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DEPARTMENT OF MINES

OTTAWA, CANADA

THE LUBRICATION OF THE GASOLINE ENGINE

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Prepared for the Committee on Enquiry into Fuel and Lubricating Oils of the Government of the Province of Alberta.

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THE LUBRICATION OF THE GASOLINE ENGINE

By P. V. Rosewarne*

The problem of lubrication is a very complex one that until a few years ago the general public was content to leave in the hands of those scientists and engineers who by accident or desire had become interested in the subject. A great deal of information is available concerning lubrication, much of it being of a highly technical and mathematical character that formerly served the need of those who were interested. With the advent of the motor car and its gasoline engine, however, the general public developed a lively curiosity regarding that particular piece of machinery and the lubricating oil that it needed. There has arisen, therefore, an insistent demand for sound and reliable information concerning this commodity that is being sold on almost every street corner. Further, that it should be stated clearly and concisely, and as nearly everyday language as is possible.

This, the writer has attempted to do in the following pages. If he has failed to steer clear of all technical expressions and terms, he craves the reader's indulgence, and hopes that the meaning intended is sufficiently clear that the fault has been somewhat retrieved. He has attempted to leave out all mathematical discussions and content himself with stating only the answers. He has endeavoured to present descriptive data and information that will enable the reader to answer more intelligently the question, "What oil should I use, and why?". In bringing this information together the writer has drawn freely not only upon his own experience in the laboratory, in the shop, and on the road, but has also consulted many text-books on the subject and a large number of articles in the technical and scientific journals of the day. To all of these, he acknowledges his indebtedness, and recommends them to the interested reader who desires to pursue still further the study of this fascinating subject.

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LUBRICATION:

When two solids are pressed together, a certain force is required to cause one to move in relation to the other. If these two solids were component parts of a perfect machine, the motion once started would continue indefinitely, as long as the machine were not made to do work. However, in all cases there is a definite retarding of the initial motion due to a resistance that must be overcome. This resistance is called the friction between the surfaces. The frictional resistance varies greatly between different surfaces and materials, being less for hard materials and smooth surfaces. The function of lubrication is to minimize this frictional resistance to the greatest possible degree. Lubrication is obtained by placing between two surfaces, one of which it is desired to move in relation to the other, some substance or material that reduces the friction and this substance is called a lubricant. Part of the efficiency of lubricants is due to the fact that they keep the moving parts, whooly or partially, from coming in contact with one another. Other factors influencing the result are the change in character of the surfaces due to chemical or physical action of the lubricant; the frictional resistance of the surfaces moving over the lubricant; and the internal frictional resistance of the lubricant itself.

Many different materials have been used as lubricants some of which are: air, water, soap, grease, graphite, animal and vegetable oils, mineral or petroleum oils, etc. The degree of success attending the use of any lubricant in any particular case depends on a great many factors and a satisfactory lubricant under one set of conditions may be quite useless under other conditions. Perhaps the lubricants most generally used are those known as lubricating oils. Materials of this class include animal, vegetable and mineral oils; the last named being a complex mixture of substances containing the elements hydrogen and carbon. On that account they are called hydro-carbons. Animal and vegetable oils contain oxygen combined with hydrogen and carbon.

A good lubricant should possess the following characteristics:

(a) Sufficient viscosity, or "body", to keep the moving surfaces apart under the maximum pressure.
(b) Chemical inertness, in respect to oxidation and corrosive action on the metals of the bearings.
(c) A low co-efficient of friction.
(d) Greatest possible capacity for carrying away heat so that the bearings may remain cool.
(e) A high temperature of decomposition.
(f) A low solidifying point.

It is unlikely, however, that any one oil or grade of oil will be found to give the best results in every particular. In choosing an oil for a particular machine it is necessary, therefore, to obtain a lubricant that possesses the quality or qualities which enable the machine to function properly under operating conditions. For that, the two characteristics first mentioned in the above list are fundamental. The remaining four will vary in importance according to the operating conditions. For instance, it is conceivable

than oil having a slightly higher co-efficient of friction and a lower solidifying point is to be preferred in some cases to another oil having a lower co-efficient of friction and a higher solidifying point.

METHODS OF LUBRICATION:

Methods of applying lubricating oil to rubbing surfaces vary all the way from the primitive oil can and the spasmodic attention of the operator, to practically automatic oiling by means of a force pump and a system of ducts, through which oil is continuously forced to the bearings from a central reservoir during the operation of the machine. The oil may or may not be used over and over again. The latter type of lubrication is usually referred to as a mechanical force feed system. In it a small predetermined amount of oil is supplied to each bearing by an individual pump and no provision is made to collect the oil for use again. The former type of lubrication is called a "circulating" system and is characterized by the fact that the used oil is collected and automatically returned to the bearings to be used again.

The circulating system of lubrication has the following four important advantages over other systems:

1. A large quantity of oil is supplied to the bearing providing that necessary for the maintenance of a perfect lubricating film and avoiding any trouble due to insufficient oil.
2. The flood of oil carries away the heat produced by the friction resulting in cooler bearings and lower oil consumption.
3. The oil keeps the bearing clean by washing away particles of worn metal or foreign matter that accidentally gets into the bearing. It also prevents corrosion by flushing away corrosive substances that may be formed in the oil or dissolved in it from the products of combustion.
4. The oil is used repeatedly thereby reducing consumption materially.

LUBRICATING SYSTEMS FOR THE GASOLINE ENGINE:

Two distinct forms of circulating system are in general use for the lubrication of the modern gasoline engine, namely, the splash system and the forced feed system.

The Splash System: In the splash system a pump draws oil from the oil pan and delivers it to troughs so arranged that the lower ends of the connecting rods dip into them with every revolution of the crankshaft. A small projection on the lower part of each connecting rod splashes oil from the troughs directly into the cylinder walls and the oil is distributed by the moving pistons. The rotating parts are lubricated by the spray of oil produced in the crankcase by the connecting rods. Part of the oil is splashed onto the interior surfaces of the crankcase and a part of it drains down to the bearings through funnel-shaped openings. If the oil is too viscous to be thrown from the troughs in the form of a mist or spray, or to drain readily down to the bearings, the rotating parts may become starved for oil in a very few minutes and excessive wear occur. The cylinder walls and pistons under such conditions may be sufficiently lubricated since they are in line with the throw of the connecting rods and are almost certain to receive an adequate supply of oil from the start. Since lubricating oils become very

viscous in cold weather, the conditions described above frequently occur during winter driving.

The Forced Feed System: In the forced feed system oil is drawn from the oil pan, pumped through a hollow crankshaft and camshaft, and distributed to the rotating parts through appropriate holes. The cylinder walls and pistons are lubricated by the excess oil from the rotating parts, squeezed out from the connecting rod bearings and thrown onto the cylinder walls by the motion of the crankshaft and connecting rods. With this system the rotating parts are properly lubricated as long as the oil pump can circulate the oil, but if the oil becomes very viscous the cylinder walls get an insufficient supply and wear is excessive. It is, therefore, apparent that lubricating oil for use during the winter months must remain fluid at low temperatures.

LUBRICATING THE GASOLINE ENGINE:

The main parts of the gasoline engine that need lubrication are a crankshaft, supported on two, or more, main bearings that are attached to the engine frame, a piston and connecting rod for each cylinder, a camshaft, cams, valve push rods, valve stems, timing gears or chain, etc. It is obvious, therefore, that an engine has a large number of moving parts, with many types of motion, and a wide range of pressure on the different bearings. There is, for instance, the sliding of the piston on the cylinder wall. This is a straight reciprocating, or back and forward, motion with low pressures and large surfaces in contact. The small end of the connecting rod and the wrist pin have very small motions, but have to support on small areas pressures that fluctuate greatly. The large end of the connecting rod has to support equally great fluctuating pressures and at the same time take care of a rotatory motion. The main bearings have to support a somewhat fluctuating pressure, but the principal motion is rotation. The gears and chain are somewhat similar to the small end of the connecting rod in that considerable pressure is transferred through small contact areas, but differ in that there is a sliding contact instead of a partial rotation.

In spite of these widely different conditions of operation, in the modern gasoline engine, one type of oil is expected to lubricate all the parts satisfactorily. This can only be done by using an oil having a high enough viscosity to stand up under the greatest pressures and permit that oil to lubricate all the other moving parts. This, of course, results in a slight loss in power, but it is considered that this power loss is more than counterbalanced by the convenience and trouble-free operation of modern lubricating systems. Accordingly, engine designers specify that bearing clearances, oil ducts and vents shall be such that oil of that viscosity can be handled.

LUBRICANTS:

The materials used for lubrication cover a wide range of materials and they may be classified in several ways. For instance, as oils, greases, and solids. However, for the purposes of this discussion it would appear to be more satisfactory to consider them mainly from the viewpoint of the material of the substance, rather than from the physical state in which it happens to be under conditions of ordinary atmospheric temperatures. The following classification is submitted, therefore, in order that a clearer picture of the subject may be secured.

1. Petroleum lubricants.
2. Animal oils and fats.
3. Vegetable oils.
4. Compounded oils.
5. Solid lubricants.

PETROLEUM LUBRICANTS:

The word, petroleum, is derived from Latin and means rock oil. Crude petroleum itself is obtained by drilling a hole down into the earth and into the rock in certain localities that have such a conformation below the surface that the oil is trapped and held there until released through the bore hold. Sometimes the oil is under such great pressure that it flows freely and sometimes the well has to be pumped in order to secure the oil. Not only gasoline and kerosene but also lubricating oil is obtained from the crude petroleum. Crude petroleum itself may be divided into several classes, namely:

Paraffin-base petroleum.
Mixed-base petroleum.
Naphthene-base petroleum.

Paraffin-base petroleums: Paraffin-base petroleums are those that contain an appreciable quantity of crystallizable paraffin wax and little or no asphaltic material.

Mixed-base petroleums: Mixed-base petroleums are those containing some crystallizable paraffin wax and also some asphaltic material.

Naphthene-base petroleums: Naphthene-base petroleums are those that contain no appreciable quantity of paraffin wax. They may contain much or little asphaltic material. Those containing a great deal of asphaltic substances are sometimes referred to as asphaltic-base petroleums.

The term "asphaltic material" may be understood to mean the thick, black, tar-like substance that is obtained as a residual product when crude petroleum is distilled. It is characterized by being "sticky" rather than "oily". It is often so viscous that it appears to be solid at ordinary temperatures. It is used in the manufacture of paints, for roofing material, for surfacing roads, etc.

The number of different kinds of lubricants and lubricating oils made from petroleum is amazing. They range in character from very fluid liquids suitable for use as lubricants for sewing machines, typewriters and similar light mechanisms, to thick, heavy greases for heavy machinery. A list of them, according to use in the order of their fluidity, includes the following:

Spindle oils.
Loom oils.
Engine oils.
Motor oils.
Car and gear oils.
Petrolatum greases.

Classified according to the degree of refining that they have undergone, are the following types of oils:

Red paraffin oils.
Pale paraffin oils.
Neutral oils.
Cylinder stock.
Black oils.

These two more or less parallel classifications are used to designate the greater number of petroleum oils used for lubrication. For instance, one may have a pale paraffin oil in a grade suitable for spindles and light, high-speed machinery, a pale paraffin oil suitable for medium weight engines, and a pale paraffin oil that may be used for lubricating gasoline engines. The same may be said for the red paraffin oils or for the neutral oils. The cylinder stocks and black oils are represented by the car and gear oils in the first classification.

Paraffin Oils:

These oils are distilled from crude petroleum and are red or yellow in colour.

Red Paraffin Oils: These oils represent the greater volume of light, medium and heavy lubricating oil that is used for general machinery lubrication. Light oils of this class may be used for lubrication of spindles in textile factories, and in other places where a thin, light oil is required. The heavy oils may be used for engines and motors when a cheap oil is required. When made from crude petroleum having a paraffin base they tend to produce considerable quantities of hard carbon when used in gasoline engines. When made from naphthene or asphaltic base crudes the carbon that is formed is softer and more fluffy. When used in circulating systems in which moisture may be present red oils have a tendency to emulsify or to produce a sort of sludge or jelly. This is often observed in the crankcase of a gasoline engine that is used in cold weather.

Pale Paraffin Oils: These oils are distilled from crude petroleum much the same as the red paraffin oils, but after distillation are usually filtered through fuller's earth or clay to improve their colour. They form less carbon than the red oils and do not emulsify so readily. They are, therefore, more satisfactory for use with gasoline engines and air compressors.

Neutral Oils:

These oils are also distilled from crude petroleum, but whereas the paraffin oils are distilled without the admission of steam to the still, neutral oils are steam distilled. After having the paraffin wax removed the mixed oil distillate is reduced in volume by another distillation with steam. This distillation separates the oils into two classes, namely: "non-viscous neutrals", which have been distilled over and condensed, and "Viscous neutrals" which have not been carried over in this second distillation but remain as a residual oil in the rerun still. In some cases they are sun-bleached to remove the characteristic fluorescence or "bloom".

Non-Viscous Neutrals: The non-viscous neutrals are usually filtered but not acid treated, and are suitable for the lubrication of spindles and other light, high-speed machinery. They are considered to be the highest grade oil for this class of work.

Viscous Neutrals: The viscous neutrals are repeatedly filtered through fuller's earth to improve the colour and are not usually acid treated. These oils are suitable for use on motors, gas engines, air compressors, turbines and other work demanding oils of the best quality.

Cylinder Stock:

This is the name given to the residual oil left in the still when paraffin-base crudes have been subjected to steam distillation. The quality of the product depends primarily on the quality of the crude from which it is made. The unfiltered cylinder stock is brown or black in colour. The cold test will vary from 20°F. or less to 50°F. or more.

Filtered Cylinder Stock: When filtered through fuller's earth or bone black, considerable asphaltic and carbonaceous material is removed. The oil becomes more or less transparent, the colour changes from brown to green when viewed by reflected light, and the cold test often rises to 80°F. or 100°F. This increase in cold test is caused by amorphous wax and is undesirable if the oil is to be used in cold weather. Therefore, a further refining operation is used to remove the amorphous wax or petrolatum and to produce what is known as "bright stock".

Bright Stock: The cylinder stock is diluted or "cut" with gasoline or naphtha, chilled to a low temperature and allowed to settle, or is centrifuged. In either case, the amorphous wax is separated as a more or less solid substance and the liquid is steam distilled to remove the naphtha. The residual reduced oil is called bright stock.

All of these oils may be blended with viscous neutrals to yield heavy-bodied oils for use where required, or may be compounded with other materials for special purposes.

Blended Oils:

The mixing of naphthas, burning oils and fuel oils to meet various specifications is called blending in the industry. When lubricants are mixed it is usually termed compounding. However, the writer prefers to restrict the term "compounding" to those cases in which different materials are mixed, as for instance, petroleum and animal or vegetable oils, soaps, or other solid substances, and to use the term "blending" to describe any operation when two or more petroleum products of different grades are mixed for any purpose.

Prediluted Oils:

All oils used in a circulating system for lubricating gasoline engines become somewhat diluted or "thinned out" by unburned gasoline that works down past the piston rings and into the oil pan while the engine is running. This occurs most rapidly before the engine and oil are warmed up and reach their normal operating temperatures. An equilibrium point is then established at which the amount of unburned fuel or "diluent" seeping into the oil is counterbalanced by the amount of diluent being evaporated by the hot metal and oil. Naturally, the amount of diluent present in the oil at the equilibrium point will vary somewhat according to atmospheric temperatures, operating temperatures of the engine, percentage of its maximum power delivered by the engine, the design and mechanical condition of the engine, volatility of the fuel used, and so forth. However, as stated above, some diluent is always present and this diluent reduced the viscosity of the oil. In an effort to counteract this condition some refiners in the United States* are offering a prediluted oil. This is simply a heavy oil blended with a petroleum distillate with a volatility similar to the average diluent produced in a gasoline engine under normal operating conditions. The amount of diluent added is the amount that may be expected to be present in an average automobile engine under ordinary running conditions. The advantage of such an oil is that the viscosity is not greatly changed after the oil is put into the engine. It also permits the use of a heavier-bodied oil than would be considered satisfactory in a fresh non-diluted oil. The engine designers also are trying to minimize or counteract the dilution of the oil. In some cases a part of the oil is pumped over a "hot spot", usually near the exhaust manifold, all the time the engine is running. The diluent is evaporated from the heated oil and led back to the intake manifold to be burned. The hot oil is then usually passed through a filter to remove foreign particles. The continuous operation of such a system tends to keep the amount of diluent in the oil at a low point. In other cases the crank case is ventilated in order to speed up the natural evaporation of the diluent from the oil in the oil pan. The vapours may or may not, be led into the air intake of the carburetor to lower fuel consumption.

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* The Isovis oils of the Standard Oil Company of Indiana are of this general type.

High Vacuum Oils:

During the past few years a new method of producing lubricating oils has gained some favour among refiners. By this method the heavier portions of crude petroleum are distilled under very low pressures, that is, much below atmospheric pressures, or as it is often called, under "high vacuum". Lubricating oils produced by this method are generally much clearer and lighter in colour than oils produced by other methods. By carefully controlling the fractionation it is also possible to greatly simplify the refining treatment that the oils receive later. In other respects they are very similar to the oils described above.

Black Oils:

The ordinary black oils are made from the residues formed by the redistillation of lubricating oil distillates, or from asphaltic crude oils that do not make satisfactory cylinder oils. They are used to lubricate large gears and heavy, rough machinery.

Petrolatum:

Petrolatum is an amorphous wax obtained in the process of making low cold test bright stock. It is sometimes called petroleum jelly or vaseline. The latter is a trade name and should be applied only to the petrolatum manufactured by one company. The colour of petrolatum varies from brown to being practically colourless. Large quantities of it are used as a base in the preparation of ointments and drug specialties. As a lubricant it possesses a rather unsatisfactory characteristic in that it becomes fluid at a comparatively low temperature and runs out of the bearing. This defect has to be remedied by the addition of other materials or by special treatment of the petrolatum.

ANIMAL OILS AND FATS:

A large number of animal oils and fats have been used for lubrication of all sorts of instruments and machines. They were, perhaps, the first lubricants that mankind used in the far-off dawn of history when the first crude machines were made. They include such materials as seal oil, whale oil, fish oils, lard oils, tallow oils, degras and so forth. Lard oils are obtained by pressing pig's fat or lard, tallow oils by pressing beef or mutton tallow, and degras is prepared from the grease obtained from sheep's wool. Animal oils absorb oxygen and will in time dry out and leave a gummy residue. The process is slow, but they eventually become rancid and give off an offensive odour. During this reaction fatty acids are formed that have a more or less corrosive action on metals. In addition they are more expensive than petroleum or mineral oils of similar viscosity. Chemically, animal oils differ from mineral oils in that they contain oxygen as well as carbon and hydrogen in their molecular structure. They belong to a class known as fixed oils

because they cannot be distilled like mineral oils without decomposition. The fact that they break down on ~~heating~~ renders them unsatisfactory for use in a gasoline engine. However, a certain quantity of animal oil is used in the preparation of compounded oils for use with certain types of steam engines. Care should be taken that such oils are not used for the lubrication of internal combustion engines.

VEGETABLE OILS:

Vegetable oils are those obtained from various plants and seeds by extraction or by pressing. Many kinds are in general use, as for instance, castor oil, rapeseed oil, cocoanut oil, etc. These oils are mainly used in lubrication by being compounded with mineral oils, although castor oil finds a considerable sale for use as a lubricant for many purposes due to its stability. It is used to a limited extent in internal combustion engines that are frequently overhauled and cleaned, as for instance, racing cars and aeroplane engines. Vegetable oils as a rule dry much more readily than animal oils, and have a somewhat similar chemical structure. They, too, belong to the class of fixed oils that cannot be distilled without decomposition. Great care should be exercised that rags or waste used to wipe up animal, vegetable or mineral oils compounded with them, are not permitted to lie around. When rags or waste have absorbed any of these oils the natural tendency to oxidation is greatly accelerated, frequently to such an extent that the mass bursts into flame spontaneously and causes many serious fires, the cause of which is often unsuspected.

COMPOUNDED OILS:

As stated above, the writer prefers to include in this class only those oils that are composed of oils of different kinds as opposed to those that are blended by mixing oils of the same kind, but different grades. Therefore, the class may be understood to include the following:

Oils containing mineral and animal oils.
Oils containing mineral and vegetable oils.
Oils containing mineral oil and other materials.

The first two compounded oils, namely, those in which animal or vegetable oils are mixed with mineral oils, find use in the lubrication of steam engine cylinders in which the steam is being used is saturated with water. Steam engines using dry or superheated steam have their cylinders satisfactorily lubricated by straight mineral oil. The former kind of oil should not be used for the lubrication of gasoline engines with the exception of those compounded oils in which castor oil is the other ingredient. Oils of this sort are on the market and have acquired an enviable reputation for service and durability in gasoline engines.

Compounded oils in which other materials are mixed with mineral oils are not used for the lubrication of the gasoline engine itself, although they find some favour for other parts of a motor vehicle. Examples are greases of various sorts in which mineral oils are mixed with various soaps in order to thicken them and permit them to support greater pressures, and mixtures in which solid substances such as graphite and powdered mica are suspended in mineral oils. Solid substances are also added to some greases as fillers.

SOLID LUBRICANTS:

Some solids such as graphite and powdered mica make very good lubricants for some purposes. They may be used in the powdered form, suspended in oils, mixed with greases, or inserted as a block or wedge in one of the members it is desired to lubricate. Some of these are found useful around the chassis of a motor vehicle, as mentioned above, but not in the gasoline engine proper. Bearings for the electric starting motor and generator may have inserted graphite blocks so that other lubrication is not necessary. The engine clutch collar may be formed of a solid block of graphite and a mixture of oil and powdered graphite or mica may be used between the leaves of the springs. For these purposes solid lubricants have been found quite satisfactory.

SIGNIFICANCE OF LABORATORY TESTS:

Lubricating oils for use in gasoline engines are usually tested in a laboratory to determine the following characteristics:

Specific gravity.
Viscosity.
Flash and Fire point.
Carbon residue.
Acidity.
Colour.
Saponification value.
Emulsibility.

The significance and value of these tests is not always clearly understood and therefore an attempt will be made in the next few paragraphs to outline some of the main conclusions that may be drawn from the results.

To begin with it must be understood that the value of any test depends upon the viewpoint of the individual and what he wishes to know. Further, it should be kept in mind that most tests for lubricating oils have been developed by the manufacturer and not by the purchaser. For that reason many tests were designed and widely used whose only value was to assist the refiner in maintaining a uniform product, and were of very little value when used as a criterion for judging the comparative merits of two oils refined by different methods. Since petroleum oils are used almost exclusively for the lubrication of gasoline engines at the present time, tests for this class of oils only will be considered.

Specific gravity: The specific gravity of an oil is the ratio of the weight of any volume of the oil to the weight of an equal volume of pure water. The specific gravity of a lubricating oil is an indication of the class of crude petroleum from which it is made. Paraffin-base petroleums usually produce oils having a relatively low specific gravity, while mixed-base and naphthenic-base petroleums produce oils with a relatively higher specific gravity. It may be pointed out here that the terms, "light," "medium" and "heavy", refer to the viscosity of an oil rather than to its specific gravity. In the refinery, the specific gravity is used a great deal as a control test to indicate the progress of distillation. Its chief advantage for this purpose is that the specific gravity of an oil may be read off a hydrometer almost instantly, and, providing that the same crude oil is being handled, may be relied upon to give comparable results.

Viscosity: Different liquids have different internal resistances; that is, some are more fluid than others. This varying resistance to flow is closely related to viscosity and to internal friction. The internal friction is usually expressed as the "coefficient of friction". There is a theory that has been very widely accepted by lubrication engineers that the coefficient of friction is proportional to the viscosity for all speeds and pressures, except for very slow speeds and very high pressures. As stated before, lubrication is attained by inserting a thin layer, or film, of some substance possessing the property of "oiliness" between solid surfaces that move in relation to each other. This property of oiliness is related to the "adhesion" of an oil, that is, the tendency of an oil to cling to the surface being lubricated, and it is also related to the "cohesion" of an oil, that is, the tendency of a particle of oil to cling to another particle of oil. Cohesion assists lubrication by holding together the particles of oil and so aids in maintaining the lubricating oil film. Adhesion assists lubrication by clinging persistently to the solid surfaces, and therefore also aids in maintaining the lubricating oil film. It is apparent from the above discussion that cohesion and internal friction are very closely related to each other and to viscosity. It is held further, that viscosity is a measure of the combined effects of cohesion and adhesion. The writer is inclined to believe, however, that this is only apparently true rather than true in the abstract, and is due to the fact that viscosity is usually determined in contact with brass, and brass and similar alloys are largely used for the manufacture of bearings. The viscosity of an oil is usually measured by determining the time required for a given volume of oil at a specified temperature to flow through a definite sized opening.

The viscosity has been accepted generally as a criterion in judging the quality of an oil. From the standpoint of the consumer and the lubricating engineer it is without doubt the most important single characteristic of lubricating oil that can be determined satisfactorily at the present time. Generally speaking, the higher the viscosity of the oil at the operating temperature, the greater the pressure that can be supported by the oil film on the bearings; but, the higher the viscosity, the higher the power loss due to internal friction. On that account it is necessary,

for most efficient operation, to obtain an oil with a sufficiently high viscosity to allow a reasonable margin of safety in operation, and yet with a not unduly high viscosity which would cause a loss of power. It has been shown that lubricating oils having a viscosity of from 140 to 280 seconds at 100°F. in the Saybolt viscosimeter give good results when used in the standard automobile engine under properly controlled operating conditions. Such oils would have a viscosity at 210°F. of from 42 to 50 seconds, approximately. The oils having the lower values could be used with more safety in those engines that have a full forced-feed lubricating system. The above figures are about 20 per cent lower than the average motor oils on the market, and since those oils represent the experience of many manufacturers in supplying oil for engines under all sorts of conditions, it would appear advisable to choose an oil for ordinary use having values slightly higher than those mentioned.

It is desirable that the viscosity of an oil should not change greatly with a change in temperature. Oils made from paraffinn-base crudes show a smaller change in viscosity with change in temperature than do oils made from naphthenic base and mixed base petroleums.

S.A.E. Numbers: In the past it would appear that each refiner decided for himself how his product should be graded into "light", "medium" and "heavy" oils. The great variations that naturally occurred under such a lack of system was confusing not only to the average user but also to the engine designer. Accordingly, the Socieyt of Automotive Engineers, usually referred to as "S.A.E.", adopted a specification for lubricating oils based entirely on viscosity. In this system distinctive numbers were used instead of the old terms of light, medium and heavy, and various combinations of them. The S.A.E. recommended practice is as follows:

S.A.E. Viscosity Number	Viscosity Range Saybolt Universal, seconds	
	at 130°F.	At 210°F.
10	90-115	---
20	120-150	---
30	185-220	---
40	255- -	- 70
50	---	75- 95
60	---	105-120

At first this scheme met with a great deal of criticism from oil technologists because they felt, apparently, that it was not comprehensive enough, but it has demonstrated its value to the point where an ever increasing number of refiners are accepting it and labelling their product in conformity with it. It has some defects, of course, but it does insure that the user who follows it will get an oil reasonably near the grade of oil for which his engine was designed.

Flash and Fire Point.

The flash point is a quick and valuable refinery control test, used by the refiner as an aid in maintaining a uniform product. When considered from the consumers standpoint, it indicates two things. First, when it is reasonably high it indicates that there is no low-boiling and relatively cheaper fraction mixed with the lubricating oil. The flash point of mineral lubricating oil for use in gasoline engines should not be less than about 335°F. Second, when considered in conjunction with the viscosity it indicates the class of crude petroleum from which the oil was made. For the same viscosity, lubricating oils made from paraffin-base crudes have a relatively higher flash point than those made from naphthene-base crudes.

Acidity.

The acidity should be shown as mineral acid and as organic acid. Mineral acid is highly corrosive and indicates a careless refining. No mineral acid should be found in a good oil. Organic acids are only very lisghtly corrosive, if at all. A very small percentage of organic acid may be present with beneficial results in reducing the coefficient of friction. Petroleum oils after being used for some time usually show a higher percentage of organic acid than they do when new.

Colour.

The value of testing for colour is problematical. It was of value years ago in estimating the degree of refining the oil had undergone, and the class of crude oil from which it had been made. Modern methods, however, have enabled the refiner to produce oils of almost any desired colour.

Saponification Value.

Pure petroleum, or mineral, oils have a very low saponification value. Both animal and vegetable oils have a high saponification value. For instance, the saponification value of castor oil is about 185. Since it is desirable to know whether the oils under consideration is a pure mineral oil or not, this test is valuable to the consumer, although it is obvious that the refiner requires it only when compounding oils. If the saponification value is found to be less than 3 the oil may be considered to be a pure mineral oil.

Emulsibility.

Some oils form an undesirable emulsion with water. This is most noticeable in cold weather. It is usually a characteristic of the cheaper grade of oils. In warm weather it is not particularly harmful.

Bibliography

Among many excellent works of reference the following books may be mentioned, not because they are considered to be only authoritative ones but simply because the writer happens to be more familiar with them than with some others perhaps equally good.

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