PART 1 : SECTION 2

CHAPTER 4

OIL SYSTEMS, AND OIL DILUTION SYSTEMS

OIL SYSTEMS

Introduction

1. The primary object of lubrication is to reduce the friction which occurs when one surface rubs against another. Without effective lubrication not only would a great deal of power be wasted in overcoming friction, but the heat produced would also be very difficult to dispose of, and would soon damage the metal surfaces in contact. With correct lubrication a thin film of oil is interposed between the rubbing surfaces, and friction is reduced to that between the oil molecules as they slide over one another. This internal friction of a fluid—its resistance to flow—is called viscosity ; viscosity varies not only between different oils but also in the same oil at different temperatures. When cold, oil becomes thicker and may be difficult to distribute through pipe lines and small spaces ; on the other hand, if it gets too hot, the viscosity may be so reduced that there is a danger of the oil film breaking down and allowing metal-to-metal contact. For use in aero-engines, therefore, it is essential that the oil should change its viscosity with temperature as little as possible, and that it should be protected from extremes of temperature.

Cooling Function of Oil

2. An important secondary function of the lubricant is the dissipation of heat from the big-end bearings. Even with an adequate oil film between the moving parts these highly stressed members tend to overheat, and a generous supply of cool oil, forced through at high pressure, is necessary to keep the temperature down.

Oil Deterioration

3. The heat and churning to which oil is subjected in an engine encourage the formation of oxidization products which contaminate and darken the oil. Particularly vulnerable is the thin film on the cylinder walls which, when exposed to the very hot combustion gases, tends to oxidize and "crack", forming carbonaceous and gummy residues ; eventually carbon deposits form on the piston heads, piston rings, and combustion chamber walls. The most satisfactory oils, in addition to having a low rate of deposit, form a soft, flaky kind of carbon which, for the most part, blows out through the exhaust.

Dry Sump System

4. Unlike motor car engines, most of which are lubricated by the wet sump system, aero-engines utilize the dry sump system. In wet sump lubrication the oil is carried in the crankcase, to which it drains after being pumped through the various bearings ; in dry sump practice the oil is carried in a separate tank, whence it is pumped to the engine and to which it returns after being cooled. Not only is the latter system more efficient, but it also avoids lubrication difficulties during manœuvres.

Circulation in a Typical Dry Sump System

5. A pump (Fig. 1) draws oil from the tank through a *suction filter* and forces it through a *pressure filter*. These filters remove any sludge or foreign matter which the oil may have picked up while circulating or when in the tank, coarse particles being retained by the suction filter and finer material by the pressure filter. To ensure an adequate supply of oil at all times the pump

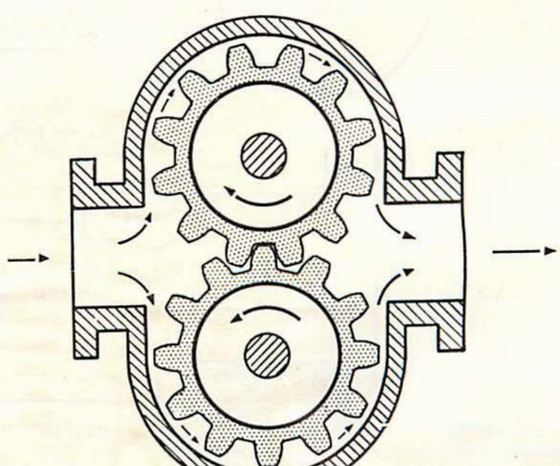

Fig. 1. Gear-Type Oil Pump.

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is designed to deliver more than the engine requires, the pressure being regulated by a *pressure relief valve* (Fig. 2), in which any

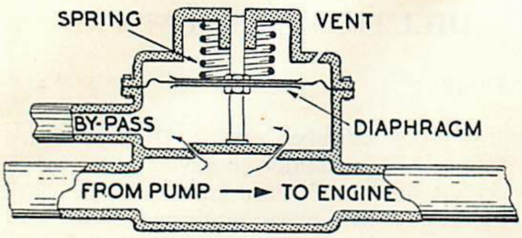

Fig. 2. Oil Pressure Relief Valve.

tendency for the pressure to exceed that of the spring causes the valve to open and some of the oil to be bypassed back to the tank. Without such a valve excessive pressures could build up under certain conditions ; when starting at low temperatures, for instance, the viscosity of the oil might be such as to lead to fractured pipe lines ; or at high r.p.m. with the oil hot and comparatively thin, the pressure could be sufficient to force oil past the piston rings into the combustion chamber, where it would foul the sparking plugs. From the pressure relief valve the oil is fed to the main bearings, thence into the hollow crankshaft via holes drilled in the main journals, through the crankwebs, and out through further holes in the crankpins to the big-end bearings. In some engines the oil forces its way out as a mist from between the crankpins and bearings, in which form it lubricates the cylinder walls and small-end bearings ; in others jets of oil are directed on to the cylinder walls once per revolution from holes in the big-end bearing shell which coincide with other holes drilled in the crankpin. Sometimes the small-end is lubricated directly from the big-end via a hole in the connecting rod. Cams, camshafts, supercharger impellers, and other lightly loaded components, are usually lubricated by low-pressure oil directed from the high-pressure supply through a reducing valve. Having fulfilled its lubricating and cooling functions the oil drains down into the sump, from which it is continuously removed by one or more *scavenge pumps*. These pumps (Fig. 3) are designed to remove oil faster than it can be supplied to the engine so that there is no possibility of the tank running dry and, consequently, of the circulation being interrupted, or of an accumulation in the crankcase causing difficulty during manœuvres. From the scavenge pumps the oil returns to the tank via the oil cooler which, in liquid-cooled engines, may be a part of the coolant radiator. Temperature regulation is usually achieved by the incorporation of an oil cooler bypass and a thermostatically controlled valve.

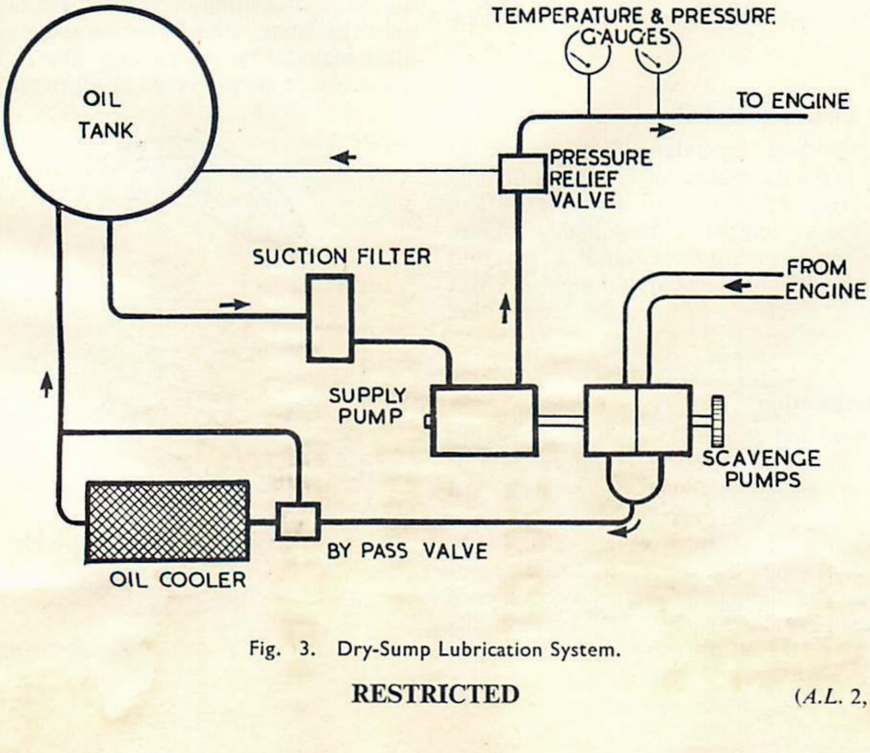

Fig. 3. Dry-Sump Lubrication System.

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OIL DILUTION SYSTEMS

Purpose

6. The object of oil dilution is to facilitate the starting of piston engines in cold weather. Fuel is added to the oil to reduce the viscosity ; this reduces the torque necessary to turn the engine, and ensures, immediately after the start, an adequate supply of lubricant to all moving parts at approximately normal working pressure. The reduced viscosity also minimizes the risk of bursting flexible pipes, couplings, and oil coolers, when starting.

7. If carried out regularly irrespective of the atmospheric temperature prevailing, oil dilution also minimizes the accumulation of sludge deposit within the engine.

System

8. A pipe is run from the delivery side of the fuel pump, or reducing valve, to a solenoid-operated valve and metering jet connected to a point in the engine oil circulating system. The solenoid is energized by pressing a spring-loaded switch or push button, and the valve then opens admitting fuel to the oil, a suitable rate of flow being assured by the size of the metering jet orifice. A rapid heating chamber known as a "hot-pot" or partial circulating chamber is generally fitted within the oil tank. This confines the dilution as far as possible to the oil in circulation. The level in the hot-pot is maintained by the entry of oil from the main tank through ports in its base, arranged to minimize the tendency for diluted and undiluted oil to mix during the dilution run and during the idle period until the next start.

9. The location of the controls for the oil dilution system is given in Part 1 of Pilots' Notes for the aircraft. In some cases recommended dilution and boiling-off periods are also given. Oil dilution, however, is primarily a technical staff responsibility and full instructions for oil dilution procedure are now being included in the Volume 1 for the engine ; any recommendations in the Pilots' Notes should, therefore, be checked with Vol. 1 and/or with the appropriate local orders.

Preparation for Dilution and Procedures

10. Oil dilution should be carried out :—

(*a*) After any flight when it is expected that the engine will next be started in a low air temperature.

(*b*) At any time when required for sludge prevention or other reasons.

11. Although essentially a ground staff responsibility, pilots may be required to co-operate. The engine should be prepared, the oil level adjusted as necessary, and the oil dilution procedure carried out according to the instructions in the Volume 1 and/or local technical instructions.

Starting on Diluted Oil, and Boiling Off

12. If the temperature at the time of starting is below the minimum catered for by the previous dilution, the engine should first be warmed up to at least this temperature by means of preheating apparatus.

13. The engine should be started in the normal manner unless otherwise recommended. Before opening up, the engine must be warmed up for long enough to ensure that some of the diluent is boiled off. If this is not done there is danger of frothing and much of the oil may be blown out through the engine breathers. The partial boiling-off period depends on the installation and the time for which the oil has been diluted. The engine should be run at the r.p.m. and for the period recommended. When the required period is 10 minutes or less, the time taken to warm up and do the usual functional engine checks will usually be adequate for boiling off.

14. In no case should any engine be opened up to high power until the oil temperature, as well as the coolant temperature on liquid-cooled engines, reaches at least the minimum permitted for take-off, and until the oil pressure is normal. If oil pressure does not start to build up immediately an engine is started, or pressure falls during the boil-off run, the engine should be stopped. Insufficient oil pressure may be due to cold undiluted oil having found its way into the oil pump suction line, to too low an oil level prior to dilution, or possibly to a leaking dilution valve. After completion of the normal engine checks and any necessary boiling-off period, the engine should be stopped if necessary, the oil tanks topped up to the required level for flight, and the engine restarted without delay.

Over-Dilution

15. Over-dilution will result in the excess fuel flowing into the reserve oil, preventing effective boiling off. Excessive loss through the engine breathers may then result. The engine should be warmed up for the recommended boiling-off period ; and then, during the normal ground checks, careful observation should be made to ensure that no loss of oil through the engine

breathers is apparent. If it is known or suspected that the oil has been over-diluted, a further check that no breather loss occurs at take-off power is essential. The pilot should be familiar with the location of the breather outlets or drains.

Periods of Effectiveness

16. Dilution should remain effective for at least two or three days during cold weather, providing the engine is not run up.

17. If the engine is run up for ground servicing purposes only, further oil dilution, if still required, should not be carried out until the engine has been run for the required period to boil off any remaining diluent. Exact times for complete elimination of diluent depend, among other factors, on the oil temperature during the run, and cannot be quoted for all cases. When no time is quoted, a period of 20 minutes at not less than the recommended r.p.m. should ensure that all diluent has boiled off; an excessive cumulative percentage of dilution may result if this is not done. After all diluent has been boiled off, the appropriate full dilution should be carried out.

Effects of Wind Chill

18. When high winds combined with low temperatures are expected, greater care should be taken to blank off oil coolers, and the period during which an engine is idle without oil dilution should be cut down to an absolute minimum.


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