Republic of Iraq

Ministry of Higher Education

and Scientific Research

Al-Mustaqbal University College

Chemical Engineering and Petroleum Industries Department

Subject: Properties of Petroleum Fuels

3nd Class

Lecture four

LUBE BASE STOCKS

- Lubricants are required in machines to reduce friction and wear between moving parts.
- Lubricant base stocks make up a large portion of finished lubricants, from about 75 to 80 percent in automotive engine oils to 90 percent or more in some industrial oils.
- Thus, base stocks contribute significantly to the finished product properties.
- Base stock has a major impact on the viscosity, volatility, low temperature fluidity, solvency for additives and contaminants.
- Petroleum lubricating base stocks are made of a higher boiling portion of crude oil that remains after the removal of lighter hydrocarbons.
- Starting material for their manufacture is usually atmospheric residue boiling above 650°F.
- Careful selection of a base stock is key to formulating a quality finished lubricant.
- Base stock properties are related to base stock composition.
- Base stocks contain three types of hydrocarbon: paraffins, naphthenes. and aromatics.
- In the paraffin group,
- isoparaffins are the preferred type because they exhibit excellent oxidation stability. low volatility, and good viscosity characteristics.
- Normal paraffins, however, are not a desirable component because of their poor cold flow properties such as pour point, cold filter plug point (CFPP).
- Aromatics are good for the solvency of additives and contaminants but generally have poor oxidation stability and high volatility.
- Naphthenes also have good low temperature fluidity and oxidation stability.
- Sulfur and nitrogen are often present in combination with hydrocarbons in a base stock, particularly the aromatics.

The manufacture of lube base stocks from crude oil involves a series of steps aimed at the removal of certain undesirable components resulting in a base oil that meets the performance requirements of lubricating oils.

- There are two basic routes for making lube base stocks:
- the conventional process, consisting of
- solvent extraction,
- solvent dewaxing, and
- hydrofinishing, and
- the hydroprocessing route, consisting of
- lube hydrocracking,
- hydrodewaxing, and
- deephydrotreating.
- The hydrotreating route produces higher viscosity index (VI) lubes with superior quality but cannot produce high-viscosity lube base stocks.

CONVENTIONAL PROCESS

The conventional lube base stock manufacturing process consists of the following steps:

- Vacuum distillation of atmospheric resid to yield several distillate cuts and vacuum resid
- Propane deasphalting of vacuum residuum to yield bright stock and asphaltic pitch
- Solvent extraction of vacuum distillates and bright stock to remove aromatics and improve the viscosity index of lubricating oil base stock
- Solvent dewaxing of distillate cuts to yield slack wax and various lube cuts, which improves the cold flow properties such as pour point and cloud point of the lube base stock

• Hydrofinishing or clay treatment to improve color, oxidation stability, and thermal stability of lubricating oils

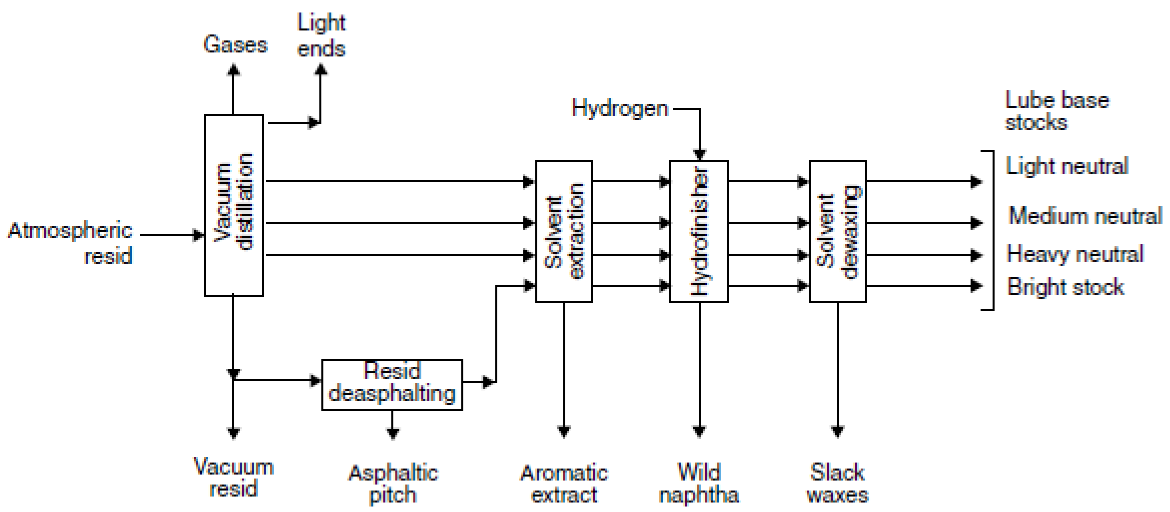

FIGURE 10-1 Conventional lube base stocks manufacture.

CLASSIFICATION OF LUBRICATING OILS

Lubricating oils and greases can be classified in many ways;

– by viscosity grades,
– by their additives package, or
– by their producers' brand names.
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- The most popular classification of lubes is according to their usage:

  - Engine oils (petrol and diesel engines, aircraft, marine engines)
  - Turbine oils
  - Gear oils
  - Compressor (refrigeration, air) oils
  - Quench oils used in metalworking
  - Cutting oils (in metal cutting)
  - Insulating oils used in transformer and circuit breakers
  - Hydraulic oils

- **CLASSIFICATION BY VISCOSITY**

Classification according to viscosity has been done by these professional societies and organizations:

- SAE (Society of Automotive Engineers. USA)
- API (American Petroleum Institute)
- AGMA (American Gear Manufacturers Association)
- NLGI (National Lubricating Grease Institute) .

CLASSIFICATION BY ADDITIVE TYPES

Lube oils may be classified by additive type as follows:

- Inhibited or RO (rust and oxidation inhibitor containing additives)
- Anti-wear (AW) containing lube oils
- Lubes with extreme pressure (EP) additives
- Compounded oils: containing 3 to 10 percent fatty or synthetic fatty oils
- Residual compounds

AUTOMOTIVE ENGINE OILS

- Viscosity is considered the most important single property of lubricating oils.
- Automotive crankcase and gear oils used in gasoline and diesel engine lubrication.
- The viscosity classification takes into account the temperature at which the oils are to be used.
- The SAE viscosity rating was based on average time

TABLE 11-3 Optimum Motor Oil Grades

SAE viscosity grade	Temperature conditions for use, °F	Recommendations for use
5W–30	<0	Provide excellent fuel economy and low-temperature performance.
10W–30	>0	Most frequently recommended viscosity grade for most automobile engines, including high-performance multivalve engines and turbocharged engines.
10W–40	<0	For greater protection against engine wear and oil breakdown from oxidation.
20W–50	>20	Maximum protection for high-performance, high r/min racing engines.
30	>40	For high temperatures and heavy loads, such as driving in the desert or towing a trailer at high speeds for long periods.

AUTOMOTIVE OIL ADDITIVES

– Viscosity index improvers
– Detergents
– Dispersants
– Anti-wear/Extreme pressure additives
– Friction modifiers
– Antioxidants/Corrosion inhibitors
– Rust and corrosion control additives
– Anti-foam agents

ENGINE OIL FORMULATION

- In an engine oil. o the base oil components may be 75 to 85 percent of the total formulated lube,

o and the remaining 15 to 25 percent may be different types of additives.

- Viscosity modifiers and detergent inhibitors are the most prominent additives.
- Other additives used in lube formulation are dispersants. AW/EP agents, oxidation inhibitors, antifoamants. rust inhibitors, and demulsifiers.
- Base oils of a required viscosity are obtained by blending different base stocks such as neutrals and bright stocks.

- The additives are added to the base oil to enhance its performance when used in various types of engines.
- The most important properties of a lubricating oil are its viscosity and alkali reserve (base number, or BN).
- In addition, many other properties of the oil affect the performance of the engine.
- Fuel quality significantly affects the kind of lubricating oil to be used.
  - For example, for a low-sulfur fuel such as natural gas. o little sulfur dioxide is formed during combustion.

  o In this case a lubricating oil with a low BN. 4 to 7. may be OK.

  - In case the fuel contains high sulfur. 0.5 to 5 percent, o a higher alkali reserve is required to prevent corrosion damage.

- For fuels containing 2 percent or more sulfur,
- The high water content can be reduced by efficient centrifuging, which can extend the life of lubricating oil.

TABLE 11-6 Typical Properties of Commercial Motor Oils

	1	2	3	4	5
SAE grade 20W–50					
Viscosity index	122	119	155	121	130
Flash point, °F	440	419	430	432	450
Pour point, °F	–15	–13	–25	–11	–15
Sulfated ash, Wt %	0.85	0.7	0.9	0.74	1
Zinc, Wt %	0.12	0.11	0.15	0.12	0.15
SAE grade 15W–40					
Viscosity index	134	136	135	146	140
Flash point, °F	415	421	399	410	420
Pour point, °F	–15	–27	–11	–25	–10
Sulfated ash, Wt %	1.3	1	0.9	1	0.99
Zinc, Wt %	0.14		0.14	0.13	0.13
SAE grade 15W–30					
Viscosity index	140	150	133	155	130
Flash point, °F	415	401	400	405	410
Pour point, °F	–33	–26	–31	–35	–26
Sulfated ash, Wt %	0.85	0.96	0.85	1	1.2
Zinc, Wt %	0.12	0.11	0.13	0.15	0.2

TABLE 11-5 Commercial Lubricating Oil Characteristics

SAE viscosity grade		15W–40	10W–30
API service classification	Diesel	CH-4, CG-4, CF-4, CF-2, CF	CG-4, CF-4, CF
	Gasoline	SJ	SH
API gravity		27.9	28.9
Specific gravity		0.8877	0.8822
Flash point	°C	218	210
Pour point	°C	–33	–33
Viscosity at °C			
–15	cP	3000	
–20	cP		2840
–25	cP	25,000	
–30	cP		19,500
40	cSt	120.7	73
100	cSt	15.5	11.0
High-temperature/high-shear viscosity	cP, 150°C	4.4	3.4
Viscosity index		134	141
Zinc	Wt %	0.142	0.142
Nitrogen	Wt %	0.124	0.113
Sulfate ash	Wt %	1.4	1.4
TBN	mg KOH/g	12.2	11.8

SYNTHETIC LUBRICANTS

- Synthetic lubricants were developed more than 50 years ago and became widely used in jet engines.
- Lower than -120°F operating temperatures, 60.000 r/min shaft speed, and 500°F+ exhaust temperatures proved too much for conventional lubes.
- Synthetic lubes were created specifically for these harsh operating conditions, and at present every jet engine in the world uses synthetic lubricants.
- A synthetic lubricant base stock is a product made from a chemical reaction of two or more simple chemical compounds.
- These base stocks are manufactured to meet specific physical and chemical characteristics not found in petroleum lubricant base stocks.
- This base stock is then used to formulate lubricants by the addition of performance additives.
- Some of the most common synthetic lubricants are as follows:

  - Polymerized alpha olefins, olefin polymers, olefin oligomers
  - Dibasic acid esters
  - Polyols esters
  - Polyalkaylene glycol ethers
  - Phosphate esters
  - Alkylated benzenes, a synthetic hydrocarbon
  - Silicons
- Their viscosity indexes and flash points are higher, however, and their pour points are considerably lower.

The following performance features are claimed for synthetic lubricants over mineral oil lubes:

• Engine cleanliness
• Improved fuel economy
• Lower oil consumption
• Good low temperature (cold starting) fluidity

  • Outstanding performance in extended oil drain intervals
  • Superior high-temperature oxidation resistance
  • Excellent wear protection

The main disadvantage of synthetics is that they are

– inherently more expensive than mineral oil and
– available in limited supply.

• This limits their use only to specialty oils and greases that command a premium price.
• Esters suffer the further disadvantage of