



High performance Ester Based oils as a superior alternate to Mineral based oils

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ABSTRACT

Petroleum based mineral oils have been popularly used for manufacturing lubricants for industrial applications. However, due to concern of environmental pollution, the trend is to migrate to environment friendly and biodegradable lubricants by using vegetable oils and synthetic esters as these too can function as lubricants. This study covers our findings that substantial performance improvements on various applications can be achieved with ester based oils against mineral based oils.

Introduction

Metalworking particularly metal-cutting efficiency can be significantly increased if the cutting surface is cooled and lubricated. As faster and more powerful machine tools are developed, an increased proportion of metal cutting involves high metal removal rates, which in turn leads to elevated cutting temperatures. As cutting temperatures increase, the primary role of a cutting fluid is that to reduce heat and to provide improved lubricity. With the growing concern on improving productivity, efficiency and safety; quest for advance technology lubricants has increased over conventional mineral based oil. Industries are looking for a new type of cutting fluid to avoid recycling and disposal problems. The ultimate solution will be the use of biodegradable cutting fluids. There has been an increasing demand for environment friendly products suitable for use as lubricants.

Modern developments have led to an introduction of advanced ester based oils which have improved wettability, lubrication, high cooling power, rust inhibiting and detergency properties. Further they have the added attraction of being natural, non-toxic, biodegradable, relatively non-polluting and cheaper than synthetics.

In the present study an attempt has been made to introduce biodegradable eco-friendly Hobbing oils.

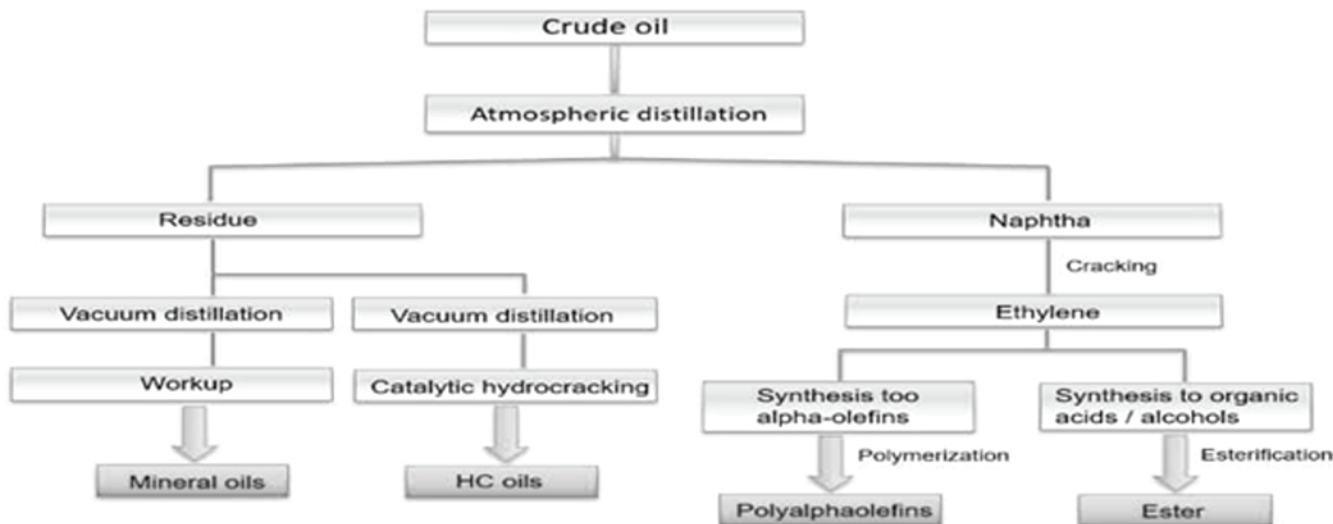
Base oils

Base oils are used to manufacture products including lubricating greases, motor oil and metal processing fluids. Different products require different compositions and properties in the oil. One of the most important factors is the liquid’s viscosity at various temperatures. Base oil is produced by means of refining crude oil. This means that crude oil is heated in order that various distillates can be separated from one another. During the heating process, light and heavy hydrocarbons are separated – the light ones can be refined to make petrol and other fuels, while the heavier ones are suitable for bitumen and base oils. Different type base oils & manufacturing process illustrated below.

Base oil Categories & Properties.

API BASE OIL CATEGORIES				
BASE OIL CATEGORY		Sulfur (%)	Saturates (%)	Viscosity Index
Mineral	Group I (solvent refined)	> 0.03	and/or < 90	80 to 120
	Group II (hydrotreated)	≤ 0.03	and > 90	80 to 120
	Group III (hydrocracked)	< 0.03	and > 90	> 120
Synthetic	Group IV	PAO Syntehtic Lubricants		
	Group V	All other base oils not included in the above groups		

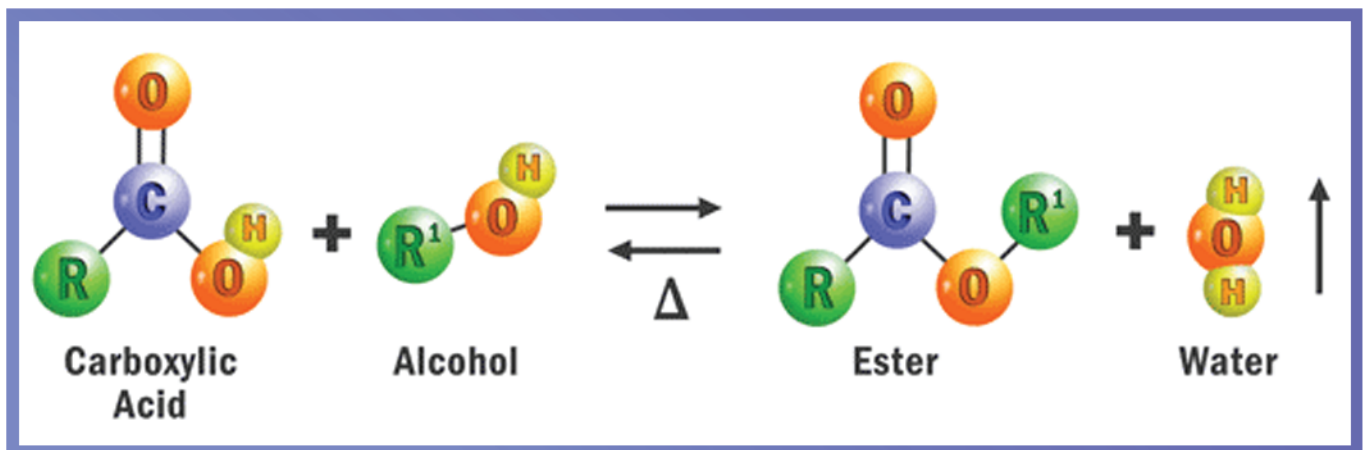
Different Base oil manufacturing process



Ester

Esters are derived from carboxylic acids. A carboxylic acid contains the -COOH group, and in an ester the hydrogen in this group is replaced by a hydrocarbon group of some kind. This could be an alkyl group like methyl or ethyl, or one containing a benzene ring like phenyl. In general, Esters used in lubricant formulations fall into one of two categories: either naturally produced triglycerides from vegetable or animal sources, or synthesized esters developed by combining acids and alcohols in a manufacturing process. Triglyceride esters do have a high viscosity index to minimize thinning at high temperatures, and they exhibit high lubricity

The lubricant industry generally treats synthetic esters as a monolithic class of Group V base oils with well-defined properties. It is not difficult to find a chart that lists esters as having “good” biodegradability, “very good” lubricity, and “excellent” oxidative stability and so on. However, the nature of esters defies such oversimplification. There are endless varieties of esters that can be built from commonly available acids and alcohols, so almost anything is possible.

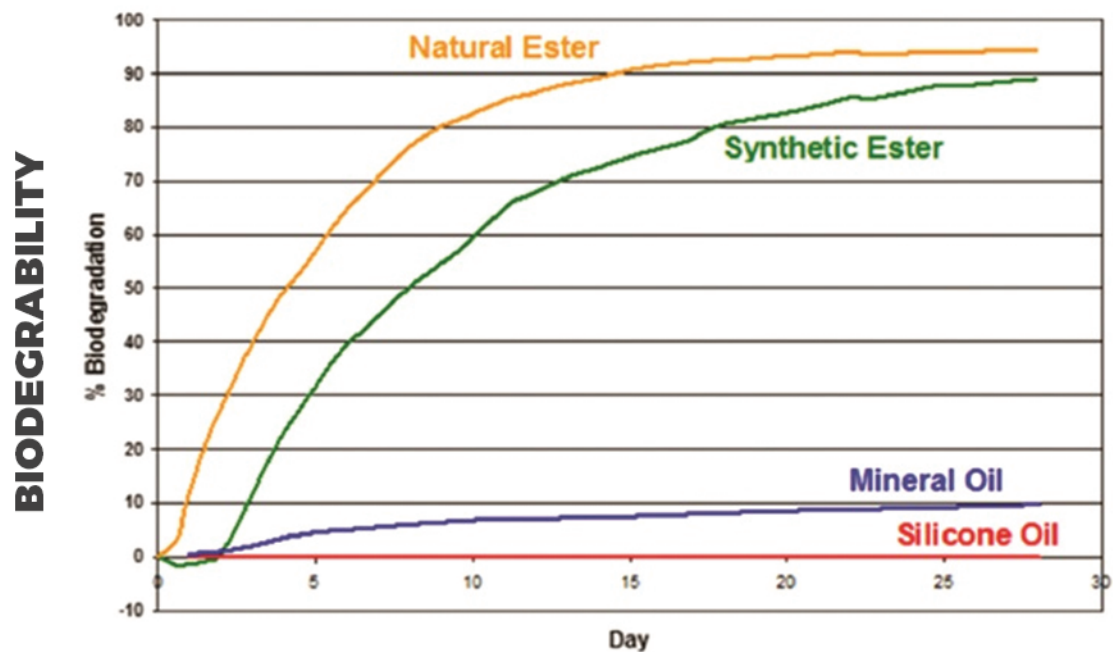


Modern synthetic esters can be “tuned” to perform in nearly any environment and application. Whether you seek excellent hydrolytic stability, oxidative stability, biodegradability, lubricity, high viscosity index or low-temperature properties, all of these are possible with the right synthetic ester.

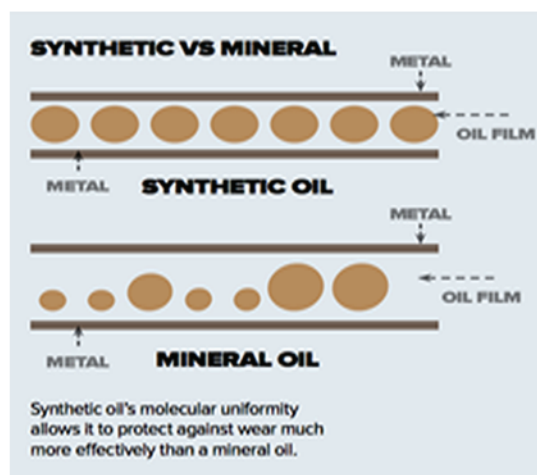
Properties of Ester Based oil

Characteristics	Mineral Based Oil	Ester Based oil
Lubricity	Good	Excellent
Flash Point	Less compare to Ester based	High
Viscosity index	Low	High
Low Temperature Properties	Poor	Excellent
Low Volatility	Poor	Excellent
EP Weld Load	Low	High

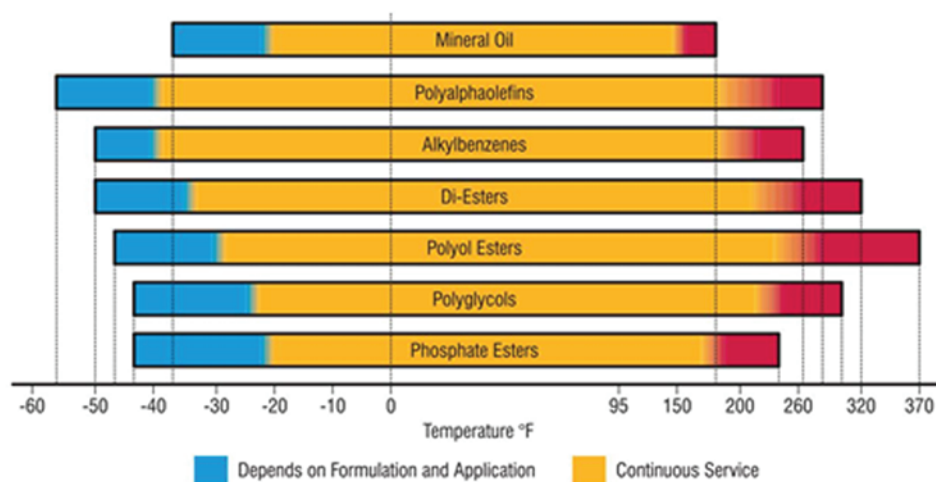
Advantages of Ester based Cutting oil



Lubricating Film Formation : Mineral Vs. Esters



Operating Temperature Range For Different Base Oils



Comparison over different Base oil

Base oil	VI	Pour point	Oxidation stability	Polarity
Hydro cracked	■■■■■	■■■■■	■■■■■	■■■■■
PAO	■■■■■	■■■■■	■■■■■	■■■■■
Ester	■■■■■	■■■■■	■■■■■	■■■■■

Hobbing

Hobbing is a machining process for gear cutting, cutting splines, and cutting sprockets on a Hobbing machine, which is a special type of milling machine. The teeth or splines of the gear are progressively cut into the material (a flat, cylindrical piece of metal) by a series of cuts made by a cutting tool called a hob. Compared to other gear forming processes it is relatively inexpensive but still quite accurate, thus it is used for a broad range of parts and quantities. It is the most widely used gear cutting process for creating spur and helical gears



Comparison Between Mineral Vs. Ester Based product

Parameters	Mineral Based Hobbing oil of 40 cSt.	Isocut E 35 (M)
Colour, Visual	Yellow	Yellow
Appearance	Hazy Liquid	Clear Liquid
Specific Gravity @ 30°C	0.875	0.92
K. Viscosity @ 40°C, cSt	40	42
Flash Point, COC, °C	180	238
Cu-cor. Test, 100°C for 3 hrs.	2	1b
EP Weld Load test, Kg	200	500

Key Features



Biodegradability & low toxicity



High viscosity index



Reduced friction & wear



High temperature stability



Low temperature flow ability



Low volatility



Clean burn properties



Reduced flammability



Excellent solvency properties





Better wetting characteristic





Seal compatibility to be checked



Input costs are higher but offer better overall cost economics

CASE STUDY : 1		
CUSTOMER	A supplier of essential machined forgings, shafts and engine valves to leading Two-Wheeler OEMS in India as well as to global markets	
TRIAL OBJECTIVE	1. Reduce the smoke 2. Reduce the mist formation 3. Reduce the overall cost	
APPLICATION/OPERATING DETAILS	1. Machine	Leibherr LC 350
	2. Tank capacity	350 Ltrs
	3. Component	Shaft
	4. Material	16Mncr5
	5. Operation	Hobbing
	6. Tool	Schnyder- Swiss carbide make
	7. Cycle time, Secs	25
	8. Filter	Magnetic Separator
	9. Existing Product	Mineral Based oil
MACHINE VIEW		
COMPONENT		
PRODUCT RECOMMENDED TRIAL RESULTS	ISOCUTE E 35 (M) ✓ No mist or smoke formations ✓ Operator Friendly - No EHS issues ✓ Achieved Good Finish as compare to earlier ✓ Improved tool Re-sharpening	

CASE STUDY : 2		
CUSTOMER	A Leading Multinational company involved in manufacturing of Helical Gear motors & Gearboxes, Precision inline Gear motors & Planetary right angle gearboxes	
TRIAL OBJECTIVE	<ol style="list-style-type: none">1. To reduce the stain marks in Components / Beds2. To ensure the better working environment by Reducing smoke3. Reduce the mist formation4. Reduce the overall cost	
APPLICATION/OPERATING DETAILS	a) Machine	Gleason Pfauter 600
	b) Tank capacity	500Ltrs
	c) Component	Planetary Gear –Spur Gears
	d) Material	20Mncr5
	e) Operation	Hobbing
	f) Tool	HSS – Alchrona /Futura Nano coating
	g) Cycle time, Secs	45
	h) Filter	Magnetic conveyor & Separator
	i) Existing Product	Mineral Based oil
MACHINE VIEW		
COMPONENT		

PRODUCT RECOMMENDED	ISOCUT E 35 (M)
TRIAL RESULTS	<ul style="list-style-type: none"> ✓ No mist or smoke formations ✓ Operator Friendly - No EHS issues ✓ Achieved Good Finish as compare to earlier ✓ Improved tool Re-sharpening ✓ Oil Cost Saving Achieved by 18%

Circular Saw Cutting



A circular saw is a power-saw using a toothed or abrasive disc or blade to cut different materials using a rotary motion spinning around an arbor. A hole saw and ring saw also use a rotary motion but are different from a circular saw.

Typically, the material to be cut is securely clamped or held in a vise, and the saw is advanced slowly across it. In variants such as the table saw, the saw is fixed and the material to be cut is slowly moved into the saw blade. As each tooth in the blade strikes the material, it makes a small chip. The teeth guide the chip out of the work piece, preventing it from binding the blade.

Characteristics

- Cutting is by teeth on the edge of a metal blade or by an abrasive wheel
- The cut has narrow kerf and relatively smooth surface finish
- Cuts are straight and relatively accurate
- The saw usually leaves burrs on the cut edge of metal and plastic (which should then be addressed with sand paper)
- Saw setting should be done geometrically



CASE STUDY : 3		
CUSTOMER	A Company in Eastern India manufacturing open and closed die forgings of carbon and alloy steel, micro alloy steel and stainless steel forgings which can be supplied in As Forged + Heat Treated + Machined and Fully assembled condition as per the customer's requirement	
TRIAL OBJECTIVE	1. To improve the blade life 2. Less smoke / sparks formations 3. To reduce cost	
APPLICATION/OPERATING DETAILS	a) Machine	Exactcut machine
	a) Tank capacity	5 Ltrs
	b) Component	Billet
	c) Material	Steel Grades - C 38
	d) Operation	Billet cutting
	e) Tool	Circular Saw – 50 Teeth
	f) Cycle time, Secs	90
	g) Spray Pressure	5 bar
	h) Cutting Speed	100 m/min
	i) Section Thickness	Ø 160 mm
	j) Existing Product	Ester Based oil
MACHINE VIEW		
COMPONENT		
PRODUCT RECOMMENDED	ISOCUTE 35 (M)	
TRIAL RESULTS	✓ No mist or smoke formations ✓ Operator Friendly- No EHS issues ✓ Improvement in blade life - 5% ✓ Oil Cost Saving Achieved by 10%	

Conclusion

- ▶ The ester based metalworking formulation will give enhanced performance.
- ▶ It is possible to use the formulated biodegradable oils commercially, which will eliminate the problems of disposal.
- ▶ Esters give good oxidation stability. The stability of the oil is not affected by controlled temperatures.
- ▶ Compare to mineral oil, ester base fluids gives better surface finish and improved tool life.
- ▶ Selection of proper lubricant will give better results, improvement in productivity & disposals properties.

Experimental Support:

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Dr. Castle Technology Centre