

Platinum and the Petroleum Industry

A FORECAST OF PROBABLE REQUIREMENTS

By M. J. Fowle

Atlantic Refining Company, Philadelphia

The efficient conversion to motive power of the energy contained in gasoline by the combustion of fuel in a spark-ignition internal combustion engine is, and for many years has been, a joint problem of the automotive and petroleum industries. The basic factors that influence the efficiency of the standard four-cycle automotive engine have been known for many years, and can be expressed simply by the graph of Fig. 1, which relates thermal efficiency and compression ratio.

In the United States there has been a constant give and take between these two industries ever since the 1920's when Walter R. Chrysler first made commercial use of the mechanical design of Ricardo to improve the performance of automotive engines by combining an efficient engine (high compression ratio) and a premium gasoline (high octane

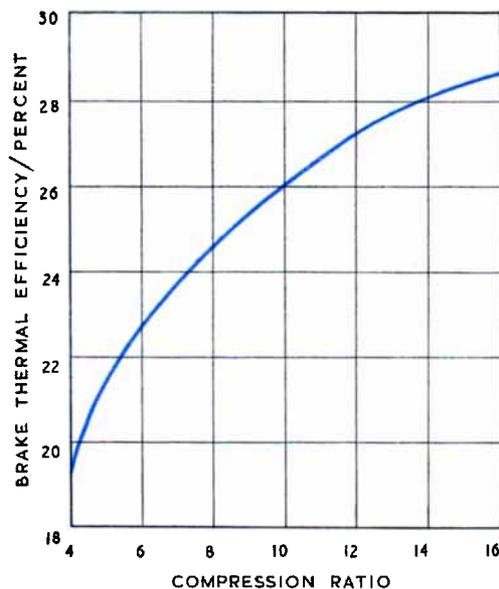


Fig. 1—Thermal efficiency of Carnot cycle internal combustion engines

rating). From those beginnings we have come to today's new cars of 10 or 10.5 to 1 compression ratio and to today's super-premium gasolines of 100 to 101 octane rating.

Unfortunately for the petroleum industry, that part of its crude oil that is already in the gasoline boiling range (normally about 20 per cent) is extremely low in octane rating, averaging only 45 to 50, and cannot be used directly even as a normal component of motor fuels. During the early 1930's the American petroleum industry found it necessary, therefore, to process this straight run gasoline to improve its octane number. The process used, called thermal reforming, exposed the hydrocarbon feed to temperatures (950–1110°F) and pressures (500–1000 pounds per sq. in.) such that there was a substantial improvement in anti-knock properties (20 to 25 octane numbers). But at octane improvements of this level the process was quite inefficient, producing gasoline yields of only 70–75 volume per cent of the feed.

Shortly before 1940 a more efficient process termed "Hydroforming" was commercially introduced. This process employed an alumina-based molybdena catalyst in the presence of hydrogen to increase octane rating by the conversion of paraffinic compounds to aromatics.

Late in 1950 the first commercial use of a supported platinum catalyst for reforming was announced, and now there are many platinum catalysts in general use producing a gasoline product that is frequently in excess of 95 clear octane number. The reasons for this almost complete domination of the reforming field by platinum catalysts are simple and straightforward; they have the ability to

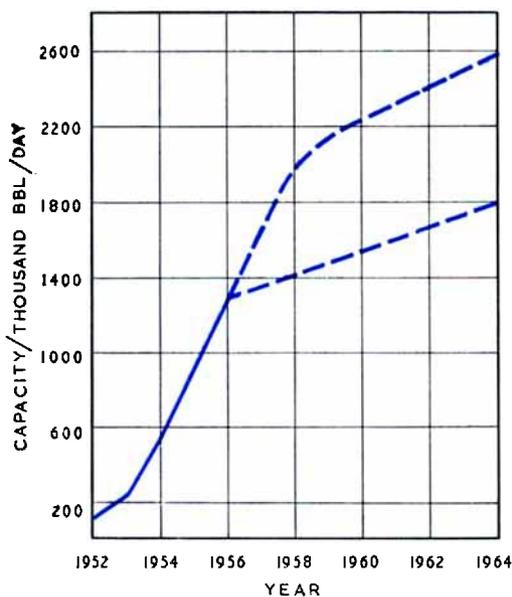


Fig. 2—Projection of United States reforming capacity. Lower curve based on expected increase in crude running. Upper curve based on reforming all straight-run naphtha

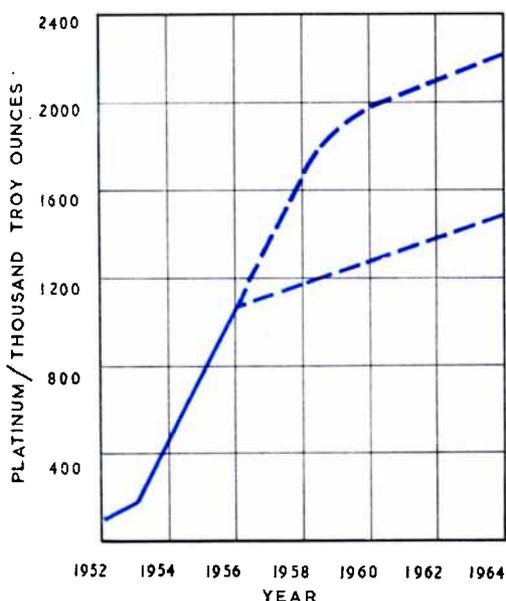


Fig. 3—Projection of platinum usage in United States catalytic reforming. Basis as in Fig. 2 and assuming a weight/space velocity of 2.25, a platinum on catalyst ratio of 0.6 weight per cent, and use of 2 batches per unit

produce the required product octane levels, and at costs far less than by any other catalyst. In this statement cost means the net cost, that is the capital cost of the process equipment, the cost of yield loss, and all direct operating costs including the cost of the catalyst. It is very interesting that the most economical job is done by a catalyst whose total cost approximates \$9 per pound, and where net cost is about \$4 per pound, and that involves the use of platinum, one of the costliest of metals.

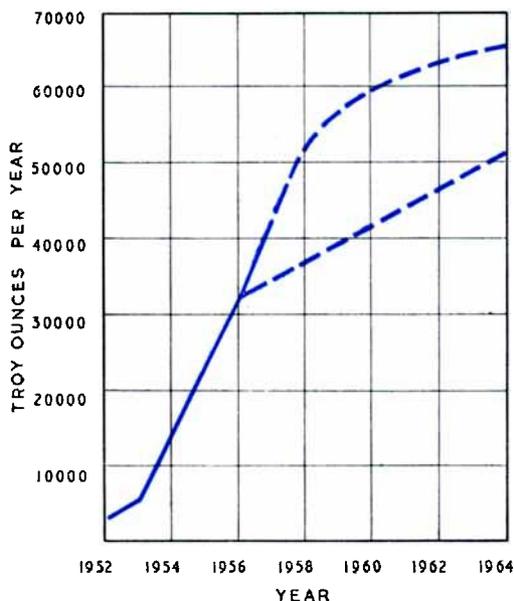


Fig. 4—Projection of annual platinum consumption in United States catalytic reforming

The dependence of the petroleum industry on platinum, and a forecast of its probable requirements, both as to total inventory of platinum on catalyst and to the expected long-time consumption of platinum to maintain the volume of reforming to be done, is naturally of primary interest to the platinum metals industry. First of all, we may consider the quantity of reforming and its probable rate of growth.

At the end of 1956 there were about 1,300,000 barrels per day of operating catalytic reforming capacity in the United States, or slightly less than 14 per cent of the crude run.

On the basis of expected increases in crude running, reforming should increase as shown on the lower dotted line of Fig. 2. However, at the same time octane requirements are also increasing so that the upper dotted line probably represents more closely the future trend for catalytic reforming.

On the basis of averages published by the licensors of all of the reforming processes, we have then arrived at the quantity of platinum being used at any one time, and this is shown graphically in Fig. 3. Thus, we would expect that there would be in use for reforming catalyst purposes about 2,200,000 troy ounces of platinum by the end of 1964, and that new installations at that time would require about 60,000 ounces per year on a more or less continuing basis.

In addition to the larger bulk of platinum on catalyst either in use, or being made for

use, there is a small but regular consumption of platinum in the manufacture of fresh catalyst, in the loss of catalyst during use and in handling at the petroleum refineries, and in the processing of spent catalyst for platinum recovery. As shown in Fig. 4 this amounted to about 30,000 ounces in 1956, and we would expect it to reach approximately 70,000 ounces by 1965, which would then represent a continual consumption about equal to the platinum requirements for catalyst for new units.

With the rapid spread of catalytic reforming to the rest of the world, and the greater proportion of straight-run naphtha in the motor fuel for these markets, it would appear probable that the total world requirement for platinum in the petroleum industry could be estimated by taking a ratio of total crude throughput to U.S. throughput, with perhaps a two to three year lag in the platinum uptake.

Special Platinum Alloy Thermo-Junctions

RAPID MEASUREMENT OF THERMAL CONDUCTIVITY

A platinum alloy thermocouple junction which closely resembles a single wire, uniform in size, in electrical resistivity and in thermal properties from end to end has recently been developed and produced by the Research Laboratories of Johnson Matthey & Co. Limited in collaboration with Mr. R. A. W. Hill, of the Research Department of the Nobel Division of Imperial Chemical Industries Limited, for use in a new method of measuring the thermal conductivities of poor conductors.

As described by Mr. Hill in *Proc. Roy. Soc. A*, 1957, 239, 476-486, the principle of the method is to observe the rate of heating of a fine wire when a constant radio-frequency current is passed through it, the wire being maintained first surrounded by air and then surrounded by the liquid or other medium of which the thermal conductivity is to be measured. By comparing the heating curves of the wire in the two environments, the thermal conductivity of the medium can be

determined. The measurement can be made in less than one-tenth of a second.

In order to measure its temperature, the wire is made in the form of a thermo-junction of two 40 SWG wires chosen to have the same resistivity, and the thermo-e.m.f. is observed by an oscillograph.

The alloys used for the two elements of the thermo-junction were finally chosen, after experimenting with a number of combinations, as (a) platinum with 8 per cent gold and (b) platinum with 2 per cent ruthenium. The electrical resistivities of these alloys are closely matched and the couple develops about 15 microvolts per degree C. The couple wires were welded together and the junctions drawn down in a die to the diameter of the wire so as to be quite invisible to the eye. By this means, it has been found possible to apply this method to small, rapidly changing systems at high temperatures. The accuracy has been checked by measurements on medicinal paraffin, glycerol, and water.