build up in water jackets in an engine is also observed. This can be removed by cleaning the engine in a hot tank or in a bake oven when the engine is removed from the car for a rebuild. Acid cleaning by a specialist is employed to remove the scales.

5.1.1 Cooling System Leakage: External and Internal

In automobiles, the shortage of coolants in the cooling system reservoir indicates leakage. This leakage could be internal or external. When excessive expulsion of coolant in the exhaust is observed, it could be as a result of a crack in the combustion chamber or a head gasket leak. Leaks in the combustion chamber can be detected easily when the engine is dismantled. This is seen by the absence of carbon deposit in the affected cylinder (this implies the absence of combustion in that combustion chamber). For an efficient and operational combustion chamber, little quantity of carbon deposits must be seen. When there is internal leakage of coolant into the crankcase, contamination of the oil occurs. This occurrence is called "Cross Fluid Contamination".

Internal leaks could happen in the following locations in the engine:

- In threaded plugs in the cylinder head
- In the coolant-crossover passage of the intake manifold in most V-types engine configurations.
- The top cylinder gasket region
- In a cracked cylinder head or block

Internal leaks are diagnosed using the pressure tester, block tester or infrared analyzer.

Pressurized oil finds its way into the coolant when there is a leak between the oil and coolant passageway. This makes the engine overheat and spill overheated mixture of oil and water into the expansion tank. The spilled oil in the coolant passage sticks to the walls of the radiator and reduces the rate of heat transfer from the coolant to the surrounding air.

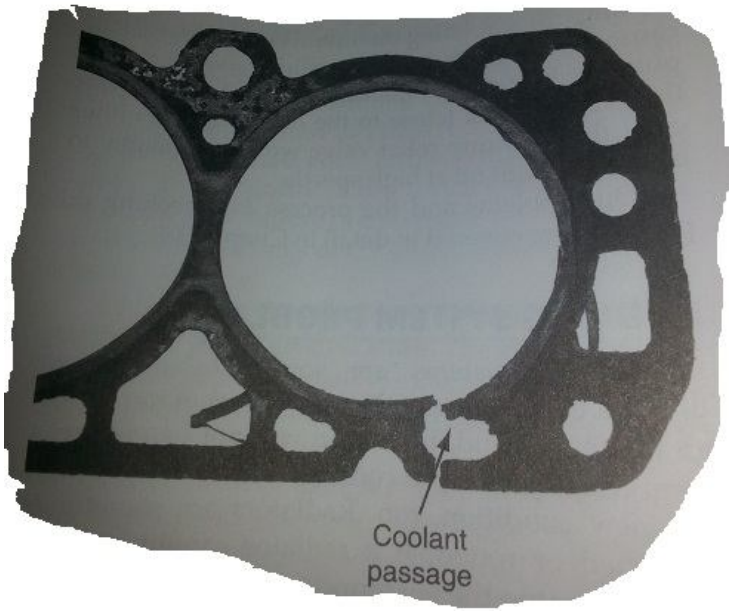

Figure 5.1: Blown Top Cylinder Gasket

Cross fluid contamination can also occur when there is a leaking automatic transmission cooler. For leakage in an automobile heat exchanger, cooling system pressure test method could be used for the detection.

5.1.2 Engine Overheating: Other Causes

While leakage of coolants both internally or externally might lead to engine overheating, other causes of overheating are as follows:-

- When the impeller of the water pump is loosed or corroded
- When the thermostat fails to open at the attainment of the engine operating temperature.
- Retarded ignition
- When the catalytic converter or exhaust system is blocked.

5.2 LEAKAGE DETECTION METHODS

5.2.1 Pressure test of the Cooling System

The detection of an internal leakage in the cooling system of an engine can be diagnosed with a pressure tester installed at the radiator opening. Leaking locations of a leaking core plug can be pinpointed through pressure testing. Some of these core plugs are located behind the flywheel on some (not all) engines.

The steps involved are:-

- The engine is turned off and the system is pressured.
- The pressurized system is checked for stability or consistency of the pressure value over time.
- When leak cannot be detected immediately, the system is left pressurized overnight.

5.2.2 Presence of Exhaust Gas in the Coolant

When there is a leakage in the top cylinder gasket head, the leakage cannot be detected through pressure testing. Another method used in detecting the leakage of exhaust gas in the coolant is by using the "**combustion leak tester**" which is also known as "**block check tester**". This operates by sampling the air in the filler neck of the radiator while the engine is running.

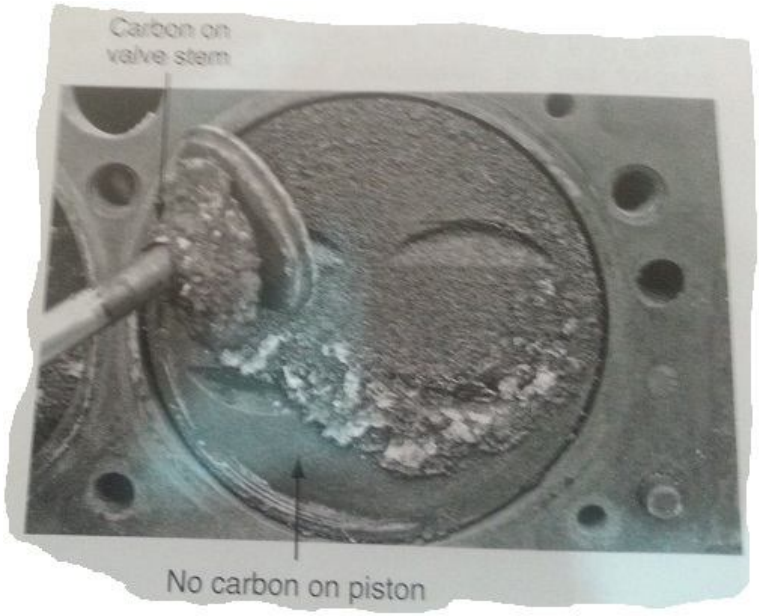

Figure 5.2: No Carbon Deposit Found on Piston Crown

The tester works as follows:-

- This testing equipment is used when the engine is running.
- Before this test is performed, the level of coolant in the radiator is lowered to at least two (2) inches below the radiator filer neck.

- It operates by changing its colour when carbon monoxide (CO) from the exhaust gases is detected in the radiator
- If the leaking cylinder is not firing, the tester will not work because of the absence of CO.
- If the cylinder compression is low (leakage of exhaust gases into the coolant will be impossible), and combustion does not take place, the tester will not work.
- It should be noted that block check tester could give a false result with coolants with additives. It best works with pure water.
- To force gases in the radiator through the fluid in the tester, the bulb of the tester is squeezed repeatedly for about 60 seconds.
- If the colour of the tester fluid/liquid changes from blue-green to yellow colour, combustion leak is confirmed.

When the test is positive in a V-configuration engine block, all spark plugs in one bank is disabled and the engine is left to run for at least 300 seconds, to purge the radiator of residue gas. If the test is negative, the same process is carried out on the other bank to find out where the leak is from.

5.2.3 Infrared Exhaust Analyzer

The Infrared exhaust analyzer is also used to detect exhaust gas presence in an engine cooling system.

- This technique of detection can be carried out while the engine is on or off.
- The engine load is increased by accelerating the engine by opening the throttle for 3 seconds or less with the gear engaged while the brakes of the vehicle is firmly engaged
- The probe is placed over the radiator filler neck for checks of HCs in the coolant. It is to be ensured that the coolant is not sucked into the tester's probe.
- If CO is detected in the cooling system, exhaust gas leakage during combustion is confirmed.

5.2.4 Checking for Bubbles in the Coolant

In V-configuration engines, cylinder head crack or gasket leakage can be determined following these processes:-

- Water pump and thermostat drive belts are removed
- Plug the top end of the radiator
- The engine is run
- Leak is confirmed by the sight of bubbles in thermostat opening.

For coolant leakage in a V-configuration engine, the spark plugs on the side of the leak will always be wet during the cold running of the engine.

5.3 ENGINE OIL SHORTAGES AS A RESULT OF CONSUMPTION OR LEAKAGE

When an automobile user observes a shortage of oil using the “Dipstick” (reading a low at the marked point) and external leakage is not observed, the piston rings are usually the first suspect. Oil consumption in engines could be internal or external and in cases of error in measurement; the use of wrong “dipstick”.

Excessive internal oil leakage can be detected by spotting oily deposits in the exhaust pipe. Thick soot in the exhaust line is as a result of incomplete combustion as a result of the engine running on a very rich mixture.

The rates of consumption of engine oil in an automobiles engine are dependent on:-

- The engine size
- The viscosity of the oil
- Service rating
- Engine load during use
- Engine speed (rpm)
- The level of oxidation and dilution of the oil
- Weight and shape of the vehicle
- Engine temperature

5.4 CAUSES OF INTERNAL OIL LEAKAGE AND DETECTION METHODS

5.4.1 Oil Consumption from Piston Rings

When the piston rings loose there contact pressures on the cylinder wall, the engine oil finds its way to the combustion chamber. This leads to the consumption of oil internally. This loss of contact pressure is as a result of wears on the rings. Excessive oil could also be as a result of blocked passage in the oil control rings. All these occurs as a result of lack of regular change of oil when due.

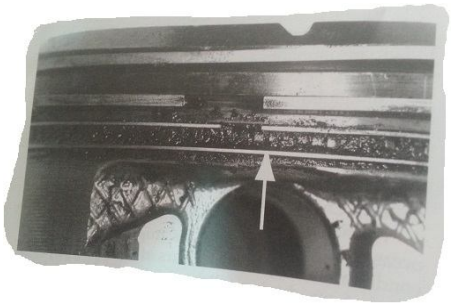

Figure 5.3: Blocked Oil Control Rings

5.4.2 Bad Valve Guides or Seals

Increased oil consumption in automobile engines could be caused by worn valve guides or defective valve guide seals. This defect gives rise to smoky exhaust as a result of the sipping in of oil into the combustion chamber. This defect in engines is detected by an observed oil stain on the side of the spark plugs affected and deposits on the necks of the affected intake valves.

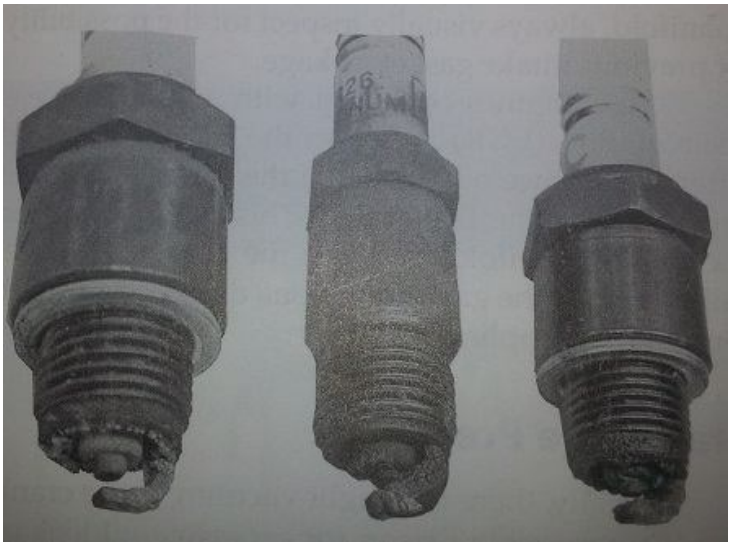

Figure 5.4: Oil-Fouled Spark Plugs

5.4.3 Leakage from the oil seal/gaskets

Leaks from the rear crankshaft seal on the engine side where the torque converter or flywheel is mounted. This is evident in a circular pattern of oil spray. This leak majorly occurs as a result of excessive crankcase pressure. When oil leakage is seen in the opposite side, it indicates leakage of the front transmission seal.

When oil leaks trickles down the block, it is indicative of a leaking oil gallery plug, cam plug or seal retainer block. The engine block could also be porous or cracked.

5.4.4 Other Oil Leak Detection Methods

- Adding dye to oil.
- Spay of foot powder on clean areas of the engine.

5.5 ENGINE SMOKE TYPES

Automotives powered by internal combustion engines combust and expel the combusted products through its exhaust in the form of smokes. The nature (type) of smoke expelled says much about the “health” of the engine. The tables 5.1 and 5.2 below highlight the possible types of smokes seen in gasoline and diesel engines, diagnosis and possible causes.

Table 5.1: Some Types Observed in Gasoline Engines

SMOKE TYPE	DIAGNOSIS	POSSIBLE CAUSES
White smoke	Vapourized water and/or coolant in the combustion chamber	➢ Coolant sipping into the combustion chamber due to a damaged gasket. ➢ Cracked cylinder block or head. ➢ Too cold engine (Not a problem, because the engine will eventually warm up).
Black or gray smoke	Most likely as a result of incomplete combustion of fuel.	➢ Blocked manifold ➢ Retarded ignition timing ➢ Malfunctioning carburettor, fuel injection or emission systems, choke, etc. ➢ Oil leakage into the exhaust system. ➢ Partially blocked air filter
Blue Smoke	Engine oil being burned	➢ Worn cylinder, piston rings or valves. ➢ Leakage of oil into the combustion chamber.

Table 5.2: Some Types Observed in diesel engines

SMOKE TYPE	DIAGNOSIS	POSSIBLE CAUSES
White smoke	Fuel not combusting	➢ Overheating engine ➢ Incorrect ignition timing ➢ Faulty injection system ➢ Too cold engine (Not a problem, because the engine will eventually warm up).
Black or gray smoke	Most likely as a result of incomplete combustion of fuel.	➢ Blocked manifold ➢ Retarded ignition timing ➢ Engine overheating ➢ Faulty injection system ➢ The use of wrong grade of fuel ➢ Oil leakage into the exhaust system. ➢ Partially blocked air filter
Blue Smoke	Engine oil being burned or atomized	➢ Worn cylinder, piston rings or valves. ➢ Excess amount of engine oil in the engine.