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Lube Oil

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Report Abstract
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Nexant

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INTRODUCTION

Lubricant base oil, mineral oil or "lube oil" refers to a mixture of components originating from crude oil and partial or fully synthetic fluids originating in an oil refinery that combine to form a class of pale-colored and generally odorless liquids. Typically the boiling range of lube oil is between 300 to 800 °C. The hydrocarbons that are found in lubricant base oils generally consist of paraffins, isoparaffins, naphthenes, and aromatics.

Finished lubricants are a blend of base oils and additives. Base oils are the majority constituent of lubricants, generally accounting for around 90 percent of lubricant formulations by volume, with the remainder being additives used to enhance the lubricant's physical properties.

The fundamental function of a lubricant is to reduce the friction and wear associated between moving parts. There are literally thousands of lubricant formulations serving all manner of commercial (e.g., motor oil) and specialty (e.g., transformer oil) applications. Lubricants are classified into two major groups, automotive and industrial. The majority of commercial applications consist of internal combustion engines, vehicle and industrial gearboxes, compressors, turbines, and hydraulic systems.

Base oils are marketed based on the American Petroleum Institute (API)'s grouping system, which differentiates base oils based on representative environmental and performance properties. API's grouping system is globally recognized and employed:

Table 1 API Base Oil Groups

Group	Saturates Content, Weight %	Sulfur Content, Weight %	Viscosity Index
I	<90 and/or	> 0.03	80-119
II	≥ 90 and	≤ 0.03	80-119
III	≥ 90 and	≤ 0.03	≥ 120
IV	Poly-*alpha*-olefins		
V	Base oils not included in above		

A key and on-going business development in the lube oil industry have centered on the sale or shutdown of Group I base oil plants, as increasingly stringent environmental and performance standards have reduced the demand for Group I base oils in most parts of the world. Over the last decade, most of the major industry developments have been regional in nature. More significant industry-wide business developments occurred in the late-1990s, which was marked by substantial merger and acquisition activity among the oil majors. Business developments regarding mergers and acquisitions that have occurred recently are outlined in the report.

Commercial and developing technologies, process economics for production of various lube oils, global overview of the commercial market, and an outline of strategic considerations are discussed in the report.

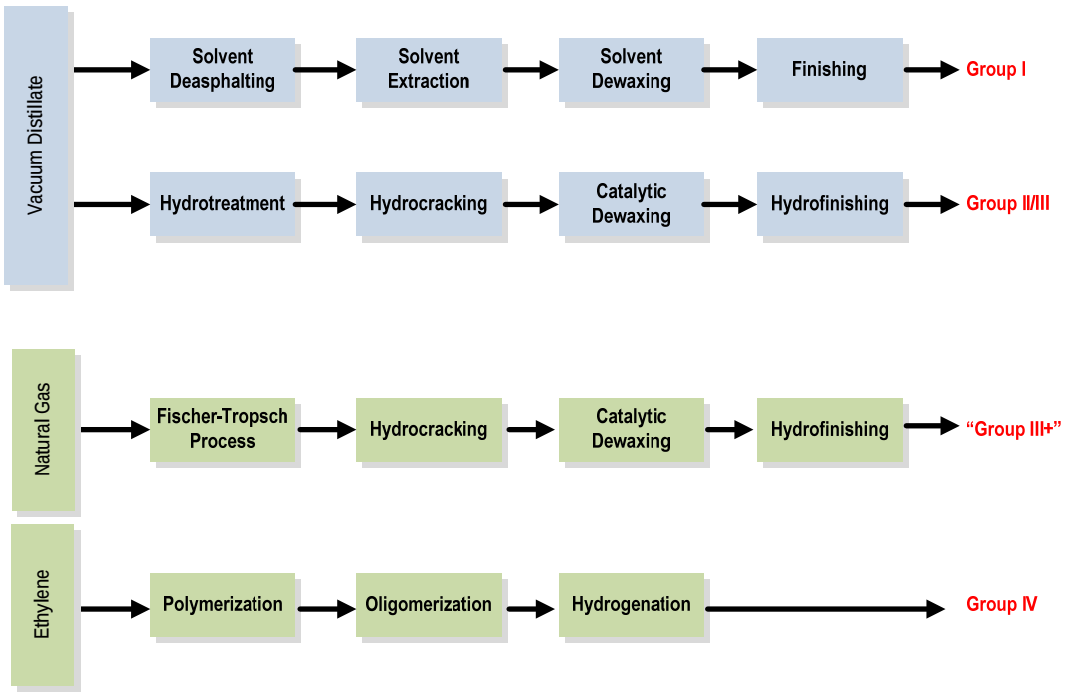
COMMERCIAL TECHNOLOGY

From a technical perspective, Nexant's report focuses on how synthetically-made base oils (namely polyalphaolefins and base oils from gas-to-liquids) compare to conventional base oils made from crude oil. In particular, traditional versus synthetic base oils have been evaluated in light of natural gas prices becoming increasingly more favorable relative to crude oil prices, which has made gas-to-liquids (GTL)-based high quality base oils increasingly attractive.

Numerous traditional methods of producing base oils of varying quality from crude oil have been profiled in this report. These generally consist of upgrading various streams in a refinery, followed by polishing, hydrogenating, and/or extraction to yield favorable lubricating properties. Nexant has provided representative economics for these processes, and has compared GTL-sourced Fischer-Tropsch liquids as well as PAOs as alternates to these various streams.

A high level overview of representative process flows to produce the base oil grades for Groups I-IV is presented below

Figure 0 Common Routes for Base Oil Production



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Not all producers utilize every step in each of the process flows to produce their desired base oil and, further, certain steps in one process may be combined with steps in another process to yield "hybrid processes."

The decision regarding which route to utilize is generally dependent on the desired quality of the base oil, its production cost and its ultimate disposition. An in-depth coverage of current

commercial technologies is given, with particular focus on the following four technology families:

- Traditional Oil Refining
- Hydroprocessing
- Gas-to-Liquids (GTL) production
- Poly-*alpha*-olefin (PAO) production

In lube oil manufacturing, there are generally no licensed technologies that cover the entire manufacturing process, although Chevron Lummus Global does license an all-hydroprocessing technology package. For the most part, companies will license individual sub-processes. Major technology licensors in the lube oil industry are discussed in the report.

DEVELOPING TECHNOLOGY

A review of recent patents dating back to 2006 indicates that noteworthy developments in base oil production technology have focused on "green" base oils. Research and development into bio-based base oil has been a focal point of a number of major lube oil manufacturers. Technologies of three of the more promising companies in the bio-lubricant area (Elevance, Solazyme and Amyris) are outlined.

Other noteworthy developments have been focused around the continuing improvement and compatibility of GTL-based lube oils. For instance, Chevron was awarded a patent for its process that provides a means for the hydroisomerization, dewaxing and hydrofinishing of a Fischer-Tropsch derived wax. In addition, Shell was awarded a patent for its process that prepares high quality base oil from a mixture of crude-derived and Fischer-Tropsch-derived feedstocks.

PROCESS ECONOMICS

Nexant assessed the margin for base oils based on the key reference price for the base oil grade and that of the base oil feedstock, which are vacuum gas oil or hydrocracker bottoms in the case of Group III base oil production.

- Conventional Lube Base Oil Cost of Production

  Base oil production in refineries can vary depending on available suitable feeds that can be treated to improve lubricant properties. A typical cost for manufacture of Group II or Group III lube oil from hydrocracker bottoms streams has been evaluated.

- GTL Cost of Production

  The production of starting gasoil range feedstocks via "Gas-To-Liquids" processes that produce the proper molecular weight Fischer-Tropsch liquids from syngas (mixtures of CO and H_2) is commonly referred to as the GTL process. The use of these synthetic GTL liquids in place of conventional petroleum derived streams is increasingly important, as the price of crude oil continues to rise faster than the price of natural gas. Costs of production estimates via Shell and ExxonMobil processes have been evaluated.

- PAO Cost of Production

  Poly-*alpha*-olefins (PAO) are oligomers of alpha olefins, most commonly decene-1, which is one of a range of alpha-olefins that is produced in the polymerization of ethylene. Alpha olefins can also be extracted as a byproduct of the syngas-based GTL process. PAO synthetic lubes are normally categorized as high quality Group IV base oils. PAOs generally need no additional polishing, purification or separation to yield a viable lubricant. Costs of production estimates for PAO via conventional decene, and also via GTL derived decene are provided.

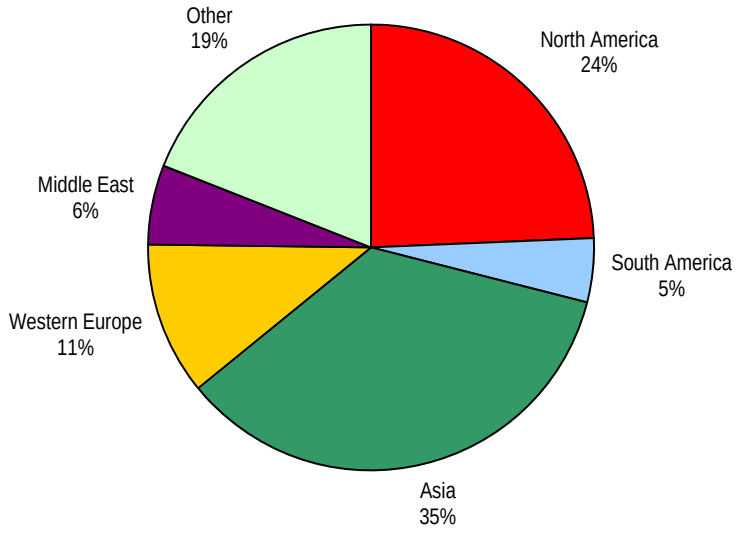
All cost tables given in this report include a breakdown of the cost of production in terms of raw materials, utilities, and direct and allocated fixed costs. These categories are presented annually by unit consumption and per metric ton. The contribution of depreciation is also included to arrive at a cost estimate.

COMMERCIAL MARKET REVIEW

Finished lubricants are vital to the operation of machinery and other mechanical devices, and thus their use is widespread. Global demand for finished lubricant is expected to exhibit slow growth through 2025, with a major focus being on quality improvement.

- Global demand, supply, and net trade data are provided and discussed, including an outline of the key drivers of finished lubricant demand and quality.

Figure 2 Global Base Oil Production Capacity By Region, 2012
(Percent)



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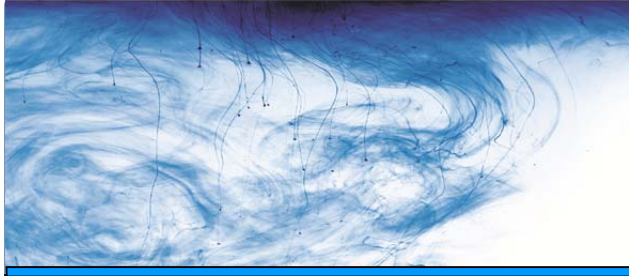

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