

Lubricating the Diesel

Lubrication of a diesel engine breaks down into three parts: (1) providing an oil film between shafts and bearing surfaces at main, crankpin and wristpin bearings (2) performing the same job for camshaft, valve gear and various engine auxiliaries, and (3) maintaining an oil film between piston and cylinder walls.

Lubrication Systems. Most engines have a pressure circulating system to lubricate main and connecting-rod bearings and many extend this system to include all camshaft, valve gear and auxiliary bearings. Diagrams at right show typical systems for large and small engines. Major difference lies in the provision for lubricating cylinder walls. In small engines, oil forced out of the ends of the crankpin bearings sprays into the crankcase, filling it with an oil fog. This oily mist, plus oil from wristpin ends in some designs, lubricates cylinder walls. Excess oil from various parts of the system returns to the crankcase for recirculation.

In large engines, a separate mechanical forced-feed system is usually installed for the cylinder walls. Number of feeds per cylinder depends on diameter. Usually each feed connects by tubing to an individual pump cylinder in a mechanical lubricator.

Lubricators. A mechanical lubricator usually consists of a group of small reciprocating pumps mounted in a single casing, which serves as an oil reservoir. The pumps supply a measured quantity of oil at each stroke and are driven from the engine by an eccentric, crank and ratchet, or gearing. Amount of oil fed by each cylinder is usually separately adjustable; control is by varying pump stroke or changing position of sleeve ports. In most cases, a sight feed keeps oil flow visible.

Oil particularly suited for cylinder lubrication may be used in the lubricators. Of the oil that is fed to the cylinders, part stays on the walls, part is burned by exposure to hot gas, and part drains away. In some cases, excess oil, with its contaminants, is caught and drained off to waste or to a separate tank for reclaiming. In most cases, excess oil drains off cylinder walls and joins the oil in the crankcase.

Wet and Dry Sumps. Many engines have what is known as a wet sump; that is, oil is stored in the crankcase or in a sump integral with the crankcase. Where it is desired to eliminate crankcase "fog," which may cause excessive cylinder wall lubrication, the

dry sump arrangement is used. This includes a storage tank outside the engine and oil drains from the crankcase as fast as it returns.

Auxiliaries. The complete pressure-lubrication system includes a pump, often a gear unit, driven from the engine. In some cases an auxiliary pump, motor-driven, is also installed to supply lubrication before engine reaches speed and after shutdown. The system usually includes a strainer or a filter, or both. An oil cooler is frequently employed to hold oil temperature within desired limits.

LUBRICATION PROBLEM

It is not too difficult to find a lubricant to perform the work outlined above, nor to devise a satisfactory system for delivering the lubricant to the desired spots in the right amounts. The difficulty arises from the fact that conditions involved in engine operation cause all known lubricants to deteriorate in service. This occurs in lubrication of most machinery; the high temperatures and pressures of diesel work make the action much faster. This also represents the difference between lubrication of large low-speed engines and small high-speed units. The same kinds of changes take place in each case, but in large engines they occur at a slower rate and in a much larger body of oil. Consequently, the results, which are much less evident over normal operating periods, are likely to be regarded as less critical.

Oil Deterioration. Lubricating oils deteriorate in service because of changes that take place in the oil itself and because of contamination from outside sources. Let's look first at changes that occur in the oil itself.

High temperatures, particularly in the piston-ring area, cause petroleum oils to crack or break down in molecular structure. Carbonaceous and tarry products result that play a part in ring-sticking and other troubles.

Oxidation also takes its toll. Combination of petroleum hydrocarbons and oxygen forms organic acids of two general types: (1) volatile acids having low molecular weights and low boiling points, which are usually highly corrosive, and (2) acids having high molecular weights and high boiling points which play a part in formation of gums and lacquers.

These oxidation products lie at the root of a number of the diesel's lubri-

cation problems. If allowed to become sufficiently concentrated, organic acids attack certain bearing metals, causing pitting and failure. Also they react with remaining parts of the oil to form sludges. Chemically, sludge may be defined as precipitated oxidized hydrocarbons. Sludge deposits in valve chambers, sumps, on filters and strainers, and in the oil cooler.

Acid-reaction products are also blamed by some for varnish deposits on pistons, valve stems and other metal parts. These hard, black films occur when oxidation products, soluble in oil up to a certain point, deposit on heated metal surfaces. On valve stems, varnish may cause sticking or burning, and on pistons it promotes ring sticking.

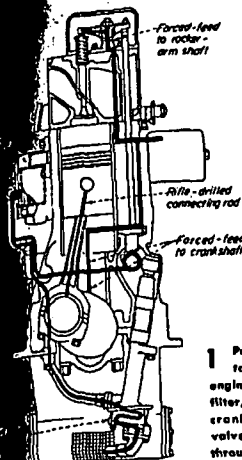
Outside Contamination. These lubrication problems result from changes that take place in the oil itself as a result of exposure to heat and air. Contamination from outside sources contributes to these problems and adds new ones. In the cylinder, products of combustion—ash, carbon particles, soot, unburned "heavy ends" of the fuel, and water—mix with the lube oil. Ash, carbon and soot help to build up ring deposits. Unburned fuel may be cracked or oxidized in the high-temperature zone, making a resinous gummy material that forms a binder for soot or carbon particles.

Unburned fuel that finds its way past the rings and into the crankcase dilutes the lube oil. For every gallon of fuel burned, about a gallon of water forms as a combustion product. This normally passes out the exhaust as vapor but some of it may condense, particularly on the lower parts of the cylinder liner. This prevents proper wetting of surfaces by oil and in combination with hydrogen sulphide or sulphur dioxide may cause corrosion.

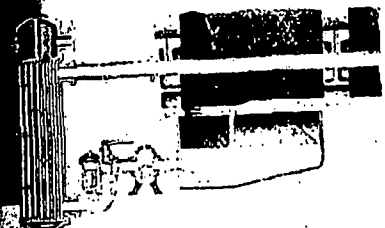
Water that reaches the crankcase may cause mayonnaise-like emulsion, which accumulates over screens and in the circulatory system. As water also tends to increase the activity of organic acids, it may accelerate corrosion of bearings and other parts.

The engine itself may form another source of contamination. Metallic oxides, which accumulate in the lubricant in service, act as powerful catalysts and hasten the oil's deterioration even though present in amounts as small as fractions of 1%.

Foreign Matter. Dirt and dust may enter the cylinders through the air-intake system, particularly if filters are in poor shape, and may enter the crankcase through the breather if it is not protected. Under operating conditions oil film on cylinder walls is of microscopic thickness and thus even smallest dust particles have a deadly



1 Pressure-lubrication system of small high-speed engine: pump forces oil to filter, then distributes it to crankshaft, camshaft and valve mechanism. Oil flows through con rod to wristpin



2 In a large engine, pump takes section from sump, forces oil through strainer and cooler to an engine header supplying all bearings and working parts. Note use of telescopic pipe to return oil from cooled piston to separate lubrication for cylinders

abrasive action. Further contamination may result from small metal particles or wearing surfaces.

Solving the Problem. Lubricating the diesel is, on the evidence, a tough assignment. Yet it is accomplished successfully. How? For one thing, refiners are producing ever better lubricants. These oils are refined to have suitable physical characteristics and, even more important, desired chemical characteristics. Considerable research has been done to increase the resistance of oils to oxidation. This has been accomplished to some extent by improved refining and also by adding oxidation inhibitors. Still other additive compounds may be used to produce so-called detergent oils, that is, oils which tend to keep oxidation products dispersed and suspended.

The operator plays his part by maintaining engines and accessory equipment in good mechanical condition, thus reducing contamination by blow-by, condensation and foreign matter. Finally, he can, by adopting a sound

program of lubricating-oil purification, eliminate the unavoidable decomposition and contamination products, maintaining the oil at or near its original state of effectiveness.

Lube-Oil Treatment. Various methods can be employed to remove some or most of the contamination that occurs in service. Treatment may be carried out in any one of three ways, or in a combination of them: (1) batch treatment, (2) continuous total treatment, and (3) continuous bypass treatment. In the first, oil charge is withdrawn and treated at one time for later replacement. Where rate of oil circulation is not rapid and with certain types of equipment, it may be possible to treat the entire charge as it circulates, but most common method is to bypass a portion of flow (about 10% say) to treating equipment. With this arrangement, condition of a portion of the oil is being restored continuously, which keeps total amount of impurities below danger point and avoids need for large treating facilities.

Treating Methods. Space does not permit discussing here the many types of treating equipment available (see Power, July 1945, pp 88-90, Aug pp 92-94; Jan 1941, pp 70-73, Feb pp 60-62). Mechanical methods include centrifuging and various forms of filtration. Centrifuging separates out impurities by differences in specific gravity.

In mechanical filters the oil is passed through materials such as cotton or glass fiber, cellulose, yarn or waste, or between closely stacked disks; foreign particles are caught and held.

Another class of lube-oil purifiers uses adsorbent materials to filter out foreign matter and to adsorb acids and oxidation products. Medium may be Fuller's earth, bauxite, bentonite, or combinations of these materials.

Mechanical filtration is usually employed on a continuous bypass arrangement; centrifuging and purification with adsorbents may be handled either on a batch or bypass basis. There is a tendency to combine treating methods to obtain best features of each.