MORRIS LUBRICANTS

Steam Lubrication Theory

Introduction

A steam engine operates on the basic principle of converting steam energy into reciprocating mechanical motion. The heat energy of steam expands in a piston/cylinder system and is transmitted by a crank mechanism due to the nature of the reciprocating motion more readily in use.

A steam propulsion system has the following main components:
1. A boiler which converts water into steam.
2. A piston/cylinder system to transform the energy of steam into mechanical energy;
3. A crank mechanism to convert the reciprocating motion of the piston into rotary mechanical motion.
4. Piston rod guide system.
5. A steam condenser (optional).

Selection of the lubricant

In steam engines the demand for lubrication of the cylinders and other parts in contact with steam differs considerably from that of the crank mechanism and other external parts.

Cylinder lubrication

The function of the cylinder oil is to form an oil film to prevent friction and wear of piston/cylinder surfaces and steam leaking past the valves, pistons and stuffing boxes.
The normal method of applying oil uses an atomiser system in the steam line or valve chest. The oil is dispersed in a fine mixture with the steam and in this way is carried to the cylinder walls. For high-superheat engines, oil is often injected directly into the cylinders.
Generally speaking, the lower the oil viscosity the better the atomisation of the oil and thus the better lubrication. However, the higher the temperature of the steam, the higher the oil's viscosity and the more stable it must be. Compound oils (mixture of mineral oil and fatty oils) atomise more easily and produce a more tenacious oil film than pure mineral oils of the same viscosity.
Compound oils tend to decompose at high superheated temperatures, however, and in these conditions offer no advantage over pure mineral oils. Also, because of their greater ability to emulsify, separation of compounded oils from condensed steam is more difficult so they are thus used more often in non-condensing engines than in condensing.
Notwithstanding the advantage of compound oils, the majority of steam engines, both saturated and superheated, are in fact lubricated with pure mineral oils. For the lubrication of steam cylinders, steam refined cylinder stocks are used. The selection of the cylinder oil should be made contingent upon the following factors:

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1. The state of the steam (wet, dry, saturated or superheated).
2. The presence or not of a condenser (the condenser recovers the water from the steam and re-circulates it, while the non-condenser rejects the steam in to the atmosphere.

Lubricating the crank mechanism and piston guide system:

1. **Open crankcase engines**: The lubrication of each bearing and guide is usually carried out separately. Sometimes on large engines a gravity feed system distributes oil to each point. Both compound and pure mineral oils are used, the compound being more suitable for vertical marine engines, where the guides and bearing that are exposed to projections of steam and water are coated from the stuffing box and valve.
2. **Closed crankcase engines**: the bearings of this type of engine can either be splash or force lubricated, and precautions are taken to prevent condensed vapour and steam from entering, although a certain quantity nevertheless mixes with the oil. In the case of the splash lubricated engine, which is being continuously agitated, this provides ideal conditions for the oxidation of the oil, water emulsions and sludge. High quality oil with resistance to emulsion and oxidation is therefore required.

Steam Engine Lubrication

The oil must atomize efficiently and spread readily over the working surfaces, and must be capable of maintaining a film at the temperature inside the cylinder. In addition, the oil film must be able to resist the scouring action of the steam and, depending to an extent the wetness of the steam, the washing effect of water. An essential requirement is that the viscosity should be high enough to enable the oil to lubricate adequately the rubbing surfaces at the temperature of operation. Higher steam temperatures demand that the oil has greater stability towards heat, that is to say, lower volatility and a minimum tendency to form gummy or carbonaceous deposits. In general, therefore, steam cylinder oils are classified in accordance with the range of stop valve temperatures for which they are appropriate: the higher the steam temperature, the greater the required heat stability, which generally, but not always depends upon the viscosity grade.
Efficiency of atomisation, which depends upon the uniformity of distribution of the oil in the steam, is a factor of importance. It is influenced chiefly by the velocity of steam, apart from the characteristics of the oil and the design of the atomiser. High velocity favours good atomisation, while relatively poor atomisation frequently occurs in engines working at low loads; for this reason, it is common practice in such cases to fit ancillary oil feeds. In general, the lower the viscosity of the oil, the better the atomisation. Since, as a rule of thumb, the rise in temperature lowers viscosity, high steam temperatures favour good atomisation.

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As compounded oils atomise very easily under conditions of moderate superheat and produce more tenacious films than the straight mineral oils of the same viscosity, they may therefore be used at a lower rate of feed and on these grounds are often preferred. Under conditions of high superheat, however, fatty oils decompose. Under such conditions, compounded oils generally show little or no advantage over straight mineral oils. Because of their emulsifying properties, separation of compounded oils from water may be difficult; they should therefore be used with caution where oil in the condensate is a problem. Despite the advantages of compound oils, it must not be assumed that straight mineral oils are unsuitable for the lubrication of all but highly superheated steam engines. The great majority of steam engines are in fact satisfactorily lubricated by straight dark mineral oils. Where, however, it is desired to reduce to a minimum the possibility of deposit formation in the cylinders, so-called filtered cylinder stocks are in certain circumstances preferable to dark cylinder oils.

Causes of operating troubles

Most of the operating troubles experienced in steam engine cylinders can be attributed to one of the following:

Over-lubrication:
The rate of oil feed should always be generous, but should not be so great as to allow oil to accumulate in the cylinders. Ideally the rate of feed should vary with the engine power, but continuous control is not possible with certain types of lubricator. Over lubrication often occurs where such lubricators are fitted to engines subjected to fluctuations of load. Excess oil will then tend to accumulate in the cylinders, and at high temperatures may form carbon deposits. In such cases deposit formation can usually be decreased by reducing the rate of oil feed to a safe minimum or by changing to a more easily atomised oil. To assist determining the most appropriate feed rate for any engine please see table.

Incomplete distribution:
Groaning, chattering and excessive wear are generally due to incomplete distribution of the cylinder oil and often occur when engines have to operate for long periods at low load. Troubles of this sort can usually be overcome by changing to an oil of lower viscosity or to a compounded oil of the same viscosity (if a compounded oil is not already in use) or by improving the design or location of the atomiser.

Impurities in the steam:
Impurities such as rust and feed water salts can be carried from the boilers to the engine cylinders and lead eventually to the formation of hard deposits. A simple analysis of these deposits will show if steam impurities are responsible for their formation. MORRIS Compounded Oils are the first choice of lubricant when large amounts of water and carry over chemicals have to be handled at the cylinders, and these give excellent results under such conditions.

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Incorrect lubricant:
If the oil is too viscous it will not atomise properly, and this can lead to problems (particularly on small engines) of severe drag and poor lubrication until running temperatures are achieved. In extreme cases where a too high viscosity is used, severe wear or hydraulic damage can result.
However, if the oil is not viscous enough for the application, it will be unable to form the correct load bearing oil film on the working surfaces. The results of this will be excessive wear and steam leakage past valves, pistons and glands.
Please ask for a Morris Selection Chart before buying any lubricants.

Bearing Lubrication

1. **Open type steam engines**:
A lubricator is often fitted to each bearing or sliding surface, but a gravity feed system with separate feeds to each point requiring lubrication is sometimes employed for large engines. Both compounded and straight mineral oils are used, the former being preferable for vertical marine type engines in which the slides and bearings may be exposed to considerable quantities of water from piston-rod and valve glands.

2. **Enclosed-type steam engines**:
The bearings of enclosed-type steam engines may be supplied with lubricant either by splash or force feed. With splash lubrication, the level of oil requires careful regulation so that when the engine is running, a proper amount of oil is thrown from the big ends to all surfaces requiring lubrication in the upper part of the crankcase. Where force feed lubrication is provided, the oil is drawn from a reservoir and pumped through a strainer to the bearings and slides.
With either method of lubrication, the oil is continually flung from the bearings to all parts of the crankcase in affine spray. In this state, it is most susceptible to oxidation, leading to the formation of acids, sludge and emulsions. For this reason mineral oils of high resistance to oxidation should be used. Precautions are usually taken to prevent the entry into the engine crankcase of condensed steam from the glands, but a certain amount of water inevitably finds its way there. The oil, must, therefore, have good demulsibility. Sufficient water may enter the crankcase to cause the oil to rise well above the correct level. The result is excessive churning of the oil and water with consequent emulsification. The gland steam condensate may also carry small quantities of cylinder oil, rust and impurities from the boiler into the crankcase. These impurities are often very difficult to detect and minute quantities of them can cause emulsification troubles. All possible precautions should therefore be taken to exclude them. In addition, the oil should be maintained in a clean condition by regular purification to remove moisture, sludge and other contaminants.

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Stanley Steam Cars:

Two types of bearing lubricant should be considered depending on the type of gearbox system employed.

a) If it is an early model, the gearbox will be prone to water ingress and therefore a lubricant with good demulsification properties is required so that the free water can be drained off on a regular basis. A product such as Sentinel Crankcase oil would be recommended.

b) In later models, where the gearbox is separate and does not suffer from water ingress, a good quality, high viscosity gear oil should be chosen. A product such as Morris Lodexol SS 880W/140 would be recommended.

Compiled by Morris Lubricants Technical Department 19.5.2011

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Steam Engine Recommendations

STEAM CYLINDER OIL SELECTION CHART LOCOMOTIVE AND STATIONARY ENGINES

Grade	Steam Temperature, °F	Boiler Gauge Pressure lbs./sq.in	Steam Type	Condensate Recovery
Compound Steam Cylinder Oil 460	Up to 320	Up to 100	Saturated	No
Sovereign 460	Up to 320	Up to 100	Saturated	Yes
Compound Steam Cylinder Oil T	Up to 450	Up to 175	Saturated	No
Compound Steam Cylinder Oil 680	Up to 550	Up to 250	Saturated and Light Super Heat	No
Sovereign 680	Up to 550	Up to 250	Light Super Heat	Yes
Compound Steam Cylinder Oil 1000	Over 550	Over 250	High Temperature Super Heat	No
Sovereign 1000	Over 550	Over 250	High Temperature Super Heat	Yes

SENTINEL STEAM WAGGONS

MODEL	CYLINDERS	CRANKCASE
Standard, Super, D.G.	Compounded 680 Or Compound Steam Cylinder Oil T	Sentinel Crankcase Oil
"S" Type	Compounded 1000	Sentinel Crankcase Oil

TRACTION ENGINES

TYPE	CYLINDERS	OIL POTS AND SLIDE LUBRICATORS
Showmans Road Locomotives Ploughing Engine, Agricultural Rollers (portable), Steam Wagons, other Sentinels	Refer to Cylinder Oil Selection Chart	Compound 220 (worsted wool) Golden Film 220 (cotton)

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Steam Cylinder & Bearing Oils

GLOSSARY OF TERMS USED ON MORRIS PRODUCT DATA SHEETS

VISCOSITY	The resistance to flow in a liquid. In oils it changes with temperature, increasing as temperature decreases i.e. it thickens as it cools. The units of viscosity used today are called Centistokes (cSt), and are usually measured in 40^{o}C or 100^{o}C.
ISO	International Standards Organisation
ISO NUMBER	This is a system of numbers usually used with industrial and hydraulic oils to indicate their viscosity. Each ISO number relates to the viscosity in Centistokes at 40 ^{o}C. Therefore, the higher the number the thicker the oil. This number is not an indication of quality, just viscosity.
SAE	Society of Automotive Engineers
SAE NUMBER	A scale used to indicate the rate of viscosity change with temperature. The higher the VI number, the less viscosity change there is over a range of temperatures. A high VI can be very advantageous for steam cylinder oils because they would retain their properties more at high temperatures.
FLASH POINT	The temperature at which vaporised petroleum fractions would ignite, this can be quoted as a closed flash point (air excluded) or an open flash point (exposed to air).
POUR POINT	The lowest temperature at which an oil will pour or flow when chilled under controlled conditions.
DEMULSIBILITY	A measure of the ability of an oil to separate from water.
ADDITIVES AND COMPOUNDS	Substances added to lubricating oils that modify or enhance their natural properties.
EXTREME PRESSURE	This usually refers to a gear oil containing additives to increase film strength. These EP additives are usually triggered by increasing temperatures in the oils.

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