PETROLEUM-REFINERY TECHNOLOGY

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In 1932 the petroleum-refining industry of the United States, like other industries, experienced severe distress caused by decreased demand coupled with inability to regulate supply to market demand, which resulted in low prices for products. Despite this unfavorable condition important engineering and technologic advances were made, and improved products were placed on the market.

In the following paragraphs the changed status of petroleum refining during the past few years is given in brief résumé. A few years ago steadily increasing demand taxed the capacity of refineries in the United States in spite of continued enlargements of plant equipment. Since then a major portion of the export trade in petroleum products has been lost to United States refiners, who formerly supplied the major portion of the world demand for some products, for example, lubricating oils. Domestic demand also has been reduced, temporarily at least, and refiners in the United States now have facilities ample to supply current demand, both domestic and foreign, for refined products without drawing on stocks of finished products.

The changed situation of petroleum refining in the United States also is shown by the fact that consumers now are more critical of the quality of petroleum products and are better informed as to the essential properties of the various products than they were in the past. There is an unmistakable trend toward rationality in referring to the properties of petroleum products. This change has been due almost entirely to efforts within the petroleum industry and not to consumers' efforts. Consumers generally have done little to educate themselves on the essential properties of petroleum products; such education as has come to them has been urged upon their attention by the petroleum industry.

The change in requirements for automobile gasoline constitutes an outstanding example of results obtained from a basic cooperative investigation. The fact that the essential properties of fuels for automotive equipment are understood much more clearly and generally than formerly is due largely to cooperative work by the petroleum industry, the automotive industry, and the Federal Government in the Cooperative Fuel Research project (C.F.R.). The work of the C.F.R. on distillation range and vapor pressure of gasoline recently has been augmented by the adoption of a method for determination of octane number ("antiknock" rating) as a tentative standard method of the American Society for Testing Materials. Although this cooperative project began as an investigation of motor fuels to improve motor performance, tests of the C.F.R. have shown definitely
that many troubles were due to inherent faults in the construction of automobiles and could be eliminated more easily and satisfactorily by changes in automobile design than by changes in properties of motor fuels.

Another example of cooperation is the commercial standard for fuel oil. This standard was developed cooperatively by manufacturing and consuming interests, the Bureau of Standards acting as a coordinating agency, for the purpose of unifying consumer demands for fuel oils and correcting an undesirable condition of ambiguity and emphasis on nonessentials in fuel-oil requirements. An important research now in progress is the cooperative study of Diesel fuel oils by the American Society for Testing Materials, the American Society of Mechanical Engineers, and the Society of Automotive Engineers, assisted by the research laboratories of oil companies, engine builders, engineering colleges, and the Federal Government. This research has a similar object to the C.F.R. research, although the technical problems are somewhat more involved.

Similar cooperative effort would bring forth needed information on the essential properties of other petroleum products, such as automotive lubricating oils, turbine oils, and electric-insulating oils. These products are used in large quantities without definite knowledge of the influence of inherent properties on the quality of the service obtained from them.

As a result of technologic developments obsolete refining equipment in the United States has been replaced by equipment that yields better products at lower cost. These changes in refining practice have increased the difficulties of poorly equipped refiners who operate under high production costs in markets where the supply equals or exceeds the demand.

The following paragraphs refer briefly to some of the outstanding new installations, new processes, and new products that have been announced during the past year; these give a general idea of the range and variety of technologic progress that has been made.

A partial list of refinery-construction jobs completed in 1932, or in progress, was published in the Oil and Gas Journal for September 29, 1932, page 17. This list shows the enormous amount of modernization undertaken at refineries in the United States during severe business depression.

All phases of refinery operation have been modernized, but results have been particularly significant in the following: (1) Remodeling older installations; (2) building new cracking plants, especially combination plants for skimming, cracking, and reforming; (3) vapor recovery and stabilizing plants; (4) improvements in the manufacture of lubricating oils; (5) installations for better utilization of heat; and (6) improvements in minor details of refinery operation, making for better over-all efficiency of the plants.

Cracking plants built only a few years ago have been rendered technologically obsolete. Refiners have been confronted with the alternative of junking the plants or modernizing them. It has been possible and economical to remodel many plants to increase throughput, improve the quality of products, obtain a better utilization of heat, and reduce manufacturing costs.

Modernization of cracking plants has not increased production enough to supply the demand for cracked gasoline, and a considerable
increase in cracking capacity has been attained by the construction of new plants. Many of these plants have embodied significant improvements in design and construction. For example, a cracking plant with a throughput capacity of 9,000 barrels daily which was installed in 1932 in an eastern seaboard refinery, includes a bubble tower 12 feet in diameter and 93 feet in length which was completely shop-welded; all seams were X-rayed, and the entire tower was stress annealed. This installation is an example of the progress that has been made in the fabrication of large vessels to operate under high pressures and temperatures and is in marked contrast to the type of construction formerly used that was hazardous under less severe conditions of pressure and temperature.

A single cracking unit with a capacity of 10,000 barrels per day was installed in a California refinery in 1932. The furnace is designed for a heat absorption of 50,000,000 B.t.u. per hour, 85 percent of which are transferred in the radiant-heat section. Tubes in the cracking furnace are 4½ inches in outside diameter with a wall thickness of 0.4 inch made possible by the use of K245 alloy (a low-carbon, nickel-chromium steel). Contemporary metallurgical developments have provided the necessary materials to make much of the modern refinery equipment possible.

A combination skimming, re-forming, and cracking plant with a throughput capacity of 20,000 barrels of crude oil per day was installed at an Indiana refinery. The plant is reported to be capable of converting 20,000 barrels of crude oil daily into 70 percent gasoline with an octane number of 70, leaving byproducts consisting only of refinery gas and fuel oil having a viscosity of approximately 150 to 200 seconds Saybolt Furol at 122° F. Coke formation is said to be almost negligible. This large recovery of high-octane gasoline illustrates the progress that has been made in adapting gasoline production to modern demands. The normal octane number of average Mid-Continent straight-run gasoline is approximately 50 and raising the octane number to 70 materially increases the price at which the gasoline can be sold.

Refiners in the Pennsylvania district have found it advantageous to install cracking and re-forming plants to produce gasoline with high octane numbers from their straight-run gasoline, naphthas, kerosene, gas oil, and other fractions of the crude oil to impart a greater degree of flexibility to their refinery operations, thus enabling them to adjust manufacture of products in their plants to market demands.

The increased use of cracking processes, the re-forming of straight-run gasoline, and the necessity for lowering vapor pressures of refinery products have had an important bearing upon the great development that has taken place in another phase of refinery operation, namely, gas-absorption and stabilizing plants. Moreover, the severe requirements of present gasoline specifications necessitate the utmost operating flexibility and thorough stabilization of products. In consequence, combination stabilizing units and vapor-recovery systems, have been installed in a number of refineries. One such unit is reported to recover 45,000 gallons of gasoline per day from refinery gases.

In refineries where the plant gases contain large proportions of hydrogen sulphide and other sulphur compounds, it is desirable to treat the gases to minimize corrosion of equipment used for the
recovery of gasoline from the gases. One such plant, in a Gulf coast refinery which treats approximately 9,000,000 cubic feet of refinery gas daily, is reported to remove an average of 14 tons of hydrogen sulphide per day from the gases. This gas is treated only to the point that serious corrosion of recovery equipment does not occur. After being stripped of its gasoline content the gas is burned as fuel in the refinery. The hydrogen sulphide is liberated at one stage of the purification process and blown into the atmosphere.

Burning refinery gas under stills, however, is not justified if more economic outlets are available. Better methods of using it are being found, either as fuel in public-service corporation lines or as raw material for the production of chemical products.

A method of utilizing refinery gases is illustrated by a plan for supplying gas from three petroleum refineries in the Chicago district to a public-service corporation. The purification plant for processing this gas completely frees it of hydrogen sulphide. The capacity of the purification plant is 3,000,000 cubic feet per day, and the gas is supplied to service mains at 1,000 B.t.u. per cubic foot, equivalent in heating value to natural gas from the fields and almost twice the B.t.u. content of "producer gas".

A method based upon the use of a solution of lime and salt in water as an absorption medium for scrubbing gases to remove hydrogen sulphide prior to the extraction of gasoline is described by Rue.1

Other methods, most of them patented, are being used. These include the caustic soda and triethanolamine processes.

The use of ammonia in combating corrosion of refinery equipment has increased due to the decrease in price and availability of anhydrous liquid ammonia. The ammonia usually neutralizes hydrochloric acid that results from the decomposition of metallic chlorides during the distillation process.

At a new refinery in Michigan the crude oil is treated for removal of sulphur by mixing it with a treating compound before the oil enters a heat exchanger, and vapors from the crude oil are contacted again with chemicals in a treating tower in which the vapors pass upward countercurrent to the chemical mixture.

A vacuum pipe still for redistilling heavy naphtha is an interesting example of economy in operation. A Texas refinery has installed a plant with a capacity of 7,000 barrels of heavy naphtha per day. The plant operates with an absolute pressure of approximately 53 mm of mercury at the dry line (beyond the partial condenser) and 60 mm at the base of the column. It is stated that the steam requirement is approximately 20 to 25 percent of that necessary for steam distillation at atmospheric pressure. The maximum temperature of the oil in the column is said to be 275° F., and the end point of the overhead product is approximately 400° F.

New processes for treating light distillates that have been developed recently include the Lachman process, which employs aqueous solutions of metallic chlorides, typically zinc chloride, and the brucite (magnesium hydroxide) process. Both processes are used for treatment of light distillates in the production of motor fuels. The zinc chloride process, developed in California, has been adopted in refiner-

ies in other areas. The brucite process, developed in Oklahoma, was announced in 1932.

The most interesting new products are those developed in connection with the beneficiation of lubricating distillates by the use of selective solvents. The following solvents are employed in processes announced recently: (1) Benzoil in liquid sulphur dioxide, (2) nitrobenzene, (3) dichlorethyl ether, and (4) phenol. These processes are designed to improve the viscosity-temperature characteristics and the thermal stability of oils. The processes usually are covered by patents.

Development of the hydrogenation process on a plant scale in the United States has been in the hands of one company and its subsidiaries. Such general information as is available indicates that development has been steady, and the process apparently has been proved commercially feasible.

A new product of the hydrogenation process is a motor fuel that has the required volatility characteristics for use in aviation and yet is fire safe. In view of the flash point of approximately 105° F., it appears that the Reid vapor pressure at 100° F., is practically nil; however, it is stated that the volatility characteristics of the fuel are excellent.

The proposal to require the inclusion of grain alcohol in gasoline as a measure of agricultural relief has caused much discussion. The various aspects of the proposal have been discussed extensively in the newspapers as well as in the technical press, and the plan has been tried in some corn-growing States of the Middle West. Several bills have been introduced in Congress making the mixing of alcohol with gasoline alternative to heavy increases in the Federal gasoline tax.

Advancements in the field of heat conservation in refineries are evidenced by the following applications: (1) Higher pressures on steam boilers, (2) use of fluids such as diphenyl and mercury with special thermal properties, and (3) use of refinery wastes as fuels.

A large refinery in the Chicago district has installed high-pressure boilers to generate electricity and supply process steam. The operating pressure of the boilers is 400 pounds. Steam at this pressure is put through turbines for generating electricity, thereby reducing the pressure to 125 pounds gage, at which pressure the steam is used for plant processing. The boiler-feed water is Lake Michigan water that has been used for cooling and condensing in the refinery. The water, after treatment to remove dissolved solids and traces of oil at a treating plant, is heated to 200° F., before it enters the boilers. Part of the steam for heating the feed water comes from the exhaust from three low-pressure turbines operating at 125 pounds initial pressure.

Conditions in the petroleum-refining industry in 1932 can scarcely have been regarded as satisfactory from the standpoint of economic considerations, but important advancements were made in technology. These advancements occurred in (1) plant improvement and enlargements, (2) improvement in products, and (3) increased economy of operation which resulted in the production of better products at lower costs.