Lubricating Oil For Paper Mill - Its Selection, Status of Reclamation, Purification, And Recycling Practices In India

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ABSTRACT

Lubricants are chemical substances, derived oils obtained from natural resources or synthetic materials which are used to carry the task of lubrication in an engine or machine for any industry. It is used so as to reduce the risk of severity between two sliding or rolling surfaces by developing the smoothening film between them. The basic reason for applying the lubricating materials between the two surfaces is that it has low shear stress which permits easy sliding of one surface over the other surface by shearing the layers of lubricating components. These materials not only reduce friction and ease out maintenance ,but also reduce wear, absorb shock, reduce temperature, minimize corrosion and sealing out contaminants. Lubricant has characteristics with large number of physical and chemical properties that help to improve its strength during its applications in varying working environment. A good lubricant in general, therefore possesses characteristics like high boiling point, low freezing point, high index, thermal stability, hydraulic stability, demulsibility, corrosion prevention, high resistance to oxidation and many others.

The use of lubricant is subjected to the state, phase and mode of application. Industry using oil based lubricant needs to identify its use in specific machine and its component parts. Hence its selection with specific characteristics is to be identified and accordingly various additives have to be added to comply with. Due to high price of oil and to save valuable foreign exchange , there is an imperative necessity felt by the mill to regenerate, reclaim, purify and recycle the used oil.

In this paper, a detailed discussion on lubrication oil, both petroleum based as well as synthetic one their requisite properties for specific use, classifications, additives required for right selection are made. Selection of lubricating oils in terms of special characteristics for paper industry with special emphasis on paper machine elements is highlighted. Case studies of mill applications, extent of energy saving and cost benefits are demonstrated.

Introduction

Lubrication is one of the most important phenomenon required for the smooth and uninterrupted running of the trio-components fitted in the various parts of an engine or machine. The subject dealing with lubricants and friction in rolling system is called Tribology. Tribology based diagnosis technology (lubricant analysis) is now one of the major methods for maintenance engineering of any rotating machine.

The primary objective of lubrication is to reduce the risk of severity of the normal stress and shear stress in the solid surface contacts. Since only a small fraction of apparent area of contact between the two surfaces is in the actual contract. The stress-state exceeds the yield point of the ductile sliding or rolling materials because all the mechanical energy applied to unlubricated contact area causes to heat and deform the sliding surfaces.

Lubrication is equally important for all kinds of automotive, industrial, agricultural and domestic machines. More precisely, the phenomenon of lubrication helps to eliminate friction, wear and tear of machines to the maximum possible extent by making use of suitable lubricating material so called lubricant. The property of reducing friction is known as lubricity (slipperiness)

A lubricant is a substance introduced to reduce friction between moving surfaces. It may also have the function of transporting foreign particles. Lubricant is the chemical substance or synthetic materials which are used to carry the task of lubrication in an engine or machine. . One of the single largest applications for lubricants, in the form of motor oil, is protecting the internal combustion engines in motor vehicles and powered equipment. It is used so as to reduce the risk of severity between two sliding or rolling surfaces by developing the smoothening film between them. The basic reason for applying the lubricating materials between the two surfaces is that it has low shear stress which permits easy sliding of one surface over the other surface by shearing the layers of lubricating components. Lubricant has a large number of physical and chemical properties that help to improve its strength during the applications in varying working environment. The use of lubricant is subject to the state, phase and mode of application.

Since the major role of lubricant is to separate the moving surfaces with a smoothening or lubricating film of solid, liquid and gaseous materials which can reduce the undesirable friction and wear without causing any damage to the sliding or rolling surfaces, lubricant manufacturers are highly concerned to the consideration of all the parameters that are involved during the working mode of lubricants. These parameters are necessarily linked to the various properties of the lubricants. Physical properties, chemical properties, mechanical properties and thermal properties all together constitute the gross characteristics of lubricants.

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Function (Objective) Of Lubricants:

Lubricants are applied to the moving surface or interface of the machines for providing a large number of techno-economical functions. These functions are independent of area of contact, area of lubrication, contact geometry but necessarily dependent on the state, phase and lustre of lubricants. Almost all functions or objectives are the direct consequence of the additive compounds added to it

The major objective which is common for all categories of lubricants is to reduce friction between sliding or rolling surfaces and fatigue, surface wear, and tear of machine, surface heat and act as coolant by reducing temperature, maintenance and running cost, interfacial deformation and expansion of metals, absorb shock, avoid figure of moving surfaces, help in sealing the boundaries and in power transmission., improve the efficiency of machines, prevent corrosion and rust(1-12)

Characteristics Of Good Lubricating Oils:

A good lubricant possesses the following characteristics:

(1) high boiling point (2) low freezing point (3) adequate stable viscosity for proper functioning in service (4) high resistance to oxidation and heat(thermal stability). (5) non-corrosive properties and corrosion prevention (6) stability to decomposition at the operating temperatures, (7) high viscosity index (8) hydraulic Stability (9) demulsibility (10) desired Flash Point and Fire Point, Cloud Point and Pour Point and Aniline Point.

Classification Of Lubricants:

Lubricants are classified on the basis of their physical state, as follows;

(a) Liquid lubricants or Lubricating Oils such as gear oil, bearing oil, hydraulic oil etc.
(b) Semi-solid lubricants or Greases
(c) Solid lubricants. such as poly tetra fluro ethylene (PTFE), hexagonal boron nitride, and tungsten disulfide are examples of materials that can be used as solid lubricants, often to very high temperature.

(a) Liquid lubricants or Lubricating oils: Lubricating oils also known as liquid lubricants or lube oils.

Lube oils are further classified into three categories;

(i) Animal and Vegetables oils,
(ii) Mineral or Petroleum oils and
(iii) Synthetic oils.

(i) Animal and Vegetables Oils:

Animal oils are extracted from the crude fat and Vegetables oils such as cotton seed oil and caster oils. These oils possess good oiliness and hence they can stick on metal surfaces effectively even under elevated temperatures and heavy loads. But they suffer from the disadvantages that they are costly, undergo easy oxidation to give gummy products and hydrolyze easily on contact with moist air or water. Hence they are only rarely used these days for lubrication. But they are still used as blending agents in petroleum based lubricants to get improved oiliness.

(ii) Mineral Or Petroleum Oils:

Typically lubricants contain 90% base oil (most often petroleum fractions, called mineral oils) and less than 10% additives. These are basically lower molecular weight hydrocarbons with about 12 to 50 carbon atoms. As they are cheap, available in abundance and stable under service conditions, hence they are widely used. But the oiliness of mineral oils is less, so the addition of higher molecular weight compounds like oleic acid and stearic acid increases the oiliness of mineral oil.

(iii) Synthetic Lubricants :

Synthetic lubricants are the combination of synthetic base oil, additives plus thickeners that provide a consistent set of desirable characteristics for the wide range of performance. These are artificially synthesized from compounds other than crude petroleum oil. Synthetic lubricants are used in such a diverse situation where petroleum oil based lubricants do not provide the excellent performance. These provide natural lubricity, excellent low temperature properties, high viscosity indices and better additive compatibility. In addition, it can provide much better thermo-chemical and mechanical properties such as anti-oxidation, anti-corrosion, anti-friction, anti-wear and extreme-pressure properties etc. Further, those have excellent anti-scuffing, anti-seizure, and anti-corrosive characteristics (2).

(iv) Additives :

A large number of additives are used to impart performance characteristics to the lubricants. Additives deliver reduced friction and wear, increased viscosity, improved viscosity index, resistance to corrosion and oxidation, aging or contamination, etc

The main families of additives are: antioxidants, detergents, anti-wear, metal deactivators, corrosion inhibitors, rust inhibitors, friction modifiers, extreme pressure, anti-foaming agents, viscosity index improvers, demulsifying/emulsifying, stickiness improver, provide adhesive property towards tool surface (in metalworking),and complexing agent (in case of greases) (3).

Physico-Chemical/Thermal Properties

Physico-chemical properties are available in Indian Oil guide book for lubrication usage. Heat transfer characteristics of lubricants have been reported in details in connection with its application for Internal combustion engines. These include thermal conductivity, specific heat, density, and viscosity. In this study only viscosity as a transport properties is discussed in detail.Other relevant thermal properties such as flash point , fire point, cloud point , pour point and aniline point are highlighted briefly.

Viscosity:

It is the property of liquid by virtue of which it offers resistance to its own flow (the resistance to flow of liquid is known as viscosity). The unit of viscosity is poise. It is the most important single property of any lubricating oil, because it is the main determinant of the operating characteristics of the lubricant. If the viscosity of the oil is too low, a liquid oil film cannot be maintained between two moving/sliding surfaces. On the other hand, if the viscosity of the oil is too high, excessive friction will result.

Effect Of Temperature on Viscosity:

Viscosity of liquids decreases with increasing temperature and, consequently, the lubricating oil becomes thinner as the operating temperature increases. Hence, viscosity of good lubricating oil should not change much with change in temperature, so that it can be used continuously, under varying conditions of temperature. The rate at which the viscosity of lubricating oil changes with temperature is measured by an arbitrary scale, known as Viscosity Index (V. I). If the viscosity of lubricating oil falls rapidly as the temperature is raised, it has a low viscosity index. On the other hand, if the viscosity of lubricating oil is only slightly affected on raising the temperature, its viscosity index is high.

Effect Of Temperature on Service Life:

As a rule of thumb, the service life of a mineral oil is specified as 30 years at 30°C(85°F), 15 years at 40°C(105 °F), i.e the oil's life is halfed for each temperature increase of 10°C(18 °F). At 100 °C (210°F) service life will be approximately three months. One should use a synthetic oil at temperature above 100°C (210°F).This fact is demonstrated in Fig.1

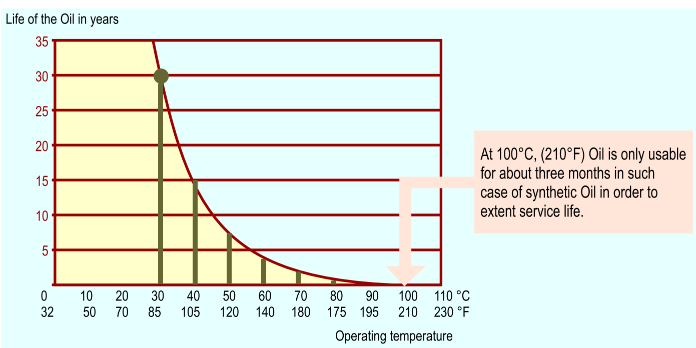


Fig. 1: Effect of temperature on life of oil in years

Flash Point and Fire Point

Flash point is the lowest temperature at which the lubricant oil gives off enough vapours that ignite for a moment, when a tiny flame is brought near it; while Fire point is the lowest temperature at which the vapours of the lubricant oil burn continuously for at least five seconds, when a tiny flame is brought near it. In most cases, the fire points are 5° C to 40° C higher than the flash points. The flash and fire do not have any bearing with lubricating property of the oil, but these are important when oil is exposed to high temperature service. A good lubricant should have flash point at least above the temperature at which it is to be used. This safeguards against risk if fire, during the use of lubricant.

Cloud Point and Pour Point

When the lubricant oil is cooled slowly, the temperature at which it becomes cloudy or hazy in appearance, is called its cloud point; while the temperature at which the lubricant oil cease to flow or pour, is called its pour point. Cloud and pour points indicate the suitability of lubricant oil in cold conditions. Lubricant oil used in a machine working at low temperatures should possess low pour point; otherwise solidification of lubricant oil will cause jamming of machine. It has been found that presence of waxes in the lubricant oil raise pour point.

Aniline Point

Aniline point of the lubricant oil is defined as the minimum equilibrium solution temperature for equal volumes of aniline and lubricant oil samples. It gives an indication of the possible deterioration of the lubricant oil in contact with rubber sealing; packing, etc. Aromatic hydrocarbons have a tendency to dissolve natural rubber and certain types of synthetic rubbers. Consequently, low aromatic content in the lubricant oil is desirable. A higher aniline point means a higher percentage of paraffinic hydrocarbons and hence, a lower percentage of aromatic hydrocarbons (4).

Lubricant Oil Selection

As already indicated, essential requirements or characteristics of a good lubricant are:

- It should have a high viscosity index.
- It should have flash and fire points higher than the operating temperature of the machine.
- The cloud and pour points of a good lubricant should always be lower than the operating temperature of the machine.
- It should have higher aniline point.
- The volatility of the lubricating oil should be low.
- It should deposit least amount of carbon during use.
- It should have good detergent quality
- It should have high oiliness.
- It should possess a higher resistance towards oxidation and corrosion.

Application Of Lubricants

Lubricants are extensively employed in various applications such as automotive engine oils, tractor , aviation, marine, horological , agriculture and for personal use etc.

For industrial use the most useful lubricants include hydraulic oils, air compressor oils, food grade lubricants, gas compressor oils, gear oils, bearing and circulating system oils, refrigerator compressor oils,steam and gas turbine oils. In this study discussion is limited to gear oils, bearing and circulation systems. Information about lubricants for internal combustion engines are available elsewhere (5).

Economic Benefits Of Good Lubrication:

The Phi (Φ)chart (Fig. 2) shows the results of 229 industries audit reports in Japan(6) about the economic benefits of using a good lubricant vis a- vis the resulting cost benefits obtained. Similar level of values are obtained from Indian industries as shown in Table.1. The magnitude of energy saving is also shown in both Fig.2 and Table 1.These are almost at the same level of magnitude.

- Proper selection of oil viscosity / grease thickness
- Adequate viscosity reduction
- Application of anti-wear / low friction lubricant
- Synthetic lubricant with high viscosity index
- Reduction of maintenance work (oil change, repair etc.)

Table 1: Benefits obtained from studies on Indian industries

Benefits	Percentage
Reduction in energy consumption through lower friction	7.5%
Saving in lubricant cost	20%
Saving in maintenance, repair and replacement cost	20%
Savings in consequential losses due to downtime- depending on type failure and type of industry	variable %
Saving in investment due to higher utilization ratio and greater machine efficiency	1%
Saving in investment through increased life	5% of new expenditure
Saving in manpower	13%

Fig. 2 Composition of economic effect for tribology improvement(Japan Lubrication Society)

Similar results are obtained from Indian industries (7) as given in Fig. 2 by carrying out process audits in Indian paper mills.

Comparison Between Mineral Oil and Synthetic Oil: Case Studies

Causes for Energy saving by synthetic Oil, Poly α-olefin(pao)

- Viscosity stable temperature characteristics(High viscosity index), carbon chain is long and flexible
- High oxidation stability: there are no impurities such as S and N , and good effect of addition of additive effect
- Low volatility and high flash point; molecular weight is uniform and a few volatile component
- Low pure point; molecular weight is uniform and there is no polymer which is easy to be solidified at low temperature

The superiority of synthetic oil over mineral oil is shown in figs. 3 and 4 at around 40°C.

$\Delta \mathbf{e} = (1/E)\{1-(1-E)[\eta_{PAO}/\eta_{mineral\ oil}]\}^{0.3}-1$

where E=Transmission efficiency of gear =90% and Δ**e**= energy saving effect.

Temperature, C	0	5	10	25
Energy Saving effect	2.7	2.3	1.8	1.0Δ

Case studies of PAO hydraulic oil application have indicated that
(1) Structure of hydraulic carrier
(2) Oil color change while in use
(3) Contaminant level

The following graphs compares the mineral oil with synthetic oil (PAO) for the above two parameters and indicate the superiority of the later over the former.

Lubricating Oil Used In Indian Paper Industry:

lubrication oils are used everywhere in any industry ,be it chemical,such sugar , paper , polymer, etc, , mechanical or metallurgical. Servo 140(2,30400 Cps at 40°C) and servo 46(47.6 cps at 40°C) are employed for mill turbine in sugar mill while Servo 68 (viscosity CPs at 40 °C varies between 55.9 to 68.1) is used in power turbine in paper mill/ sugar mill. It has been found (8) that slow speed spur gear tooth breakage for reduction of viscosity of gear oil(viscosity 14,800 CPs at 40°C at the breakdown).It has been strongly felt that periodic checking viscosity must be done after every 100 days. Thus timely analysis of viscosity of gear oil favourably takes care of preventive maintenance,thus controlling and saving of consumption of costly petrochemicals and foreign exchange. The various lubricating oils used in paper machine possess the following characteristics:

Oil Health Analysis:

The following parameters are required to indicate about the lubricating oil health. These should be routinely checked by Indian paper mills.

- Viscosity (kinemetic viscosity), mm^2/s, cst
- **Viscosity Index(min.)**
- Total acid number, mg KOH/g
- Insoluble content, wt%

- Alkalinity value: 0.1 N HCl ml/100 ml
- Demulsibility
- Foam stability
- Anti-rust property
- Consistency(Grease)
- Hydraulic fluid index(HFI)
- **Minimum Flash point, °C**

Figs.3-5 indicate the variation of kinematic viscosity as a function of temperature, and temperature dependency of gear efficiency(transmission efficiency) of both mineral oil as well as synthetic oil. Figs.6 and 7 represent variation of color and contamination level during operation as a function of operating time.Fig. 8 gives the methods of lubricating oil analysis.

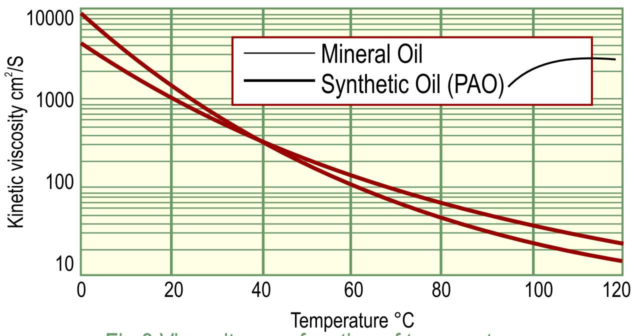


Fig.3 Viscosity as a function of temperature for PAO gear Oil (ISO VG320)

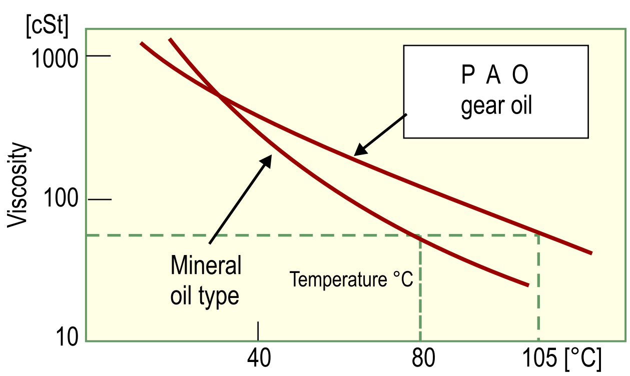


Fig. 4: Preliminary calculations for energy saving effect

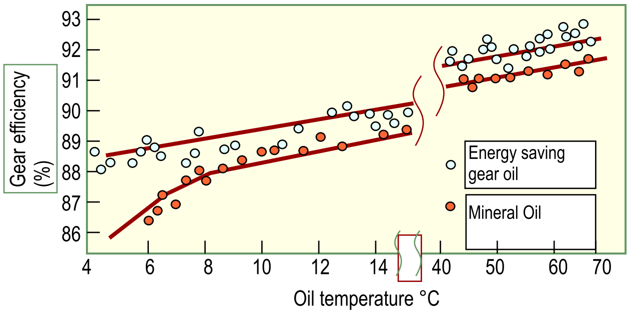


Fig. 5 Characteristics of gear oil-(Transmission efficiency) as a function of temperature

Paper Industry Maintenance Diagnosis Technologies

Table. 2 shows the lubrication oils normally used in Indian paper mills in different key machine elements along with three important physic-thermal/ transport properties.

One of the examples of process of abnormal lubrication and occurrence of machine trouble is oil leakage. Preventing oil leakage will reduce lubricant consumption significantly. Others are : change of oil color, level of contaminant, choice of bad lubricant, abnormal load, temperature rise and many others cited above. Some of the parametric effects are already demonstrated in Figs. 3-5.

How To Select Lubricant Oil For Bearing For Paper Industry?

There are many types of element bearings, including ball, roller, spherical roller, thrust roller, needle roller and single- and double-row types. Fortunately the selection process for the various types is similar. The following discussion pertains to the common ball, roller, spherical roller and thrust roller type element bearings. Element bearings operate under a wide array of temperature, speed, load and environmental conditions. The first step is to select an appropriate viscosity grade followed by selection of additive type (R&O, AW, EP). Bearing manufacturers provide fairly useful charts that assist us with this process. The five steps to this process are:

Table 2: Characteristics of Lubricating Oils used in Indian Paper Industry

Product	Kinemtic Viscosity CST at 40 °C	VI Min	Flash Point °C Min	Application
Servo Prime 57	55-60	95	210	Servo prime oil used in hydraulic systems requiring long life Lubricant of outstanding properties.
Servo System-320 (Circulating Oils)	315-350	90	230	Dryer cyliner Bearing, Pumps etc.
Servo System-121	118-124	90	220	Particularly Compressors, Pumps etc.
Servo Mesh SP-320 (Gear Oil)	320-350	90	232	Servo Mesh SP oil recommended for all heavy duty enclosed gear drives with circulation or splash lubrication system operating under heavy or shock load conditions upto a temperature 100°C
Servo Cyl C460	460-480	90	280	Servo Cyl C oil are recommended for high temp. above 100°C. Servo Cyl C used in high temp. Gear Box.

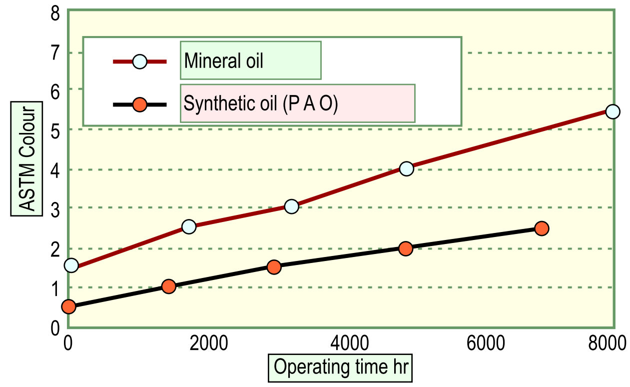


Fig: 6: Oil color change while in use

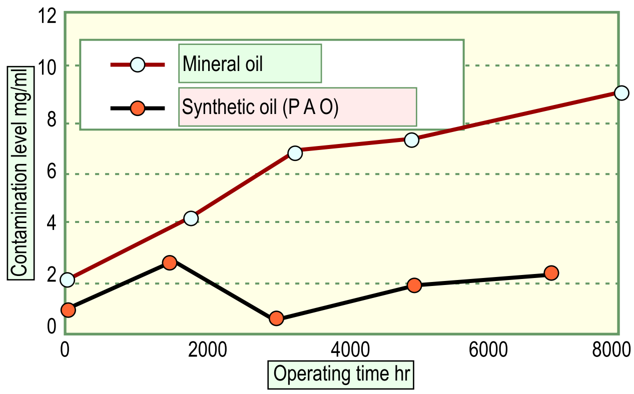


Fig. 7: Contamination level changed during operation

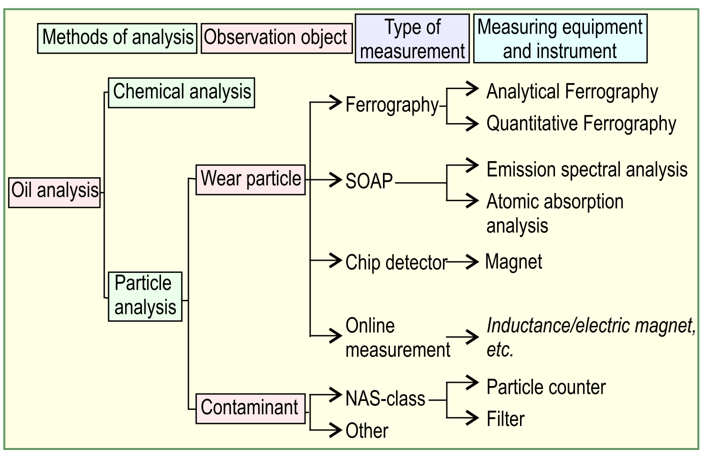


Fig. 8: Methods of Lubricating oil Analysis

1. Determine the bearing physical size (width, outer diameter, inner diameter), element type (ball, cylindrical roller, spherical roller, thrust ball or roller) and shaft speed. These details often can be found in the shaft RPM machine construction diagrams and drawings. Example: A 6320 bearing has a bore dimension of 100 mm, an outer diameter dimension of 215 mm and a race width of 47 mm.

2. Determine the bearing's limiting speed factor. This value is referred to as the "pitch line velocity" or the "nDm." Equation 1. shows the speed limit calculation for element bearings. Bearing speed limits differ for each bearing, but general rules exist around bearings by bearing type and function.

Example: The 6320 roller bearing turning at 1,200 rpm has an nDm (speed limiting) value of 120,000. This information is particularly useful to assess whether the bearing should be lubricated by oil or grease. Equipment operators often convert oil-lubricated bearings to grease, even though the operating speed of the bearing is beyond that which is considered safe for grease lubrication. Grease type and relubrication volumes and frequencies should be adjusted to maintain bearing reliability under these circumstances.

Bearing speed limit parameters are calculated using the following equation:

nDm = n(ID+OD)/2**...........(Eq.1)**

where ndm = pitch line velocity of the bearing

n = shaft speed

ID = bore diameter

OD = outside diameter

D_m = mean diameter

3. Calculate the Pitch Diameter (PD) of the bearing ([inner diameter + outer diameter] ÷ 2). Example: The 6320 bearing pitch diameter is ([100 mm + 215 mm] / 2 = 157.5 mm). This parameter will be used to identify the minimum viscosity for the bearing at its operating speed.

4. Plot the bearing PD on a bearing specific viscosity limit reference chart. Locate and plot the shaft rotational speed and triangulate to the suggested viscosity for the given running speed. The result provides the lowest viscosity point at which the bearing would be expected to achieve its projected minimum life cycle. The optimum viscosity is three to five times the minimum recommended viscosity.

Example: This is a multistep process. Begin by locating the pitch diameter value from Step Four at its appropriate location on the X (bottomhorizontal) axis of **Fig.** 9. Next, draw a vertical line from the X axis toward the top of the chart until it intersects with the diagonal line that represents the shaft rotational speed. Next, at that intersecting point, draw a line to the Y axis. Make sure that the final line is horizontal to the X axis. The Y axis represents the bearing minimum suggested viscosity value for a given size and shaft speed. In this instance, the PD value (157.4) is labeled Point A. The

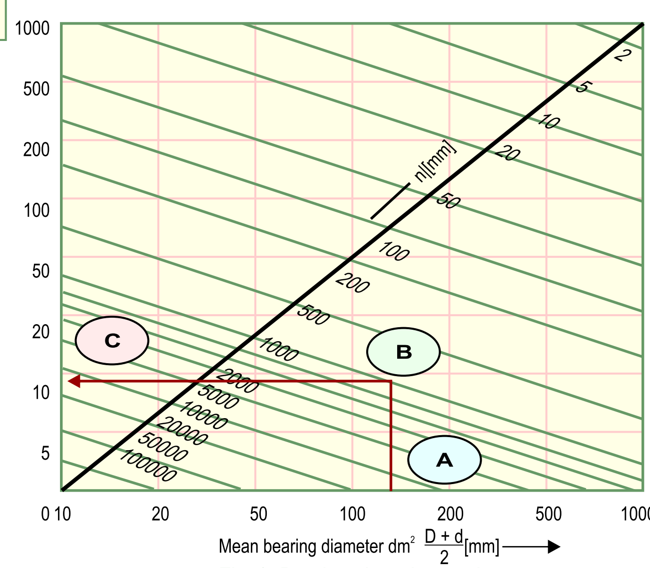


Fig. 9 .Bearing viscosity graph

intersection with the diagonal line for shaft speed is labeled Point B, which is the initiating point for the line that terminates at Point C, this bearing's required viscosity in centistokes. This element bearing would have a minimum oil viscosity requirement of 13 cSt when operating at 1,200 rpm. Ideally, the operator should maintain three to five times the minimum viscosity in the element at its normal operating temperature. Therefore, for this bearing, the low-end optimum is (13 cSt* 3 = 39 centistokes), and highend optimum is (13 cSt* 5 = 65 centistokes). If viscosity error must be tolerated it would be best to err on the side of increased oil thickness as long as the overage does not induce heat through fluid friction.

5. Plot the viscosity of the target lubricant on an ASTM viscosity-temperature graph and determine the actual viscosity at the expected operating temperature. Repeat the process until the correct lubricant has been selected.

Example: **Fig.** 10 is a temperature viscosity chart provided by FAG Bearing Co. The bearing operating temperature is located on the Y axis, and is labeled Point A. Draw a straight line from the point that is horizontal to the X axis until it intersects with a red line, representing a standard viscosity grade (32, 46, 68, 100, etc.). An ISO 68 should provide the desired viscosity at the normal operating temperature of the application (50 C). The intersection point with this line for ISO 68 is labeled Point B. Lastly, from this intersection point (B), draw a straight line to the X axis to locate the actual operating viscosity, 38 cSt, which is labeled Point C. It is evident from this exercise that this bearing, operating at a running speed of 1,200 rpm at 50 C temperature requires an ISO 68 viscosity grade (with a VI of 100)(9).

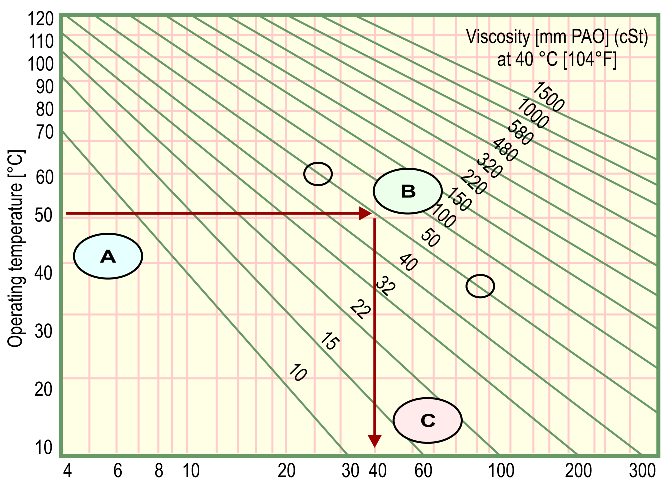
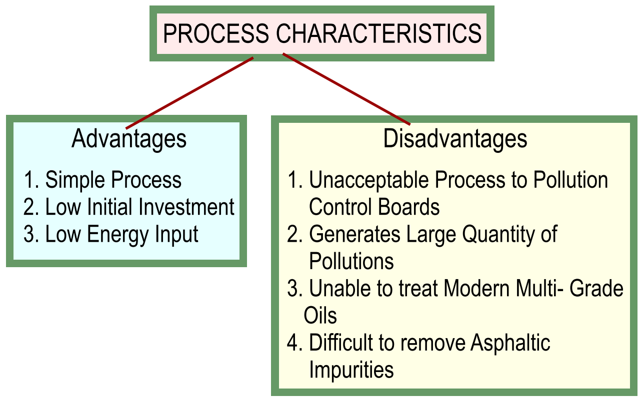


Fig. 10 Operating viscosity for mineral oils (with a VI of 100)

Lube Oil Purifaction

It is well known that due to the ever-increasing price of oil and with an objective of saving valuable foreign exchange, every industry-user of mineral oil put forward efforts for regeneration of used lubricating oil. Management of waste lube oil is a serious environmental problem. Almost all types of waste oil have the potential to be recycled safely, saving a precious non-renewable source and at the same time minimizing environmental pollution. Unfortunately, most of used oil is handled improperly.

Disposal of used lubricating oil into the eco system creates environmental hazards. In most cases, used oil can be re-used after reconditioning with or without the addition of any additives resulting in huge saving and conservation of precious oil. Thus regeneration, reclamation or recycling of spent lubricating oils has become an important process industry, adopting various techniques for oil purification(10). But there are some advantages and disadvantages as described in the following chart.



Contamination Or Impurities of Used Lubricating Oil

Lubricating oils are impaired temporarily only because of accumulation during use or handling of contaminants coming from extraneous impurities and products of oil deterioration, which can be separated from the used oil by re-refining of oil or reconditioning. The treated oil, then becomes almost equivalent to fresh/virgin oil.

The major contaminants in the waste oil are:

1. Metalic Impurities
2. Non-metallic impurities
3. Water, moisture and untreated acid
4. Carboneous particles
5. Fuels, impaired additives and their by products
6. Chemical contaminates
7. Polycyclic Aromatic Hydrocarbons(PHAs)

In India, re-recycling waste oil industry is mainly an un-organized one. Most of the units, till now, were adopting “Acid Clay Process”, which now has been dis-approved by the pollution control boards, resulting in their closure until they adopt new certified process**(10,11)**.

Acid Clay Process :

In the conventional acid clay process the used lubricating oil is settled or filtered after collection and is dehydrated(10,11). The oil is then treated with concentrated sulphuric acid to remove polymers, asphalts, degraded additives and other products of degradation.The sludge formed is allowed to settle and removed. The oil is neutralized with activated clay, at elevated temperatures. The clay also bleaches the oil and adsorbs certain impurities not removed by acid treatment. The clay-oil slurry is filtered to removed clay and other solids. If the raw material **contains** more than one grade of lube oil product further processing may be required.

Spent oils, which have not deteriorated to great extent, are often clay contracted or treated with absorbents without any acid treatment. They are generally given a preliminary setting, filtering, centifuging or vaccum dehydrating treatment. Insulating oils and Transformer oils are often treated in this way.

Processes approved by the regulatory bodies used now by the Re-refiners and Re-cyclers are environmentally sound technologies(EST) and they have switched over from acid clay process or modified acid clay process to vacuum distillation with clay treatment , thin film evaporation or vacuum distillation with hydrotreating. For vacuum based operation selection of efficient vacuum pumping system is required. Two main processes are shown in Figs.11 & 12.

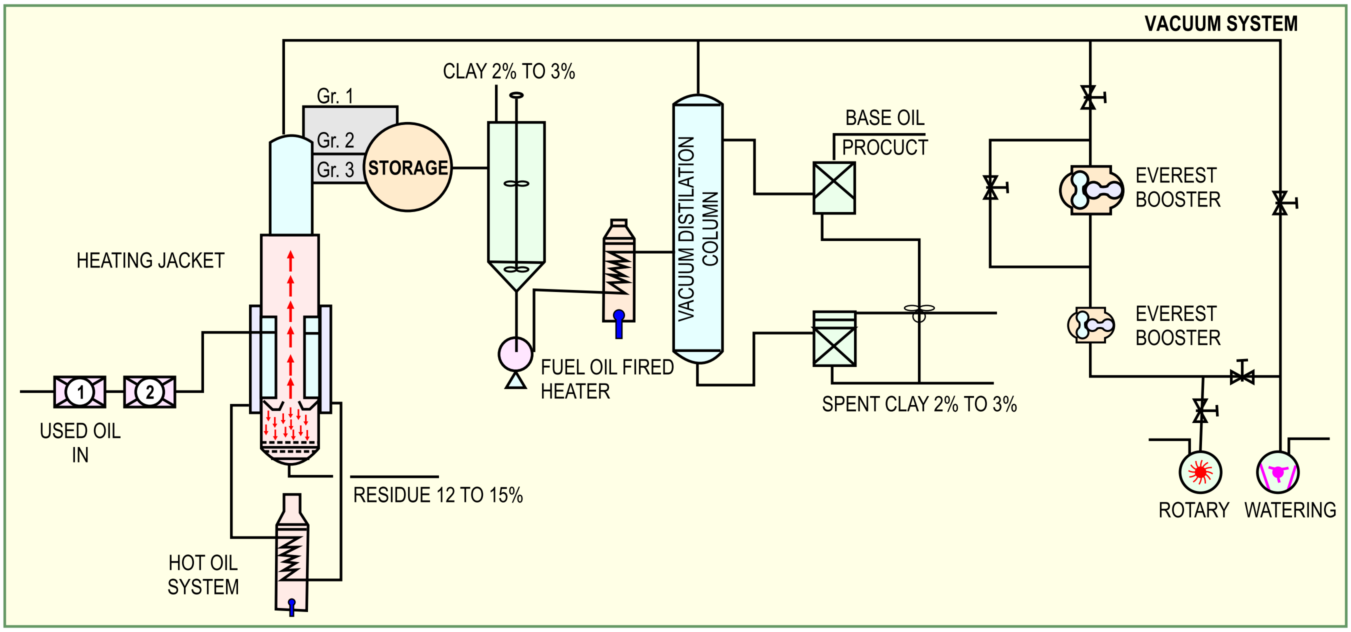


Fig.11 Reconditioning of waste lubricant (thin film)

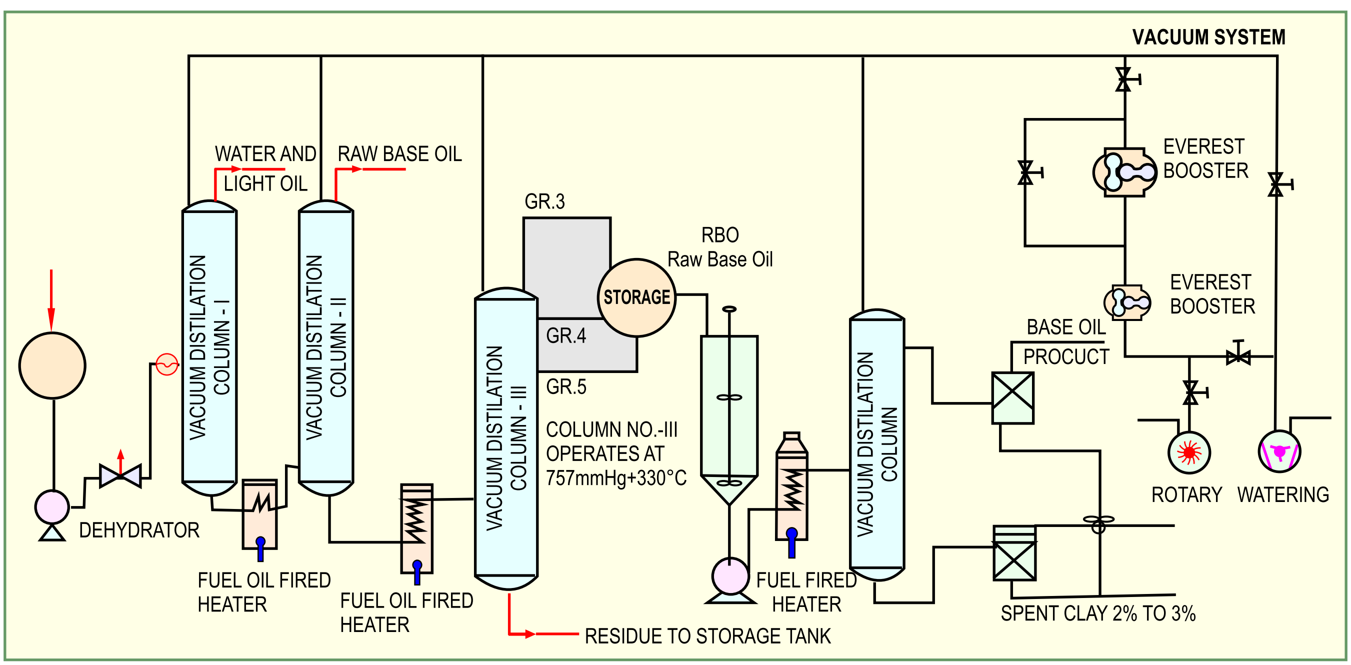


Fig- 12 Reconditioning process vacuum distillation

Conclusion:

Lubricants are modified petroleum products or derived chemicals or synthetically manufactured not only reduce friction and ease out maintenance ,but also reduce wear, absorb shock, reduce temperature, minimize corrosion and sealing out contaminants. A good lubricant in general, therefore possesses characteristics like high boiling point, low freezing point, high index, thermal stability, hydraulic stability, demulsibility, corrosion prevention, high resistance to oxidation and many others.

Industry using oil based lubricant needs to identify its use in specific machine and its component parts. Hence its selection with specific characteristics is to be identified and accordingly various additives have to be added to comply with. Due to high price of oil and to save valuable foreign exchange , there is an imperative necessity felt by the mill to regenerate, reclaim, purify and recycle the used oil. In this paper, discussion on lubricating oil, both petroleum based as well as synthetic one, is made with reference to classifications, selection oils in terms of special characteristics for paper machine gear system. Benefits of energy savings vis a vis cost benefits are highlighted.

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