Synthetic Automotive Engine Oils--A Brief History

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The story of synthetics development is peppered with war, frigid cold, and variable commercial success.

The synthetic automotive engine oils of today had their start many decades ago, perhaps as early as in the last century. And it seems that since the beginning, the compounds have generated controversy. Some of it has been positive: Many companies claim to have been the first with such-and-such a development, for instance. And some has been less flattering: Witness the emergent challenge to even the definition of “synthetic.”

In this article, we examine the history of the compounds traditionally considered to be synthetic lubricants and offer some insights into their former, current, and future role in the automotive engine oil market.

Initial Research and Development in the United States

Although the first “synthetic” hydrocarbons are believed to have been synthesized by C. Friedel and J.M. Crafts in 1877, the first attempt at commercial development of synthetic hydrocarbons did not occur until 1929, by Standard Oil of Indiana. These results were reported later, acknowledging that many gallons of synthetic oil had been made by polymerizing different olefins. However, there was no demand for these new synthetic oils because of their high costs, and this initial attempt failed.

During the same time frame, other types of synthetic oils were also being investigated. One such type, a water-insoluble polyalkylene glycol (PAG), was being developed by Union Carbide and Carbon Corp. H.R. Fife of the Mellon Institute of Industrial Research carried out the original work in the 1930s. Later, these research efforts were augmented by development activities of the Carbide and Carbon Corp. and Linde Air Products Co. It was readily recognized that these synthetic oils, referred to as Ucon LB Lubricants, were inherently more expensive to produce than the best petroleum oils being marketed at that time. Although these synthetic oils possessed special qualities--such as excellent low-temperature fluidity, desirable viscosity-temperature relationships, reduced carbon formation tendencies, and good solvency--Union Carbide and Carbon Corp. realized that the high production costs could eventually become market barriers for their synthetic oils.

Extensive field tests of these PAG engine oils in fleets of new, older, and commercial vehicles were conducted starting as early as 1942 and continued into the mid-1940s. The results indicated the PAG engine oils performed extremely well. However, one shortcoming of the PAG engine oils revealed during testing was their ability to absorb water (about 3%-4% at room temperature). This water tolerance resulted in a tendency for rusting and corrosion on oil-wetted surfaces when engines were exposed to high humidity.

Some limited testing was conducted in diesel engines, but ring sticking and piston deposits indicated the need for additional research. A number of U.S. Army aircraft operating in Canada and Alaska were lubricated with the PAG engine oils through the summer of 1944 and accumulated more than 150,000 hours with no problems.

The German Contribution

The synthesis of petroleum substitutes from carbon monoxide and hydrogen by means of the Fischer-Tropsch process was commercialized in Germany by 1939. Germany realized early on that supplies of crude oil would become a major problem in operating its war machine during World War II. So the country expended a considerable amount of technical effort to develop its own synthetic fuels and lubricants industry.
From this industry, which was based on coal gasification technology, three processes became commercialized, producing about 10% of the German supply of lubricating oil. One process produced lubricating oils by polymerization of cracked waxes, another by reacting chlorinated Fischer-Tropsch middle oils with naphthalene, and the third by the synthesis and then polymerization of ethylene. Additionally, Germany was able to produce a synthetic bright stock by the condensation of paraffin with olefins and subsequent ethylene polymerization. Germany also developed special engine oils for operation on the Russian front because of the extremely low prevailing temperatures. These oils were blends of light synthetic oils with adipic acid ester, giving the resultant blended oils very low pour points and high viscosity indexes.

Impact of the Turbine Engine

After the war, development of PAG engine oils continued. National Carbide Company Inc. marketed its first commercial PAG engine oils--Prestone Motor Oil--in two areas in the East during the winter of 1946. The geographical area selected and short duration of marketing were due to limited production capabilities. Concurrently, the New York Power and Light Corp. had been conducting extensive fleet testing using PAG engine oils in a variety of commercial vehicles, tractors, and trucks that eventually accumulated some 605,000 miles without experiencing problems. Because of the limited production capabilities and higher costs, the emergence of the gas turbine engine and its demand for more thermally stable engine oils terminated further consideration of PAG oils for automotive engine applications.

Diester oils (that is, dibasic acid esters) became the focus in the late 1940s and early 1950s, as petroleum-based engine oils were simply inadequate to meet the demands of turbine engines. High- and low-temperature operability, low basestock volatility for controlling oil consumption, and resistance to thermal and oxidative degradation were all prerequisites for these engines.

The turbine-powered aircraft provided the need for synthetic-based engine oils, and the diester oils satisfied this initial requirement. As the operating temperatures increased with newer and advanced turbine engines, hindered neopentyl or polyol esters came into use; these compounds possessed good thermal and mechanical stability. These synthetic oils had fully demonstrated their superior performance over petroleum-based oils in the aircraft turbine engine. Their demonstrated performance qualities (higher operating temperatures, fluidity at very low temperatures, reduced oil consumption, reduced carbon deposits, etc.) were all viewed as potential technological opportunities that could certainly become benefits for automotive engine oils.

The Emerging Passenger Car Market

As the commercial availability of these diester and polyol ester basestocks had been established for the aircraft turbine engine industry and was growing, oil formulators began to experiment with using these for automotive engine applications. At the same time, production capability was evolving for polyalphaolefins (PAOs), which had actually been synthesized in 1937. Created by polymerizing long-chained olefins, these PAOs were being viewed as possible basestock components for automotive engine oil applications.

Apart from the improved low-temperature starting benefit that would be realized with a synthetic automotive engine oil, other such potential benefits quickly came to the forefront. These benefits included extended drain intervals, increased fuel economy, reduced engine wear, cooler-running engines due to less friction, all-season oil applications, higher operating temperatures, and cleaner engines due to the lower levels of deposit formation. The extended drain interval quality perhaps took on the most importance and provided the key selling point for these oils.

Army’s Experience and Contributions

During the 1960s, the U.S. Army had been experiencing significant problems in operating vehicles and equipment in Alaska in using its MIL-L-10295 Lubricating Oil, Internal Combustion Engine, Sub-Zero (OES). This was a petroleum-based engine oil that produced unsatisfactory performance in a variety of engine systems, particularly in the two-stroke diesel engines manufactured by Detroit Diesel that have sensitivity to lubricant volatility. These engine systems powered a large number of both wheeled and tracked vehicles.
Recognizing the problem to be one related to basestock volatility, the Army initiated a program to develop engine oils for both gasoline- and diesel-fueled ground vehicles and equipment required to operate in cold-temperature environments and year-round. Working closely with industry, the Army subsequently completed engine dynamometer, transmission, and field tests of three types of synthetic-based oils that eventually became qualified and part of a purchase description called “Aberdeen Proving Ground Purchase Description Number 1 (Lubricating Oil, Internal Combustion Engine, Arctic),” issued in 1968. The products qualified under this purchase description included three types of synthetic base products. One qualified product was formulated using an alkylated aromatic oligomer. Another product was qualified using a diester. And the third qualified product was formulated using an olefin oligomer, or PAO. This purchase description was converted to the military specification MIL-L-46167 (Lubricating Oil, Internal Combustion Engine, Arctic) in the early 1970s.

These synthetic oils, which all passed the necessary sequence and component testing initially called out in the purchase description and later the military specification, were quickly “adopted” by the commercial operators in Alaska once the oil was introduced into the military supply system. As a result of later successful field demonstrations at four U.S. Army military installations, use of this class of lubricant spread in the mid-1980s to “outside arctic” use in the northern-tier states and in the higher elevations of the U.S. Because of this, the Army is recognized for leading the introduction of synthetic oils for automotive engine and powertrain applications.

The Push in the ‘70s and ‘80s

The 1970s brought a new momentum to synthetic engine oils for application in both passenger car and commercial vehicles. This may have been due in part to the Arab oil embargo, which resulted in many new synthetic engine oils being introduced. All of these claimed to provide extended drain or “lubrication for life” benefits, and improved fuel economy, clearly brought into focus because of long lines at service stations. Some companies also promoted use of these synthetic oils because of their not being dependent upon crude oil resources. At the same time, the successful application of synthetic engine oils by the U.S. Army in Alaska led to synthetic engine oils being exclusively used during the construction of the Alaskan pipeline system.

The successful penetration of synthetic engine oils was temporarily curtailed as a result of action taken by the automotive industry in the late 1970s. Questioning the quality of synthetic-based engine oils as well as the claims that were being made about them, the automobile manufacturers included statements in their owner’s manuals warning that using synthetic oils would not justify extended drain intervals and that engine warranties could be impacted. Since the extended drain benefit was the largest drawing card for synthetics and served to offset their higher costs, consumer interest in synthetic engine oils declined during the late 1970s.

During this temporary lull in the U.S., Europe began to take the initiative. Oil marketers saw the opportunity to increase their profits by selling synthetic automotive engine oils there, and the European automobile manufacturers pushed the higher performance qualities of synthetics rather than extended drains. This apparently did accelerate the development of the synthetic engine oil market in Europe, which has sustained itself to the present time.

A resurgence of activity in synthetic engine oils has since returned to the U.S. This is in part due to the declining price of synthetic basestocks, the fact that synthetics have gained legitimacy, and the increasing performance requirements for automotive engine oils (e.g., higher engine operating temperatures, increased emission regulations).

Past Problems and Solutions

Many problems confronted synthetic engine oil formulators, ranging from additive package incompatibility to high oil consumption and oil filter deterioration. The additive package problem was perhaps the most troublesome to resolve. Individual additives within an additive package depend upon the composition of the basestock, which affects both solubility and additive responsiveness. Formulators learned early on that additive packages that responded well in petroleum basestocks did not necessarily work as effectively in the different synthetic base oils. PAOs were found to exhibit excellent additive response, but were poor additive solvents. Diesters, on the other hand, were found to vary in additive
response but were excellent solvents, except for those additives with which they reacted to form precipitates.

High oil consumption became a real problem with the early PAO-based products, as the formulations caused slight shrinking effects on the engine seals. This in turn caused oil to migrate past the seals; the lower viscosity of these synthetic oils further exacerbated the problem. This was later corrected by incorporating a diester component into the basestock, which provided positive seal swell and improved the additives’ solubility in the base oil.

Oil filter deterioration also initially created problems. Because of the increased solvency of some of the synthetic oils, the adhesives binding the end caps, as well as the phenolic resin treatment on the conventional pleated paper filters, became affected, resulting in filter leakage or bypassing of oil directly to the engine. These problems were subsequently remedied by improving filter construction and going to more efficient depth-type filters.

New Kid on the Block

Although the field of synthetic engine oils had principally been led by the PAOs and to a lesser degree the diester base oils, a new base oil emerging in the mid-1990s began to compete with established market: the very high viscosity index, or hydrosomizer, base oils. Since the introduction of these base oils, there has been much controversy as to whether engine oils formulated with the hydrosomerized base oils can be considered synthetic. In April 1999, a ruling by the National Advertising Division of the Council of Better Business Bureaus allowed engine oils formulated with hydrosomerized base oils to be classified as “synthetic oils.” (See LW’s two-part series, “A Defining Moment for Synthetics,” October and November 1999.)

The Future

Synthetic-based engine oils have continued to grow during the past decade and many expect a continued increase in automotive applications of these products. Almost every oil company now carries a premium-type synthetic-based engine oil in its product line. Moreover, many automobile manufacturers are now specifying synthetic oils for not only engine crankcases, but also transmissions, differentials, and transaxles.

Bibliography
The following sources were used in developing this article: