Care and Operation of Multi-Cylinder Engines

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An internal combustion engine must have air, water, fuel, and oil fed to it in order to keep it operating. The condition of these four items determines the useful life of the engine. We will attempt to point out what the standards are and the best methods of combating the "below standard" factors where we have no choice but to use them as they exist in the field. It is not possible to describe and elaborate on fuel alone without considering its affect on the lubricating oil.

Natural gas, containing sulphur, has undesirable results when used as engine fuel, the principle hazard being acid formed by the products of combustion. Since all engines leak a small percentage of the combustion gases past the rings into the crankcase, the lubricating oil tends to become acid. Sulphuric acid contained in these gases causes sludge to form in the sections of the engine where temperature is the lowest. This sludge frequently forms to such a degree that lubricating oil cannot reach the bearing surfaces resulting in failure and down time. This is true especially where splash lubrication is employed. Where temperature tends to fluctuate several degrees and cold winds are blowing on engines, condensation creates a surprising amount of water in the oil reservoir.

One of the best means of eliminating these gases and liquids from the crankcase is to operate the engine at sufficient temperature to cause them to dissipate from the crankcase in the form of vapor. Fuels of all types should contain less than .05% of sulphur and be practically free of solids or abrasive materials. In the case of natural gas, it should be free of crude oils and other liquids.

Since wells produce some solid materials and pipe line corrosion is usually present, fuel filters in most cases will save many times their cost in longer engine life. Fuel filter cases should have a drain in the bottom to be used for draining off all accumulation of liquids.

Natural gas is piped to the engine location under several pounds pressure. Should this pressure exceed 100 pounds, a high pressure regulator is required to reduce the pressure to a point below 100 pounds, and a low pressure regulator, with an orifice size to match the pressure on the inlet side, must be used.

When a high pressure regulator is required, it is general practice to reduce the pressure to between 15 and 20 pounds, using a 7/16-in. orifice in the low pressure regulator. With 15 pounds inlet pressure, a 7/16-in. orifice, and a 10-in. to 16-in. water column discharge pressure, the regulator will flow 1400 cu.ft./hr. or operate an engine at 125 h.p.

After regulating the gas pressure down to 6-8 oz., a volume regulator feeds fuel to the carburetor in the right amount - according to the demands of the engine. The fuel then passes into the carburetor where it is mixed with air and enters the intake manifold, ready for the cylinders to receive it in turn as the intake valves open.

With gas furnished to the location properly regulated, free of solids and liquids, and less than .05% sulphur, a natural gas engine would operate many thousand hours with little or no trouble from fuel. It is possible to easily meet all the requirements above except for the sulphur content and this alone will not materially damage an engine operating at 180 deg. temperature, unless the sulphur content is more than 2%.

LUBRICATION

Modern lubricating oil does many useful jobs in a modern high speed engine besides simply lubricating the moving parts. The oil serves as a cooling medium by flushing through the bearings and absorbing heat from them. It is in turn cooled by air circulating around the oil pan. The crankcase capacity determines how long the oil has to cool before it is picked up by the oil pump and recirculated through the engine bearings. In this respect the crankcase capacity determines the final operating temperature of the oil.

The crankcase has a fine spray of oil coming from the connecting rods, main bearing, cam bearings and other pressure fed points of the engine. This fine spray contributes to the mixing of combustion gases and the oil. Combustion gases consist of water vapor, carbon monoxide, carbon dioxide and other compounds of sulphur including some free sulphur. When these compounds are present in the lubricating oil spray in conjunction with carbon particles, fine metal particles resulting from wear, and dust from the atmosphere, a stable compound of oil and water results, in the form of sludge. The sludge is usually acid in nature and concentrated enough to attack the materials found in engine crankcases such as rod and main bearings, aluminum pistons and bronze.

The acid action pits the cam lobes and cam followers, gear train and other high unit pressure items of the engine, causing a very high wear rate. The fact that sludge is present reduces the likelihood of oil reaching the parts that depend on splash for lubrication. The oil pump screen soon becomes restricted with sludge deposits causing the oil pressure to drop below normal, further reducing the lubrication of splash lubricated parts.

Manufacturers of lubricating oils have solved a large percentage of the problems encountered in lubricating the engine parts by adding detergents, inhibiters, and agents for different purposes. The detergents serve the same purpose in lubricating oil as they do in a washing machine. They suspend the materials sludge is composed of, including fine solid materials, and carry them out of the oil rings, bearings and other parts which come in contact with the oil. The oil then passes through the oil filter and the majority of the contaminates are removed. The action of the oil filter prevents the carbon deposits from building up and sticking the rings, and tends to remove the heavier residue from the oil created by the "cracking" process oil is subjected to in the cylinders. To sum up the detergent action, it must be pointed out that it is actually a cleaner such as soap and performs the same duties.

Heavy duty oils are inhibited against their becoming acid as readily as non-inhibited oils or straight mineral oils. Therefore, for this reason alone, they should be used where fuels have a higher than standard sulphur content.

All engine manufacturers are forced to set a recommended oil change interval by their customers. However, they cannot predict the life of lubricating oil under many conditions engines are subjected to, because of the quality of fuel, atmospheric conditions, such as dusty locations, the condition of the engine after an extended period of service, percentage of maximum load and the quality of the oil to be used. For these reasons their recommendations represent the minimum rather than actual oil life. The maximum number of hours of oil life can only be determined by a laboratory analysis after samples have been drained from the crankcase at regular intervals and tested. The ideal condition is to use the oil just as long as it performs its duties without damage to any part of the engine. This is a condition rarely achieved, and then usually by accident. This condition can be approached as close as possible without danger of damage by sending off samples for a reliable report while the engine is still in good condition; then again after the engine begins to show oil consumption not normal to it. This second report will indicate the oil should be changed at more frequent intervals. An adequate oil filter on the engine can increase oil life and engine life only if it is serviced regularly. Oil filters should be changed when they appear on inspection to be only slightly dirty or discolored.

Many engines have crankcase breathers, usually on the oil filler neck, and valve cover assembly, which should be washed in a petroleum solvent at the same time the oil filter is serviced. Crankcase breathers must be clean in order to allow the products of combustion to vent out in the form of vapor.

COOLING

The condition of the water used in internal combustion engines is one of the most important items contributing to long life. The cooling system must be protected against corrosion and scale deposits. Scale deposits begin to form several degrees below the usual operating temperature of the engine. The higher the temperature, the more scale deposits in the cooling system. This being true, then scale will deposit first on the higher temperature parts of the engine such as the upper cylinders and in the head around the exhaust valve seats. This will create an uneven cooling from one section of the engine to the other, causing the parts to distort or warp out of their original shape. Actually, the piston rings rotate on the piston while the engine is running, but on overhauling the engine, the upper cylinders are always flat. This is caused by uneven torque on the cylinder head bolts and distortion from uneven cooling due to scale deposits. As the engine increases in operating hours, the scale also increases, but this is a slow process which allows the rings to wear the cylinder walls more or less as they distort, allowing the rings to contact the cylinder walls 100%. However, should scale deposit to such an extent that it causes the engine to run hot, then it is the practice to acidize the cooling system and remove the scale. The acid actually does remove the scale in only a few cases, because in most cases the acid will remove portions of the deposit sooner than others allowing the remainder to come loose from the water jackets in the form of large thin sections. These sections are washed into the upper tank of the radiator where they are caught at the entrance of the core tube, stopping the circulation through the tubes. This reduces the cooling capacity of the radiator, and the engine often destroys itself by overheating. Should the acid treatment be completely successful, then the cylinder bore and cylinder head resume their uniform expansion and the rings no longer seat against the cylinder bore. The exhaust valves will no longer seat and they will leak combustion gases ultimately burning the valves to the point where the cylinder will not fire. The rings allow blow-by into the crankcase to such an extent that it burns the ring lands off the pistons in many cases. The increased blow-by aggravates the acid condition of the oil and increases the amount of carbon and abrasive material in the crankcase, materially damaging the bearings.

Scale will not allow efficient transfer of the heat from the upper cylinder and cylinder head to the cooling water. Scale, deposited to the thickness of 1/8-in., is equivalent to 1-in. of cast iron in insulation value. The retarding of the heat transfer into the coolant causes the engine to operate at a higher temperature, with higher oil temperature being the result. The oil temperature can raise to the point of damaging babbitt bearings without the coolant temperatures reaching the boiling point in the radiator. This type of damage is not done suddenly, but over a period of weeks or a few months.

There are actually two separate and totally different problems encountered in treating cooling jacket water, one deals with the elimination of scale deposits composed of calcium, sodium and magnesium salts, while the other deals with the elimination of corrosion consisting of oxidation of the iron, or just plain rust. Since they are entirely different in nature, they must be approached with different corrective measures. A zeolite water softener will eliminate the scale, but it tends to increase the corrosion unless corrective steps are taken in addition to simply using soft water.

There are many prepared water conditioners on the market, most of which will do a successful job if strict instructions are followed. Most of them are simply put into the radiator from a can or package. All commercially prepared compounds containing chromates will do an excellent job. Chromates will color the water a light greenish yellow. This color is enough indication as to whether the water is treated to the point of being successful in stopping corrosion. Many treatments have no color effect, and without testing equipment, it is not possible to tell whether the coolant is noncorrosive or not. With chromates, if the water is a greenish yellow color, you have enough treatment. With some solutions, it is as harmful to get too much as not enough or none at all. This is not the case with chromates. Even in water with high concentrations of scale forming compounds, chromates will prevent deposits from forming until the engine needs a general overhaul, at which time the water jackets should be sandblasted to remove anything that might have deposited in them. Of course chromates will not completely stop corrosion or scale, but they will prevent build up in the jackets to such a degree that it will not interfere with the engine operation before it needs a complete overhaul. Preventing corrosion and scale is of the utmost importance to engine life. Most oil field engines would have twice the life they normally do if corrosion and scale were not present.

Very few mechanical difficulties are encountered with cooling systems, but the most frequent is the water pump. Practically all modern engine water pumps are packless and greaseless, and require no service except to maintain the proper tension on the drive belt to prevent it from slipping. When a pump leaks water it must be either replaced with a new one or removed and repaired in a shop and reinstalled.

The radiator deserves more service from the operator than the water pump even though the radiator has no moving parts. The fins on the outside tend to stop up with dirt, grease, weeds, bugs, etc., until the flow of air through the radiator is retarded, causing poor heat transfer from the coolant to the air. Normally, the radiator can be cleaned with a paint brush and a petroleum solvent. Even a very dirty radiator can be cleaned in this manner if compressed air is available to blow the solvent and obstructing matter away.

An engine should never be operated when the temperature becomes above normal unless the cause is determined and then only until the engine can be stopped and the cause eliminated. In such instances when the radiator is stopped up on the inside, but not to the point that the coolant boils, the engine could be operated until such time that the radiator could be removed and cleaned. When an engine begins to overheat, many times the operator removes the thermostat thinking this will help to cool the engine. Thermostats should never be removed, and the engine operated without them. "V"-type engines sometime have more than one. The thermostat is a means of controlling the coolant temperature and the lubricating oil temperature; however, it serves another important function, by creating a restriction to the flow of water through the engine. Water will circulate much faster with a corresponding increase in velocity, which tends to carry along solids and loose scale particles and deposit them in the top tank of the radiator, stopping the radiator tubes and further increasing the temperature. Since thermostats retard the flow of water, they will create a pressure in the engine between the water pump and thermostats. This is desirable because it increases the boiling point of the coolant.

Most engines operating at normal governor speed will maintain between 6 and 10 pounds water pressure. At 10 pounds the boiling point is about 246 deg. The boiling point is important because the area to be cooled around the exhaust valve seat tends to create local boiling. When boiling occurs at this point, steam pockets form and increase in size until the surrounding circulating water moves them away from the valve seats attempting to wet the hot surfaces in the process.

The result is cracking of cylinder heads during engine operation or soon after the engine is stopped. This explains why the engine sometimes operates at normal temperature according to the thermometer, yet water is found in the cylinders and the head is found to be cracked on starting after being down several hours.

A cooling system in good operating condition will maintain between 1 and 2 pounds pressure on the inlet side of the water pump, 6 to 10 pounds pressure in the engine, approximately 170 deg. outlet temperature and not more than 12 degrees differential between the inlet and outlet temperatures. Should an engine overheat and the radiator be suspected of being stopped up, the engine should be operated at normal governor speed and the drain cock on the radiator opened. If a good flow of water is maintained for 30 seconds and the engine has a good thermostat, the radiator is not the trouble. Should no water come out of the drain cock, and the drain cock is not stopped up, then the radiator is stopped up without a doubt, and must be removed and cleaned.

AIR CLEANERS

Clean air is of the utmost importance to the life of an engine. Even with the very best air cleaners available, we still get too many solids into the engine. An engine takes in tremendous amounts of air throughout its life. Should there be one grain of sand in every cubic foot of air, the engine would not last a month. Oil bath air cleaners are better than 95% efficient when they are operating at peak efficiency, but even this leaves something to be desired. An oil bath air cleaner without oil is probably less than 5% efficient. No oil in the air cleaner will reduce the life of the engine as much as 90%.

Very few engines have air cleaners mounted directly on the carburetor without the possibility of air leaks between the air cleaner and the carburetor. Air leaks at this point can render the air cleaner ineffective or nearly so. Many engines have several hoses and clamps between the engine and air cleaner which must be maintained in excellent condition to prevent the possibility of air entering the engine without passing through the air cleaner.

Oil bath air cleaners should be cleaned and refilled with fresh oil as a part of the job of changing the crankcase oil and oil filter. In severe dust conditions the air cleaner should be inspected and cleaned if it is found to contain dust in the screens.

IGNITION

One of the most frequently inspected parts of an engine is the ignition system. Spark plugs operate under very adverse conditions when sour gas is used for fuel. The heat range of spark plugs are effected by fuel, load, speed and operating temperature of the engine. By heat range we mean the actual operating temperature of the plug. Many spark plugs look alike, but they have different part numbers and operate at different temperatures. A "hot" spark plug does not mean that the electric spark is in any way different from a "cold" spark plug. It only indicates the temperature at which the plug operates. If plugs are removed from the engine with black carbon deposits and, as a result, "fouled" out, then a plug should be installed that will operate hot enough to keep the deposits burned from the plug, and should have a light brown appearance on the ceramic part which extends into the cylinder head. A spark plug which operates at too high a temperature will have a very light gray color appearing on the ceramic portion, and the electrodes will be burned away. Electrodes should be kept "gapped" to between .018 and .025 to keep the load off the magneto.

Very few magnetos require oiling during operation, but a few are used with oil cups on both bearings. Oil should be added to them at the rate of 2 drops per oil cup per week. Magnetos without oil cups need no lubrication other than that which is packed in them at the time of overhaul. In the case of brush type magnetos, the brushes are carbon, and tend to leave carbon dust on the rotor and inside of the cap that should be wiped out with a clean lintless cloth about once a month.

The best service for a magneto, is simply to keep the spark plug gap from ever reaching more than .030, and to always keep the vent screens clean. The vent screens help prevent condensation from forming inside the magneto during "cooling off" periods after the engine is stopped.

CARBURETION

The carburetor, itself, is one of the most trouble free parts of the engine. On natural gas, the carburetor has only one moving part to wear. This is the butterfly shaft. Once the carburetor load adjustment is set for load, it will never need resetting unless the fuel is changed, or the adjustment lock nut comes loose. If an engine is fixed in one location, using the same fuel day after day, the carburetor will not be the cause of any engine malfunction. Most engines have Ensign carburetor equipment on them with a volume regulator in the fuel system ahead of the carburetor. This regulator can become wet with crude oil and fail to function properly. It only needs disassembling and cleaning with petroleum solvent to make it perform again. This regulator has a 1/8-in. pipe plug at the fuel inlet connection for the purpose of checking fuel pressure, and should be set at 6 to 8 oz. pressure.