

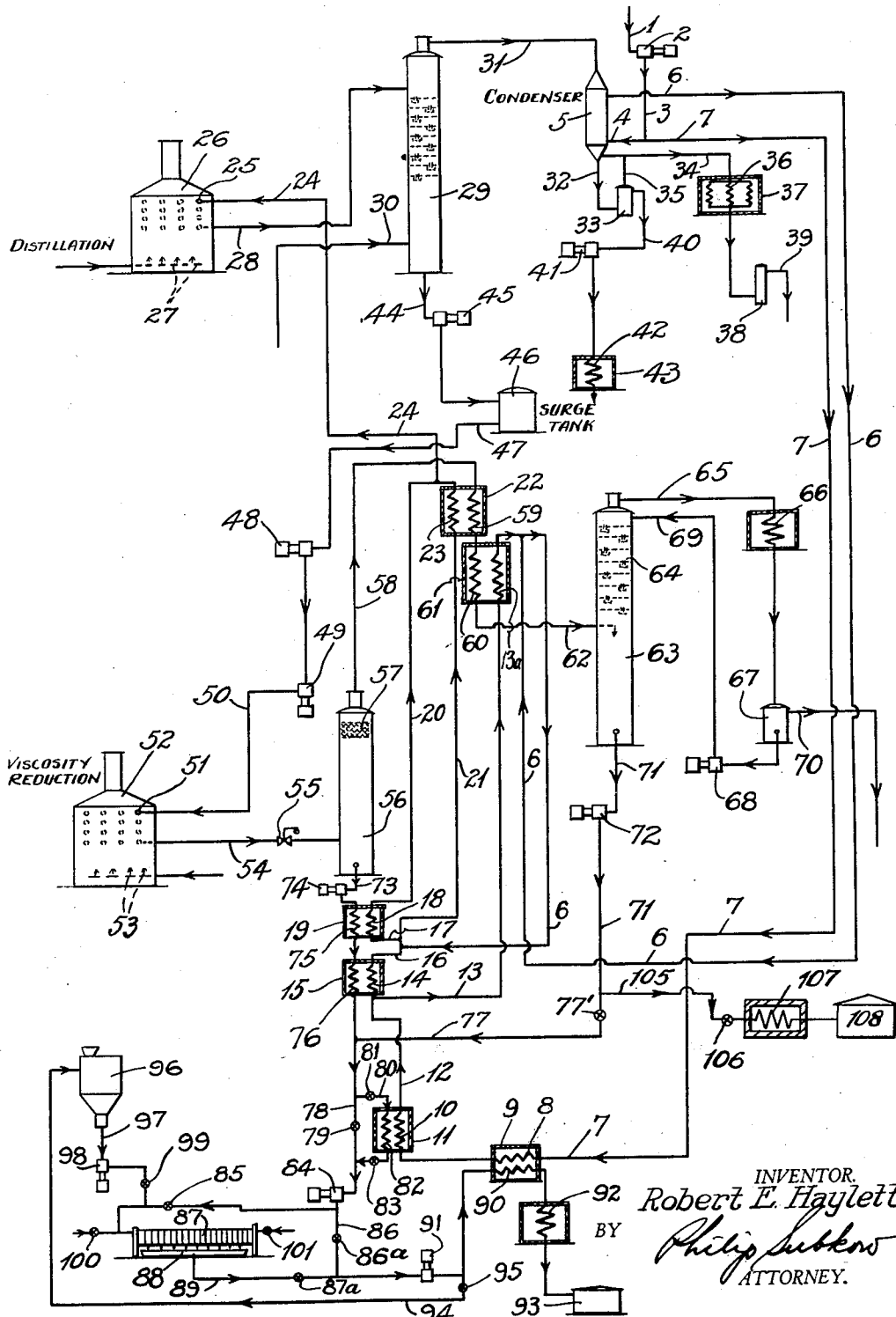
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METHOD FOR TREATMENT OF FUEL OIL

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METHOD FOR TREATMENT OF FUEL OIL

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This invention relates to a process and apparatus for distillation of crude oil and has for its primary object so processing the crude oil, that minimum amounts of fuel oil shall be formed, and a maximum amount of intermediate boiling fractions, of the nature of gas oil, produced.

As all refiners of oil know, the satisfaction of the increased demand for gasoline during periods when the price of crude oil is relatively low, as occurs during periods of high oil production is most economically obtained by straight distillation, or so-called "stripping" of crude oil. During periods of high gasoline demand considerable crude oil is so "stripped". This results in relatively large amounts of gas oil and fuel oil. Not infrequently, the cracking operations which are used to supplement the production of gasoline, consume all of the gas oil produced by straight distillation, resulting in a relatively high price for gas oil.

The main difficulty with such an economic situation is that tremendous amounts of fuel oil are produced. The fuel oil market in the last few years has not increased as rapidly as supply, so that the refiners are faced with large accumulations of fuel oil of which they cannot dispose. This means that the refiners must build storage facilities and carry a large inventory of fuel oil. Since this large investment and the interest thereon causes a charge against the refinery operation, it is reflected in the high cost of saleable products, and since practically all the gas oil is consumed in cracking operations it is reflected ultimately in the cost of production of gasoline. To a large extent, however, the value of fuel oil in storage is fictitious, since, unless the fuel oil is disposed of, the asset represented in fuel oil in storage is merely a book asset. Additionally, the storage problem has been aggravated. As has happened in the last few years, the tremendous production which has been obtained has required considerable addition in storage capacity, so that the resulting vast increase in fuel oil in storage, makes storage problems of crude oil more acute. Additionally, the demand for gas oil as a cracking stock makes it imperative that the refiner obtain a maximum yield of this product from any oil to insure for himself an adequate supply of this commodity. Consequently, a process of distillation which produces minimum amounts of fuel oil and maximum amounts of gas oil, or as one may say alternatively, gasoline, is an economic necessity.

It is, therefore, an object of this invention to so distill crude oil to obtain the above results.

The lowest acceptable grade of fuel oil has the following specification. It must have a viscosity varying from about 150–300 seconds Furol at 122° F. and it must have a sediment content, on extraction with 90% commercial benzol, of 0.25%, or less. The lowest grade fuel oil is Bunker C. (U. S. Government specifications), and has a viscosity of 300 seconds Furol at 122° F. All commercial distillation of naphthenic base crude oil produces a residuum of this type of fuel oil. This is the lowest grade crude oil fraction for which there is any considerable market. Such fractions as road oil, which is a more severely distilled fuel oil, has but an inconsiderable sale and is almost a negligible quantity in the economics of crude oil distillation. It is the accumulation of this fuel oil which is the difficulty.

The invention of this application consists in treating this fraction so as to produce considerable quantities of gas oil therefrom without materially altering the characteristics of this fuel oil and thus without destroying its commercial value as a fuel oil.

The process of this application consists essentially of distilling this fuel oil at as high a temperature as possible without any material or excessive conversion. In other words, distilling the oil at its incipient cracking temperature to produce considerable proportions of gas oil, removing the residuum which will have the form of a highly viscous low A. P. I. gravity oil resembling in nature a road oil and totally unsuitable as a fuel oil. This road oil is treated by a cracking operation to convert it into an oil with a lower viscosity of relatively lower A. P. I. gravity compared with the original fuel oil processed but sometimes with a relatively high sediment content. The sediment is removed to produce a fuel oil of substantially the same characteristics as that originally processed to thus reduce the amount of fuel oil produced by any distillation, and to increase the gas oil produced and yet still to produce a marketable fuel oil. This oil is of higher calorific value per unit of volume than the original fuel oil processed since it is of lower A. P. I. gravity.

The invention will be better understood by reference to the drawing which shows schematically a preferred form of the apparatus for carrying out my process.

Fuel oil produced by a conventional crude distillation, (not illustrated) is drawn through line 1, by pump 2, passes through line 3, where it is split, part going through line 4, and condenser 5, in heat exchange with vapors through 31 and 110

through line 6. The rest of the oil passes through 7, through heat exchange coil 8, in heat exchanger 9, where it passes in heat exchange with the clarified oil in heat exchanger 90, then it passes through coil 10, in heat exchanger 11; then through line 12, at which place it splits, part going through 13, and part going through coil 14, and heat exchanger 15. The part passing through 13 passes through coil 13a, in heat exchanger 61, after which it is co-mingled with the oil passing through line 6. The co-mingled oil then meets the oil passing through 14, and is again split, part going through heat exchange coil 18, in heat exchanger 19, and part going through heat exchange coil 23, in heat exchanger 22. The oil passing from 18, passes through line 20, and co-mingles with the oil passing through 23, in line 24, after which it passes to heating coils 25, in furnace 26, heated by burners 27.

The heated oil passes through 28, into a stripping column 29, which may be of any conventional design, such as bubble cap tower. Into the bottom of the tower is introduced superheated steam through 30. The vapors pass through 31, are condensed in condenser 5, condensate passing through 32, into collector 33. The uncondensed oil passing through 34, together with such vent gas as rises through 35, and are condensed in coil 36, in cooler 37, and collected in run-down tank 38, and are withdrawn through 39. The condensate is withdrawn from tank 33, through line 40, by means of pump 41, and is cooled in coils 42, by cooler 43, after which they pass to storage.

The residuum from column 29, is withdrawn through line 44, by means of pump 45, and run into surge tank 46, from which it is withdrawn through line 47, by means of booster pump 48, and high pressure pump 49, and passed through line 50, into the cracking coils 51, positioned in furnace 52, heated by burners 53. The heated oil passes through line 54, through the pressure reducing valve 55, into vaporizing chamber 56. The vaporized oil passes through the mist extractor 57; vapors pass through 58, through coils 59, in heat exchanger 22; through heat exchange coil 60, in heat exchanger 61, and then into the rectifying column 63. The vapors rise through the bubble plates 64, the uncondensed vapors pass through line 65, into the condenser 66. The condensates are collected in 67, part is returned as a reflux by reflux pump 68, and introduced into tower 63, by means of line 69. The rest of the condensate is withdrawn from 70 to storage. The tower bottoms in 63 are withdrawn through line 71, by means of pump 72, part, or all, may be sent to storage tank 108 if desired via line 105 controlled by valve 106 and cooler 107, but it is preferred that a regulated fraction of this condensate be sent through line 77 controlled by valve 77', as will be herewith explained.

The residuum cooled in vaporizer 56, is withdrawn through 73, by means of pump 74, passed through coils 75, in heat exchanger 19; through 76 in heat exchanger 15, after which it is co-mingled with the oil passing through line 77. The co-mingled oil is then passed through 78, a regulated portion is by-passed through 80, and heat exchange coil 82, in heat exchanger 11, by means of a proper regulation of valves 79, 81 and 83. The oil is then pumped by pump 84, through a filter press 87. The clarified oil is collected in 88, withdrawn via line 89, valve 87a, by means of pump 91. The filter press is so connected that it can be by-passed through 86, by proper regu-

lation of valves 86a, 87a, 85, 95. A plurality of filters, connected in parallel is employed (not shown) so that one may be cleaned and prepared while the other is in use.

In order to pre-coat the filter press, as will be herewith explained, a mixer 96, is provided. Clarified oil which passes to the heat exchanger coil 90, is partly by-passed through 95, in line 94, to mixer 96, where it is mixed with a pre-coating material such as clay or diatomaceous earth. The mixed materials are withdrawn through 97, by pump 98, and valves 85, 86a, 95, 100 and 101 being closed, and 99 and 87a open, it is passed through filter press 87. The oil is collected in 88, and withdrawn through 89 via pump 91, to pass through 90. Valve 95 is closed after the requisite amount of oil has been introduced into 96. Valve 99, is then closed and valve 85, open, valve 86a, remaining closed. The oil is then pumped by pump 84, through valve 85, and through filter press 87, and the clarified oil is collected in 88, withdrawn through 89, by means of pump 91, passed through heat exchange coil 90, in heat exchanger 9, through cooler 92, into storage tank 93. When a filter has become fouled it is cut out by closing valve 85, the oil being diverted to the parallel pump, not shown, or it may be by-passed through 86, by proper manipulation of valves 86a, and 87a. Valves 85, 99 and 101 being closed, steam is introduced through 100, to remove oil from the filter cake in 87. Valve 100, is then closed and steam is sent in a reverse direction through 101, to dislodge the cake. The filter is then cleaned, re-assembled and pre-coated as previously described.

The operation of this apparatus and process will be described in connection with a specific example to show its application to one operation.

The fuel oil which is formed in ordinary distillation will vary in quality with the type of crude and the market conditions. As an approximation it may be said that these fuel oils will be within the limits of 14°-25° A. P. I. gravity and within a viscosity range of 25-600 seconds Furol at 122° F. In most cases especially in California operating on California oils these viscosities will be at the present time in a range of 100-200 seconds Furol at 122° F. and will have a gravity between 15°-18° A. P. I.

The process consists in taking off a cut of gas oil as will be later explained. This will vary from 25% to 50% of the fuel oil charged depending on the oil processed and on the final product desired. The topped residuum will be a very viscous, heavy oil, solid at ordinary temperatures. For comparison it may have a viscosity of 1000 to 5000 seconds Furol at 122° F. It will have a gravity of about 10°-14° A. P. I.

This oil is then cracked to produce about 5% to 10% of gasoline of from 55°-65° A. P. I. gravity and a fuel oil having a gravity of about 10°-15° A. P. I. It will be noted that, this is lower in A. P. I. gravity than the fuel oil charged to the system. The viscosity will vary from 100-350 seconds Furol at 122°. It will be seen that it is in the range of the viscosities of the original oil, that is, the viscosity characteristics are similar while the gravity characteristics are dissimilar, i. e., this treated oil is heavier. The viscosity of the oil will depend on the amount of cracking of the highly viscous oil made in the first stage of the process.

Fuel oil to be processed may be, for example, one having a viscosity of around 100-200 seconds Furol at 122° F., i. e. 112 seconds and a sediment

content by extraction with 90% commercial benzol about 0.15% and a gravity of 17° A. P. I. It comes from the heat exchangers of the crude distillation, and is introduced into this process through line 1, at a temperature of about 235° F. The particular type of heat exchanger shown here is specifically designed to obtain a maximum of heat recovery and its purpose is to split the oil so that heat exchange of a maximum efficiency is obtained. Part of the oil is passed to condenser 5 in heat exchange with the vapors produced in the first distillation operation in tower 29, and part of the oil is passed in heat exchange with the residuum passing from tower 56, and part is passed in heat exchange with the clarified oil and the withdrawn residuum, and part is passed to heat exchange with the vapors issuing from 56. This raises the incoming oil passing in line 24, to about 700° F. It is heated in coil 25, to about 760° F. which is the incipient cracking temperature of this oil. It is then introduced into the tower 29, into which super-heated steam, at 750° F. is admitted through 30. The vapors issue through 31 at about 710° F. and are condensed in 5, to produce a condensate and uncondensed vapors at about 300° F. The fraction condensed is collected in 33 and passes through cooler 42. The oil is a gas oil of about 28° A. P. I. which forms about 40% of fuel oil charged in the process. The uncondensed vapors passing through 34, are condensed to produce a crude naphtha of about 45° A. P. I. The stripped residuum removed from the tower 29, at about 700° F. is a heavy road oil having a viscosity of about 95 to 165 seconds Furol at 122° F., in the present example it will be 120, and a gravity of 10.6° A. P. I. This oil is entirely unsuitable as a fuel oil because of its high viscosity and it is the object of the next step to convert it into synthetic fuel which will be saleable.

To this end it is cracked under high pressure under such conditions that a relatively small amount of gasoline is produced and all intermediate boiling fractions are returned to the residual oil. Thus but two commodities, i. e. gasoline and fuel oil, are produced by the cracking operation. The process can, if desired, be run to produce fuel oil, gas oil and gasoline, as will be herewith explained. The oil collected in surge tank 46, is withdrawn at about 675° F. and pumped by means of booster pump and high pressure pump, into cracking coils 51. It is heated to about 840° F. under a pressure from 500 to 1000 pounds controlled by valve 55 for a period of time to produce the required conversion. It is introduced into the flash tower where it is vaporized. The vapors rise through 57, where any entrained oil is removed from the vapor by 57. The vapors issue through line 58, at about 750° F. and are cooled in heat exchangers 59 and 61 to about 630° F. whereupon they are introduced in the rectification column 63. Vapors are withdrawn through 65 at 275° F. and are condensed in 66, and collected in 67, to produce a cracked gasoline, forming about 5%–10% of the cracked oil, or 3%–6% on the basis of the fuel oil changed in the system. It has a gravity of about 66° A. P. I. and an end point of 290° F. This amount and A. P. I. gravity will depend entirely on how deep the gasoline cut is. If more of the heavy ends are allowed to remain behind in the synthetic fuel oil the less the gasoline produced and the higher its A. P. I. gravity and the lower its end point. The oil condensed in 63, is withdrawn at about 620° F. and co-

mingled with residuum withdrawn from 56, as will be explained herewith.

The residuum collected in tower 56, is a solid, or semi-solid material and has low fluidity until it reaches about 210° F. having a high sediment content, i. e. 0.5% or 0.6%. It has a gravity of about 10°–15° A. P. I., in this particular case its gravity is 10.5° A. P. I. It is withdrawn from the tower 56, at 780° F. and cooled in heat exchanger 75 and 76 to 620° F. After which it is co-mingled with the oil passing through 77. The co-mingled oil will have a relatively high sediment content of about 0.3% to 0.4%. It is, therefore, necessary to remove this sediment. One useful method is by filtration, as previously described. The clarified oil will then be collected in tank 93, and will consist of about 55% of oil charged to the system. The viscosity of this oil will be about 120–250 seconds Furol at 122° F. In this case it is 170 seconds at 122° F. It will have a sediment content of 0.1% or less. Its gravity will be about 12.0° A. P. I. It will be observed that this is a highly satisfactory fuel oil. Bunker C. specifications (U. S. Government specifications) permit as high as 300 seconds Furol at 122° F. Obviously, the degree of the viscosity produced will vary with different oils and with the degree of cracking and blending from 77 and is at the control of the operator as will be understood by those skilled in the art. It will also depend on the viscosity of the stripped residuum i. e., on the amount of original stripping. The degree of cracking is limited, due to the fact that coke formation is great if the cracking is carried on to any excessive degree. Therefore, the viscosity of the stripped material is a limiting factor. If it is too great the viscosity of the synthetic fuel oil will be high. Additionally, the A. P. I. gravity and the end point of the gasoline will determine the viscosity of the synthetic fuel oil for the higher the end point and the lower the A. P. I. gravity of the gasoline produced the higher the viscosity of the synthetic fuel oil.

Under most circumstances the viscosity of the synthetic fuel oil will be slightly higher than the original fuel oil, perhaps as much as 75 to 100 seconds Furol at 122° F., but it will be between 1000 to 5000 seconds less than the stripped residuum. The viscosity of the synthetic fuel oil can be made to equal and be even less than the original fuel oil by taking less gas oil over in the first stage and reducing the end point and increasing the A. P. I. gravity of the gasoline taken overhead. Thus in one example, operating on a 16.7° A. P. I. 118 seconds at 122° F. Furol, fuel oil was distilled to take overhead 30% of gas oil of 28° A. P. I. in the first stage to produce a stripped residuum of 13.8° A. P. I. gravity and 1318 seconds at 122° F. This fuel oil was cracked at 766° F. at about the same rate as the first example to produce 9.9% of a 370° F. end point gasoline and a synthetic residuum of 13.1 A. P. I. gravity and a viscosity of 118 seconds Furol at 122° F. Thus, although more gasoline of higher end point was produced yet by reducing the original stripping from 40% to 30% the viscosity of the final residuum was decreased and a little more gasoline was taken overhead. By cutting the gasoline overhead to about 5% the viscosity of the fuel oil would have been reduced still more.

As a matter of fact it is preferable to take as much gas oil overhead in the first stage even though it gives a slightly higher viscosity synthetic fuel oil and to take a smaller gasoline yield

in the second stage so as to lower the viscosity of the synthetic fuel oil by this means.

In either case the synthetic fuel oil will resemble the original fuel oil in that its viscosity will fall in the same range of viscosities, i. e., it will be available for the same use as far as viscosity is concerned.

It will be observed that I have been able to obtain from fuel oil which has a comparatively small market, 40% of a gas oil, 4% gasoline and 55% of a marketable fuel oil of substantially the same characteristics as the original material entering the process. It will be seen that the first product has a viscosity substantially comparable with the original fuel oil entering the process but has a substantially lower A. P. I. gravity and will, therefore, be a better fuel oil since it will have a greater calorific power than the same volume of the original fuel oil treated. I have reduced the amount of storage necessary, due to the fact that I will now have to store but one-half the amount of fuel oil. I have produced a gas oil having a ready market and highly useful as a cracking stock, and have also, incidentally, produced a small amount of gasoline. The economic feature of this process is obvious.

The above descriptions illustrating the apparatus and process are for the purpose of explaining my invention and are not to be understood as limiting my invention. Many variations are possible depending on the character of the oil to be processed and the character of the oil to be obtained as well as the yields, as will be understood by those skilled in the art. I claim as my invention:

1. A process for treating fuel oil which comprises passing fuel oil having a gravity within the range of 14° to 25° A. P. I. gravity and a viscosity within the range of approximately 25 to

600 seconds Furol at 122° F. in a restricted stream through a heating zone, heating said oil in said restricted stream to an incipient cracking temperature but without causing any material conversion of said oil, separating said oil into a gas oil fraction and a residuum having a viscosity within the range of 1000 to approximately 5000 seconds Furol at 122° F. and a gravity within the range of 10° to 14° A. P. I., passing said residuum through a heating zone in a restricted stream, heating said oil and producing a cracked oil having an A. P. I. gravity within the range of 10° to 15° A. P. I. but lower than the A. P. I. gravity of the original fuel oil and a viscosity within the range of 100 to 350 seconds Furol at 122° F. and a light oil vapor and separating said light oil vapor from said cracked oil.

2. A process for treating fuel oil which comprises passing fuel oil having a gravity within the range of 14° to 25° A. P. I. and a viscosity within the range of 25 to 600 seconds Furol at 122° F. in a restricted stream through a heating zone, heating said oil in said restricted stream to an incipient cracking temperature but without causing any material conversion of said oil, separating said oil into a gas oil fraction of 25 to 50% of the fuel oil and a residuum having a viscosity such as to be substantially solid at atmospheric temperatures and having a gravity within the range of 10° to 14° A. P. I., passing said residuum through a heating zone in a restricted stream, heating said oil and producing from 5 to 10% of gasoline and a cracked oil having an A. P. I. gravity within the range of 10° to 15° A. P. I. but lower than the A. P. I. gravity of the original fuel oil and a viscosity within the range of 100 to 350 seconds Furol at 122° F. and separating said gasoline from said cracked oil.

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