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Marine Lubrication

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Several important differences, which call for careful consideration in the selection of lubricants, occur in the conditions which obtain in the working of Land and Marine engines.

Stationary land engines of the larger size are erected on solid heavy immovable foundations, and, except in the case of colliery engines, rolling mills and some engineering works, generally run in one direction with constant load and at uniform speeds.

Conversely, the marine engine is erected on a bed which is constantly changing its plane, and is subject to all the shocks which the hull of the vessel receives from the seas which she encounters.

Under favourable conditions the load and speed may be fairly constant, but when rough weather is experienced these factors may vary from full load and normal speed, with the propellers fully submerged, to no load and "racing," with the propellers only partly immersed.

In the case of ordinary navigation it may occasionally be necessary to reverse the engine suddenly, and in harbour operations continual variation of speed and direction are called for.

The marine engine is thus subject to a number of mechanical conditions and strains, particularly affecting the thrust block and crank-shaft bearings, from which the land engine is exempt.

Another respect in which land and marine engines are exposed to different conditions is to be found in the fact that, while land engines are subject only to the natural variation in temperature incidental to the situation in which they are erected, marine engines, as the vessels in which they are installed traverse the ocean routes of the world, may be exposed to the greatest extremes of temperature which occur between the arctic regions and the equator.

Still another, and perhaps even a more fundamentally important, difference between land and marine engines occurs in respect that, in the case of the former, ample supplies of water are usually available for the boilers while, in the case of the latter, the limited supply of fresh water calls for the almost universal use of surface condensers in order to avoid the necessity for the introduction of salt water to the boilers or provision for make up by evaporators.

The Engine.

In regard to the method of applying the lubricants, the construction of marine engines does not permit of the adoption of "splash" lubrication, which is used with success and economy in various types of land engines, nor of the more modern system of lubrication by forced oil circulation through oil channels in the moving members of the engine. Marine engines, therefore, continue to depend for lubrication upon a system of pipes and syphons by which oil is conveyed from reservoirs in conveniently accessible positions to the bearings where it is required, or upon a system of forced lubrication by means of solidified oils.

The result of these various conditions—as far as marine engines are concerned—seems to be that, in order to make provision for the more severe strains to which these engines are subject, the oil to be adopted for the bearings ought to be heavier and of greater body than would be necessary for a land engine of similar size and power.

At the same time care must be taken to see that the oil is adapted to the method of application, in order that it may ensure a uniform and sufficient supply for every bearing at the various temperatures to which it may be exposed. Where the range of temperature is very great, as in the case of vessels trading between temperate and tropical climates, it may be necessary either to provide separate grades of oil for each or to adjust the lubricators to deliver the proper quantity of oil at each temperature.

The effect of heat, as is shown in the accompanying table, is to reduce the body and to increase the mobility of oil so that a larger quantity will flow through a given orifice or through a certain size of wick at a higher than at a lower temperature. It may, however, be found that, if one oil—adapted primarily for use at a moderate temperature—be used all the way in a voyage from the United Kingdom to India by way of the Red Sea, its greater fluidity at the temperature of the Red Sea may provide a greater supply of oil when and where it is required, although economy might be effected by the temporary use of castor or some oil of similar body.

TABLE showing effect of increase in temperature on the body of oils. In this table the figures for Viscosity are the time in seconds taken by 50 c.c. of each oil to flow from a Redwood Viscosimeter at the temperatures shown. The "Ratio" indicates the relation of the Viscosity at each temperature to that of the same oil at the initial temperature. In the case of Sperm Oil and Rape Oil, the Viscosity at 60° F. is taken as standard or unity, but in the second line under each of these oils 120° F. is taken as standard in order to permit of easy comparison with the cylinder oils.

	60°	70°	80°	90°	100°	120°	140°	160°	180°	200°	210°
Sperm Oil .	198	156	130	110	92	71	58	49·5	45	40·5	39·5
Ratio . . .	100	78·8	65·6	55·5	46·5	35·9	29·3	25·0	22·7	20·5	19·9
	—	—	—	—	—	100	81·7	69·7	63·4	57·0	55·6
Refined Rape	533	406	321	257	207	143	104·5	80·5	65	55·4	52
Ratio . . .	100	76·2	60·2	48·2	38·8	26·8	19·6	15·1	12·2	10·4	9·8
	—	—	—	—	—	100	73·1	56·3	45·5	38·7	36·4
Black Cylr. .	—	—	—	—	—	997	564	344	220	149	128
Ratio . . .	—	—	—	—	—	100	56·6	34·5	22·1	14·9	12·8
Charcoal Ref'd	—	—	—	—	—	986	554	338	216	145	125
Ratio . . .	—	—	—	—	—	100	56·2	34·3	21·9	14·7	12·7

CYLINDERS.

In regard to cylinder lubrication, where that is practised, the necessity for preventing the introduction to the boilers of fatty oils which, by their decomposition and the liberation of fatty acids, might injure the plates, precludes the use in cylinders of animal or vegetable oils or of oils into the composition of which these enter, and limits the marine engineer to the use of pure hydrocarbon or mineral oils for the lubrication of pistons or piston rods.

In the earlier days of marine steam engines, Tallow and Suet were the sole lubricants used for these, but as steam pressures and temperatures were raised, and the disadvantages and dangers attendant on their use were realized, search was made for some substitute which would provide the necessary lubrication while avoiding the dangers accruing from fatty lubricants.

The first oil which was offered for the purpose was a pure distilled and refined "mineral," which, from tests made by the writer of these notes, some forty-five years ago, had about the body of ordinary light shafting or loom oil. This was, of course, wholly insufficient for the purpose, and shortly thereafter crude petroleum, with the burning oil taken off, was introduced, and among the most famous brands of that day some of our readers may recall the well-known "Globe Oil," which seems now to have disappeared from the market.

These crude oils provided satisfactory lubrication, but were found in some cases to produce tarry deposits in cylinders and boilers, and in order to get rid of the bitumen without destroying the body of the oil, the process of charcoal refining, i.e. the filtration of the oil at a high temperature through vessels filled with animal charcoal, was introduced.

Turbines

are free from the strains and stresses which occur in reciprocating engines, and, having no piston rods, big ends or cranks to be affected by the motion of the ship, they present fewer difficulties in connexion with the application of the lubricant. It would almost seem that, when, as occurs in some of the larger and finer specimens of turbines, metallic contact has been almost entirely eliminated, there should be little need for oil, but despite this theory it has been found that, alike in land and marine turbines, oil plays an important part in the successful working of the engine, and may, in some circumstances, and to a greater extent than in a reciprocating engine, be an occasion of trouble in use and may seriously impair the efficiency of the engine.

The turbine engine is generally lubricated by oil circulated by a force pump drawing its supplies from a tank of large capacity placed in the foundation of the engine. The oil is delivered, at pressures varying in different cases from 15 to 20 lb. per square inch, on the end bearings of the turbine by pipes which, by means of branches, distribute the oil over each bearing. The oil, leaving the ends of the bearings which are covered, falls into a well from which, by gravitation, it returns to the main tank, in which it passes through a filter before it is sent out again on its circuit. The oil which has taken up heat from the bearings returns to the tank at a high temperature, which ought not to exceed 120–150° F. To reduce the temperature of the oil, the tank is fitted with a system of pipes through which cold water passes, the temperature of the water being in turn kept down by any convenient method, as by passing it through a series of air-cooled vertical pipes, or other form of radiator, or by allowing the water to fall through the air in showers.

Much trouble has been experienced in the lubrication of turbines from the mixture of water with the oil, which results in the production of an emulsion of a more or less stiff character, which is liable to choke the filters, pumps and pipes, and seriously interferes with the running of the engine. This emulsification of the oil is promoted by the presence of even a small quantity of any animal, vegetable or other saponifiable oil. Therefore, in all cases in which there is a liability to the intrusion of water either from condensation of steam or from leaky joints, it is important that saponifiable oils should be wholly excluded and only pure hydrocarbon oils used, and, as the presence of water in greater or less degree seems to be common in all turbines, it follows that only pure hydrocarbon oils are permissible as lubricants.

As regards the properties required in oils for turbines, it may be pointed out—

(*a*) That as the temperature of the glands of steam turbines probably does not greatly exceed 150° F., steam cylinder oils are not required and oils adapted for the bearings of engines of corresponding size may be used.

(*b*) This is further qualified by consideration of the fact that as the bearings of turbines are generally of ample size, while the oil is delivered at a high pressure, the necessity for oil of high viscosity is largely reduced.

(*c*) This is in favour of the engineer and facilitates the selection of oil, as it is found, although the rule is not of universal application, that pure "hydrocarbons" of medium specific gravity and viscosity generally separate more readily and completely from water than do heavier oils. The writer's method of testing this property in oils is to expose the oil with an equal quantity of water for a period of two hours at various temperatures in a small agitating apparatus, in which a small model screw propeller, driven at a high speed by a water turbine, thoroughly agitates and mixes the two liquids, which are then transferred to a bottle for observation till separation has been effected.

In the case of some well-refined oils this may occur in the course of a few hours to the extent that the oil and the water occupy equal spaces in the bottle, although the oil remains cloudy and of a milky appearance from the presence of a trace of moisture in suspense, while the water also is darkened in colour and slightly opaque. Between the two liquids a strata of frothy texture is found, sometimes no thicker than the blade of a knife, in other cases from an eighth to a quarter inch in thickness and presenting an irregular cellular formation.

In some cases the separation of the oil and water at normal temperature may take several days or even weeks, and the writer is acquainted with one pure hydrocarbon oil, of low specific gravity, which had so great affinity for water that, after standing for several months, the emulsion was not reduced,

Obviously the oils which exhibit the lowest affinity for water under such conditions, and which separate most readily and most completely, are best adapted for use in turbines ; but the engineer who adopts these must not suppose that in doing so he has secured immunity from trouble, since the nature of the water, the impurities which it assimilates in use from the metal and joints with which it comes into contact, not only accumulate in the tank, pump, filter and "oil ways," but amalgamate with the emulsifying elements in the water and promote the formation of deposits.

Internal Combustion Engines.

Internal combustion engines using petroleum spirit as fuel have already, on account of their compactness, cleanliness and ease of manipulation, become popular for river boats and launches and even for sea-going yachts, in which they supersede steam. In fishing boats and drifters internal combustion engines, using paraffin oil or "Kerosene" as fuel are largely adopted, and similar engines or gas engines in conjunction with "producers" are being in troduced in lighters and barges, which formerly depended upon oars, sails or a small auxiliary steam engine for propulsion.

In all these cases the prominent feature in favour of the newer power has been the small space occupied by fuel, the promptitude with which power can be obtained without waiting to get up steam, and the small number of attendants required for internal combustion engines as compared with the large number (including firemen) required for steam engines of the same size.

These advantages have long been fully recognized by marine engineers, but the difficulties which have been found, especially in the case of large vessels with full-powered engines, in reversing and in speed control have prevented the adoption of internal combustion engines in ocean liners.

It would appear, however, from the many important experiments in ship building which are now in hand, in this country and on the continent, that, at no distant date, we may find that internal combustion engines are no longer restricted to pleasure boats and coasting vessels, but are used not only in the great ocean liners, but even in the navies of the world.

When this comes to pass the question of lubrication will naturally arise, and, in view of the various types of engines and the variety of fuels which may be used, it is likely for some time to come to afford room for considerable diversity of opinion and practice.

The writer of these notes, who has for many years devoted much attention to this subject, has satisfied himself, by personal investigation and observation and by information derived from the experience of others, that the most satisfactory results, in respect to the lubrication and running of internal combustion engines, are to be obtained from the use of compound oils, i.e. of oils prepared by blending, in suitable proportions, according to the work for which they are intended, various refined hydrocarbon and animal or vegetable oils.

We are aware that this opinion is not universally endorsed by engineers or by chemists, but we believe that all thoughtful men will recognize that we have warrant for our recommendations in the following arguments—

(*a*) It is admitted without question that fatty oils are superior to mineral oils as agents in reducing friction.

(*b*) It is suggested by some engineers, supported by some chemists, that fatty oils are liable to be decomposed by the heat of the engine and to produce fatty acids detrimental to the cylinders. But it is generally recognized by chemists that fatty acids cannot be produced without the presence of free oxygen and of moisture, neither of which can be found in the cylinder of an internal combustion engine.

(*c*) It is supposed that fatty oils are responsible for the accumulations of carbon which are found in cylinders of internal combustion engines, but if any person who desires to have ocular demonstration of the relative quantities of carbon produced by burning hydrocarbon and fatty oils will put the question to the practical test, he will find that petrol (the finest form of hydrocarbon which is available for these engines) will give dense volumes of black smoke, while olive, castor, rape or coco-nut oil will burn in open lamps without a trace of smoke.

The final argument in favour of this principle is, that the leading makers of gas engines recommend compound oils for their engines, that the makers of many of the best oil engines call for special superfatted oil for the lubrication of these, while in the case of two or three well-known engines, pure or nearly pure vegetable oils are used.

That these compound oils give satisfaction when pure hydrocarbon oils fail to do so, and that no injurious or troublesome consequences are entailed by their use, seems to be conclusive evidence in favour of compound lubricants for internal combustion engines of all types.

Dynamos and Motors.

As Dynamos require to be operated by some external prime mover deriving its energy from steam, water, gas or other agency, they cannot be regarded as the source of the energy which they collect and distribute.

But, as channels for the production of electric power for lighting and for its transmission and utilization through electric motors for mechanical operations, traction, etc., dynamos and their complimentary motors occupy a position of great and increasing importance in the field of modern engineering. In the transmission of energy for lighting, the cumbrous system of pipes, required for gas, and the tanks, barrels or other packages required for oil, are dispensed with. In the transmission of power for mechanical purposes, the expensive arrangement of shafts and counter shafts, pulleys and pinion wheels is avoided. In both cases the distribution of energy is effected easily and economically by wires or cables either locally or to distances far beyond the limits imposed by any mechanical transmission of power.

Thus mechanical friction in the system of transmission is entirely eliminated, and the only friction calling for the "oil can" occurs upon the bearings of dynamos and the motor, which are usually of ample size in relation to the weight which they are called upon to carry.

The conditions, therefore, present no difficulties, and lubrication may be satisfactorily effected by ordinary oils of moderate body applied in the usual way. A special feature calling for special consideration is introduced by the common adoption of ring bearings in both dynamos and motors. By this well known method the oil supply is carried in a bath in the under part of the bearing into which the rings, hanging from and revolving with the journal, dip, carrying a supply of oil upwards on every revolution. The conditions introduced by this method are that the oil must be of suitable consistency to rise freely, but not in excessive quantities, with the rings, that it must not thicken, coagulate or develop acidity through long exposure to the air in the bath or on the rings, and that it must be free from any detrimental action on the bearings. These properties can only be found in pure highly refined hydrocarbon oils which are free from tendency to oxidize or gum, from liability to develop acidity by age and which being wholly neutral, cannot exert any deleterious action on bearings.