PETROLEUM AND GAS PROCESSING

OPERATION OF STRIPPING SECTIONS IN ATMOSPHERIC-VACUUM DISTILLATION UNITS

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In atmospheric-vacuum units for crude oil distillation, wide use has been made of external stripping sections, a necessary part of any complex column.

Stripping sections are designed to strip light ends from a liquid product drawn from an intermediate tray of the main column, by means of stream injection. The effectiveness of such stripping sections is a major factor governing the sharpness of separation of the products obtained from the unit.

In stripping sections operating with steam injection, the liquid flowing along the tray is evaporated because of its own heat content; but, since the amount of such heat is limited, the amount of vapor thereby formed (vapor number) is also limited. In stripping sections using steam injection, the vapor stream generally does not exceed 35 to 50% of the amount of liquid residue taken as a bottom stream from the stripping section.

Although stripping sections have been used for many years in the separation of petroleum products, their operation still has not been studied sufficiently [1-5]. No data of adequate reliability are available on the effect of steam flow rate or the magnitude of the vapor number on the sharpness of separation; there has been little study of the effect of the number of trays in the stripping section, the distillation curve of the products being stripped, the total and partial pressures in the column, or other factors. Further, without sufficiently reliable data on the operation of stripping sections or on the interrelation between the most important parameters governing the sharpness of fractionation, it is impossible to set up effective process control.

We have carried out experimental studies on a stripping section for taking off winter diesel fuel in an atmospheric-vacuum distillation unit of the Moscow refinery, specially modified with control and metering devices and sampling connections, and also studies in a laboratory model unit. The refinery stripping section was 1.2 m in diameter and had seven rectangular-cap trays; the model unit was 44 mm in diameter and had three sieve trays with overflow devices.

Special tests were run on two-component mixtures, n-pentane-xylene and toluene-n-decane; these tests showed that the stripping section of the laboratory unit, when operated with various amounts of steam injection and vapor numbers varying from 0.1 to 0.5, was equivalent to 2.5-3 theoretical plates in fractionating efficiency. The seven actual rectangular-cap trays installed in the commercial stripping section, with an average efficiency of 0.45 [5], correspond to 3.1 theoretical plates, i.e., the number of actual trays in the model unit.

As is well known, the fractionating efficiency of a stripping section with a given number of trays depends on the vapor number (ratio of mass of the vapor G leaving the stripping section to the mass of the residue R drawn as end product from the stripping section), and the vapor number can be regulated by varying the amount of steam injection. The relationships that we found for three different liquid-feed samples, along with analogous data for a number of commercial stripping sections [5] for the vapor number above the top tray, are shown in Fig. 1.

The liquid-feed samples differed in content of fractions distilling below 200°C, but all had approximately the same end point (about 280°C). The distillation curve of one of the liquid-feed samples is shown in Fig. 3 (curve 1).

I. M. Gubkin Moscow Institute of the Petrochemical and Gas Industry (MINKh i GP). Translated from Khimiya i Tekhnologiya Topliv i Masel, No. 6, pp. 6-9, June, 1970.
It can be seen from Fig. 1 that the vapor number increases with the steam injection rate, with a rapidly diminishing effect at higher injection rates, and that the vapor number reaches a limiting value with almost no further change as the steam injection rate is increased. For the different curves shown in Fig. 1, these limiting values ranged from 0.28 to 0.47. It can also be seen from Fig. 1 that regulation of the vapor number by changing the steam injection rate to the stripping section is feasible only up to a certain limit, below which the function shows appreciable curvature; above this limit, even large increases in steam injection rate will not affect the vapor number appreciably. For the curves shown in Fig. 1, this limit corresponds to steam injection rates of 5 to 7%.

Since the source of heat in forming the vapor stream from a stripping section is the heat of the residue, the vapor number is a function of the temperature differential between the liquid feed and the residue drawn from the stripping section, i.e., it is a function of the temperature gradient $\Delta T_c$. The experimental data are plotted in Fig. 2 to show this function. The close grouping of the experimental points near a single curve is evidence that the function $G/R = f(\Delta T_c)$ is more characteristic and more stable than the function $G/R = f(Z)$ and can be recommended for process control.

The experimental data shown in Fig. 2 can be described satisfactorily by the equation:

$$\Delta T_c = 143 \frac{G}{R} - 129 \left( \frac{G}{R} \right)^2 - 2.3.$$  

This equation is recommended for use with values of the vapor number $G/R$ from 0.05 to 0.5.