Maintenance and Operation of Multi-Cylinder Engines

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The primary object of this paper is to stress the importance in obtaining, through proper maintenance programming, the proper engine operation, performance, and reliability. For these operational problems to be seen one must have a thorough understanding of multi-cylinder engines. The two basic categories that should be emphasized to insure trouble-free performance with a minimum of down time are operational procedure and engine components maintenance.

OPERATION

The operation of the average industrial engine, especially when it runs under the control of a governor and under the supervisory care of safety shutdown switches, is so thoroughly automatic that there seems to be little or nothing to be done directly by the operator. The operation job can become quite dull, and it also will be quite inadequate, if all the operator does is turn on the switch and open a valve to start the engine, turn off the switch to shut it down, and otherwise let it run unless it falls apart.

Proper operation means more than the above action; it means understanding the processes and actions that take place, then acting on that knowledge. By proper operation, more producing hours are possible; the ordinary wear on an engine may be reduced; and those shutdowns which come from neglect may be avoided.

There are several items that should be checked before one starts an engine, especially if it is a new or recently overhauled engine or one that has been shut down for a considerable period of time. These items concern certain aspects of inspection of the various engine systems dependent upon the operator's prior knowledge of the conditions that exist in the particular engine involved. Before the engine is put into operation, each of the following systems should be thoroughly checked: cooling system, fuel system, exhaust system, lubrication system, ignition system, and general running gear.

ENGINE COMPONENTS MAINTENANCE

Cooling System

The normal operating temperature of an internal combustion engine ranges from 150 to 185 F. If an engine operates at low temperatures, it will not have proper expansion of the pistons and rings, and there will be too much clearance between pistons and cylinders. As a result, crankcase oil is allowed to enter the firing chamber; excessive carbon will be deposited; plugs will be fouled; and combustion gases will be allowed to blow by the rings. Thus, the lubricating oil will deteriorate. A more efficient combustion is assured with a hot engine, for an engine operating at 200 F is much more efficient than one at 150 F; at these temperatures evaporation of the coolant increases making it necessary to add water more often. However, the addition of cool water to hot engines has caused more cracked heads and manifolds than have all other reasons combined.

Thermostats are the most commonly used temperature controlling devices used on engines today. They only regulate the engine temperature to within plus or minus 10° of their designed temperature. They will do a fairly good job if the engine is running under a constant load and if there is not an abrupt change in ambient temperatures. But automatic radiator shutters should be used where the climate is cold and loads are variable, for this type of shutter control has a much more accurate temperature regulation.

Contributing to radiator and cooling problems are the stepped up power requirements of modern equipment and usage. Engines are called on for more and more horsepower, or steadier horsepower without let-up in the same size equipment and with the same size or smaller radiators than they have been in years past.

If an engine is found operating below 150 F, steps should be taken to increase the temperature. The thermostats should be checked to see if they are closing. This can be done by removing the thermostat and checking to see if it will close at atmospheric temperatures.

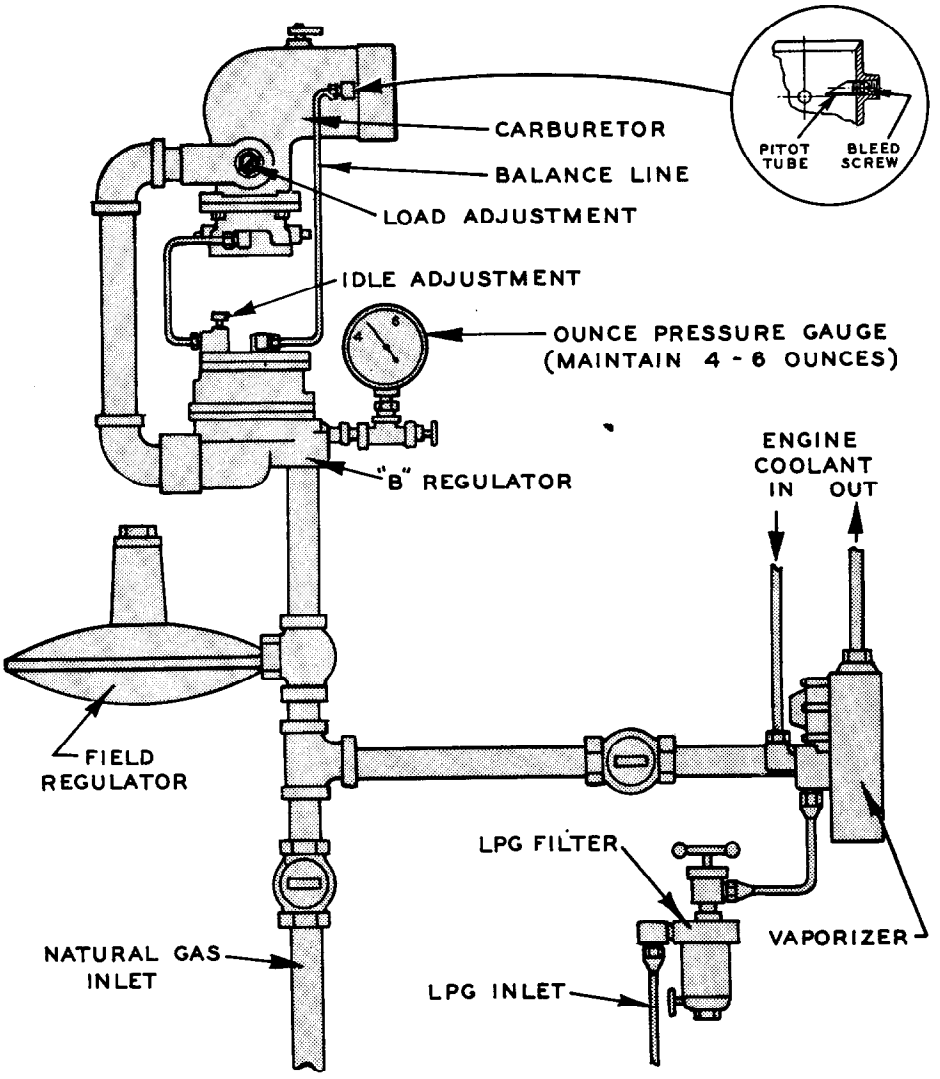
On the other hand if the engine is overheating, the thermostat may be stuck shut. This can be checked by applying heat, either flame or heated liquid, to see if it will open. If the thermostat functions properly, the water pump should be checked and its circulation noted by removing the radiator cap and opening a drain cock. If the system is clean, other causes for heating may be the improper timing of the magneto or the overloading of the engine. The temperature differential between water entering and leaving the engine should not exceed 15 F.

In cleaning a cooling system which is already in operation, a good acid-type cleaner is the safest and most effective. One such cleaner combines oxalic acid with sodium bisulphate along with alumina-silicate inhibitor and a wetting agent. This effectively penetrates various deposits in the system, and oil and greases go into suspension and permit easy removal.

When one starts a new engine or one recently acidized, a solution of soluble oil (2 oz to 1 gal of water) should be used. The soluble oil has a tendency to form a protective coating on the metal and thus keep the scale more or less in suspension. The soluble oil also acts as a lubricant to the water pump seal.

Carburetion

Engines operating on gas type fuels require that the fuel be delivered to the engine in adequate volume and pressure throughout the entire speed and load range of the engine. A gas fuel system consists of a primary or "field" regulator, a secondary or "B" regulator, and a gas carburetor. A typical LPG system consists of a carburetor and a combination regulator and vaporizer unit. If the vaporizer does not contain any pressure regulating device, a field and secondary regulator must also be included in the system.



The purpose of the field regulator is to reduce the gas supply line pressure to a valve low enough to be easily controlled by the sensitive "B" regulator. Four to six ounces pressure is required at the inlet to the "B" regulator, regardless of engine size, speed, or load.

The low pressure "B" regulator and carburetor must be considered as a unit because the regulator serves a function similar to that of the float valve in the fuel bowl of a gasoline carburetor. The regulator must accurately control low pressure gas fuel according to the need of the engine. The name "B" which is generally used in reference to the low pressure regulator is a model designation given by the manufacturer.

Low pressure regulators are equipped with an idle adjustment consisting of a gas line between the regulator and the carburetor and a screw type adjustment at the regulator.

Carburetion Adjustments

1) Install vacuum gauge in manifold between carburetor and the engine.
2) With the engine stopped, adjust the gas pressure to the inlet of the "B" regulator to read 4 to 6 oz.
3) On initial start-up back out the carburetor load adjustment approximately 5 turns and the regulator idle adjustment out approximately 3-1/2 turns.
4) Start engine and allow it to warm up 10 to 15 minutes.
5) Open throttle 1/3 and apply a partial load to the engine. Loosen the load adjustment lock nut and turn screw in or out for highest vacuum reading. Check the adjustment by turning the screw out (rich position) until the reading drops; then turn it in for highest vacuum reading. A slightly rich setting is preferred. Tighten the lock nut.
6) Operate the engine without load at low idle speed (approximately 500 rpm) and adjust the idle screw on the "B" regulator the same as the load adjustment above.
7) Operate the engine throughout its speed and load range and note the gas pressure at the inlet to the "B" regulator. The pressure must be 4 to 6 oz at all times. If it is low on acceleration or load the engine is operating on a dangerously lean mixture and the following should be checked.
   a) Make sure the "B" regulator is of ample capacity. Refer to chart.
   b) Check the gas supply line sizes. They must all be the same size from the inlet to the field regulator to the carburetor.
   c) The field regulator must be the correct model, have the correct spring and orifice, be adjusted properly, and be installed as close to the "B" regulator as possible.
   d) In applications in which a volume tank is used the pressure at the inlet to the tank must be the same throughout the speed and

load range as the pressure at the "B" regulator.

Operation of engines on LPG follows the same general recommendations as those for engines using natural gas. The basic difference between the two fuels is that LPG is initially a gas that has been compressed under extreme pressure to a liquid state. The liquid must be transformed into a gas at the engine for efficient mixing of fuel and air in the carburetor -- a mixture of 60 per cent propane and 40 per cent butane in the minimum for safe operation of engines.

The vaporizer unitizes the heat of engine coolant to provide sufficient temperature differential between the liquid fuel and the vaporizer body to aid in vaporization of the liquid and prevent icing of the regulator parts. Icing occurs when the expanding liquid absorbs heat with a resulting refrigeration effect.

Ignition

Magneto ignition is standard on practically all industrial engines and it is supplied in high (conventional) or low tension ignition. Both systems require low tension ignition, and both systems require no regular service beyond keeping them clean and dry. Under dirty operating conditions, it is advisable to remove the cap and see that all carbon brushes work freely and have spring tension. The contact points and resurface should be checked with a fine stone if they are burned or pitted, and the points adjusted to .014 in.-.016m gap.

The high (conventional) magneto has a single coil containing both primary and secondary windings and furnishes ignition voltage for the complete set of plugs. Since it performs a distributor function with high voltage electrical energy, it requires maximum performance from insulating and brush contact materials. The presence of oil vapor, moisture, wear particles of metal or carbon, and foreign matter ultimately causes breakdown of the distributing function by carbon tracking, cracking, arcing and burning which is practically eliminated in low tension ignition.

Low tension ignition is an inaccurate description of the system. Actually, equal or higher voltage is provided to the spark plug electrodes, and the only reason for the "low tension" is the important fact that this voltage is not present in the wires leading from the magneto to the transformer coils. Low voltage is used to energize the coil primaries in the same manner as in the conventional system; the difference is in the use of individual coils for each plug located close to the spark plug rather than a single coil within the magneto and remote from the spark plugs.

Timing

Correct timing procedures begin with the knowledge that the flywheel markings are absolutely correct. However, the fire mark on the flywheel might not be for correct advance on the fuel that one is using; also this mark, and top dead center mark might be wrong.

The top dead center of number one piston, or of any piston which one is timing to, can be located by marking the flywheel with the piston down an equal amount on either side of top dead center, then locating the midpoint between these marks. Calculating the distance of the circumference of the flywheel for correct advance will locate the proper fire mark.

To time the magneto to the flywheel fire mark, one rotates the engine until number one piston is approaching top dead center on the compression stroke. However, one must be sure that it is compression stroke and not the end of the exhaust, both by checking the rocker arms to see that both valves are closed and by removing a spark plug and feeling for the build-up of compression, if someone else is available to rotate the crankshaft. The flywheel pointer is set to the proper fire mark for the fuel that is being used. At this time the magneto indicating pointer, must be aligned with number one spark plug wire terminal, and wires are installed in the magneto cap in proper engine firing order. Next, one finds the exact position where the points just begin to separate and makes sure that he does not introduce any impulse retarding action. Then the ignition will be properly timed to engine. Final timing checks should be with timing light while running.

Lubrication

All engines are equipped with an oil pressure gauge and any appreciable drop in pressure reading warrants investigation to determine the cause. It is necessary to keep the crankcase to the full mark on the level indicator, and the weight of oil to be used depends on the crankcase temperature. After obtaining the crankcase temperature, the proper weight of oil can be determined from the following table:

Table 1

200-200 F	50
180-200 F	40
160-180 F	30
140-160 F	20

Because of the wide differences in loads, climates, and operating conditions it is impossible to determine the proper length of operating hours between oil changes. Practically all retail oil companies employ lubrication engineers who will be happy to analyze samples of oil from engines to determine the safe life of the oil. Oil life can be increased by properly servicing the oil filters and periodically cleaning the sludge that may accumulate in the oil pan, with particular attention to the screen of the oil pump.

As an engine wears, because of normal use, a very gradual drop in oil pressure will be noted. The pressure should be maintained at 40 psi for most engines. To compensate for the drop because of normal wear, an oil pressure relief valve is located on either the crankcase, oil pump, or both By adjusting this valve the 40 psi can be maintained until the wear becomes excessive and necessitate repairs.

Where extremely dry gas is encountered, it is necessary to furnish additional lubrication of the valves by the use of a top cylinder lubricator. A few drops per minute, 6 to 15, are sufficient for lubrication but are not enough to foul the plugs.

The water pump requires greasing only once a week; some require no greasing between repairs. But when it is needed a good grade of water pump grease should be used.

Fan bearings should be greased monthly with a No. 2, long fibre, soda soap grease. Many engines have the fan blade attached to the water pump and do not have separate fan bearings.

The clutch power take off usually has three points requiring lubrication. Further, the throwout collar should be greased daily, and the shaft bearings should also be greased daily while the pilot bearing, which is greased thru the hollow clutch shaft, requires grease about every 50 hr.

Valves

Valve tappett clearance should be checked monthly if the engine is operating continuously, for loose tappetts cause power loss and valve failure.

Tappett adjustment must be done correctly to avoid burning valves. Their clearance should not be less than the recommended setting, because too close clearance will result in burning of the valve seats and faces because of the heat and pressure of combustion.

To adjust the valve clearance, one removes the rocker arm covers and loosens the adjusting screw lock. The rocker arm adjusting screw is turned so a feeler gauge or correct stock will slip snugly between the end of the valve stem and the rocker arm contact point; then the adjusting screw locknut is tightened and the valve clearance is rechecked. For correct clearance settings, one should read instruction manual.

BIBLIOGRAPHY

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