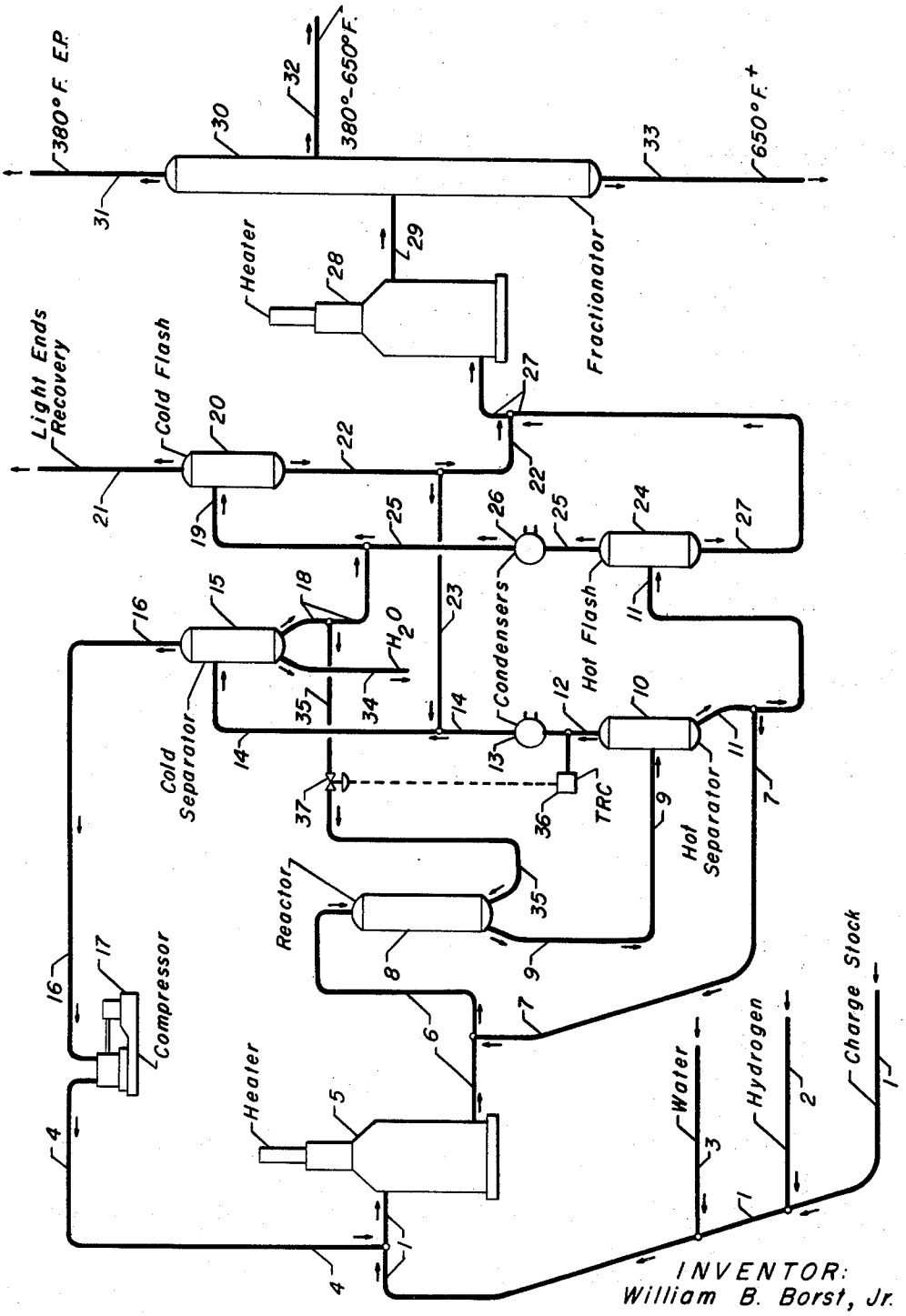
Oct. 7, 1969 W. B. BORST, JR 3,471,398

METHOD FOR THE CONVERSION OF HYDROCARBONS

Filed March 8, 1967



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United States Patent Office 3,471,398 Patented Oct. 7, 1969

3,471,398

METHOD FOR THE CONVERSION OF HYDROCARBONS

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Filed Mar. 8, 1967, Ser. No. 621,526
Int. Cl. C10g 23/00, 13/00
U.S. Cl. 208—111 9 Claims

ABSTRACT OF THE DISCLOSURE

Method for hydrodesulfurizing hydrocarbons, preferably boiling up to about 1100° F., by subjecting feed hydrocarbons to reaction with hydrogen over hydrogenation catalyst so that the feed hydrocarbons are at least mildly hydrocracked and substantially desulfurized. The reactor effluent is quenched with a specific liquid hydrocarbon stream which had been previously separated from the reaction zone effluent products. The amount of quench is responsive to the measurement of the temperature of the vapor stream out of the high pressure separator immediately following the reaction zone such that a predetermined temperature thereof (below about 775° F.) is maintained in this vapor stream. Hydrocarbon products of reduced sulfur content are subsequently recovered.

BACKGROUND OF THE INVENTION

This invention relates to the conversion of hydrocarbons. It particularly relates to the hydrogenation of relatively high boiling hydrocarbons by catalytic exothermic reaction with a normally gaseous reactant. It specifically relates to a method for hydrocracking black oil hydrocarbons by an improved manner of quenching the hydrocracking reaction.

It is well-known in the art that conversion reactions, in general, and hydrocracking reactions, specifically, are exothermic in nature; that is, the reaction releases significant quantities of heat which must be selectively disposed of if the reaction is to be controlled and optimum results are to be obtained. There have been a variety of prior art schemes proposed for such reactions and, in general, these embody indirect heat exchange schemes wherein the heated effluent is exchanged with a relatively cold material, such as incoming feedstock, so that the effluent temperature does not exceed a predetermined value and preheat of the feed is achieved.

It has now been found that there are other aspects for achieving economical thermal balance around an exothermic reaction zone which must be considered in devising a suitable quench mechanism.

SUMMARY OF THE INVENTION

Therefore, it is an object of this invention to provide an improved method for the conversion of hydrocarbons.

It is also an object of this invention to provide a method for quenching an exothermic conversion reaction.

It is a specific object of this invention to provide a method for hydrocracking relatively high boiling hydrocarbons in a facile and economical manner.

Accordingly, the method of the present invention comprises introducing feed hydrocarbons into a catalytic reaction zone maintained under conversion conditions including the presence of hydrogen gas; passing the total effluent from said zone into a first separation zone under conditions sufficient to produce a first vapor stream and a first liquid stream containing converted hydrocarbons; measuring the temperature of said first vapor stream; introducing a hereinafter specified quench stream directly into the downstream side of said reaction zone in an amount responsive to said temperature measurement sufficient to maintain a predetermined temperature of said first vapor stream; cooling said first vapor stream to a temperature within the range from 50° F. to 150° F.; separating the cooled vapor stream in a second separation zone under conditions sufficient to provide a second vapor stream comprising hydrogen and a second liquid stream containing converted hydrocarbons; passing at least a portion of said second liquid stream as quench into said downstream side as specified hereinabove; and recovering converted hydrocarbons in high concentration.

Another embodiment of the invention includes the method wherein said predetermined temperature is less than about 775° F. and more than 700° F.

As previously mentioned, the present invention relates broadly to the conversion of hydrocarbons. Therefore, as used herein, the term "conversion" is intended to include the saturation of olefinic hydrocarbons, desulfurization, denitrogenation, cracking, etc. of hydrocarbons. In short, this term includes any exothermic reaction which operates by reacting a normally gaseous reactant, such as hydrogen, with at least a portion of a suitable feedstock. Similarly, the terms "converted hydrocarbons" and "hydrogenated hydrocarbons" are intended to include any hydrocarbons which have passed through the catalytic reaction zone even though such hydrocarbons, per se, were substantially unchanged in the reaction. Thus, a converted (or hydrogenated) product would be one which has a reduced sulfur content, even though to a considerable extent the hydrocarbons have passed through the reaction zone substantially unchanged. In the illustrative embodiment of the invention, more fully discussed hereinbelow, the term "conversion" and the term "hydrogenation" are used interchangeably to describe the hydrocracking of relatively high boiling hydrocarbon feedstocks with simultaneous desulfurization of such feedstocks.

It was noted from the broad embodiment of the invention that the quench is introduced into the "downstream side" of the reaction zone. This term is intended to include the introduction of quench into the lower portion of the catalyst bed, into the lower end of the reactor vessel, and/or into the transfer line between the reactor vessel and the next succeeding vessel which is normally a high pressure separator. The term excludes a locus for quench which is into the catalyst bed wherein significant reaction is taking place, and excludes the introduction of quench directly into the high pressure separator vessel. It is preferable that the quench be introduced into the lower end of the reactor vessel below the catalyst bed to form a physical admixture with the effluent.

The present invention is uniquely applicable to hydrocarbon conversion methods which may be characterized as hydrogen consuming and in which a large excess of hydrogen gas reactant is maintained in the reaction zone, thereby necessitating the recovery and recycle of a hydrogen-rich vapor stream in order for economy of operation to be achieved. In many instances, it is also desirable to recycle with the feedstock at least a portion of the normally liquid product effluent; which recycle acts as a diluent stream and/or is subject to further conversion in order to increase the yield of converted products from the reaction.

The present invention is distinctly applicable to the hydrocracking reaction which is utilized by the petroleum refining art to convert relatively heavy carbonaceous material into lower boiling (or lower molecular weight) hydrocarbon products such as gasoline and/or fuel oil, and the like. In other instances, the hydrocracking reaction is used for the production of liquefied petroleum gas (LPG). Hydrocracking also includes the processing of heavy residual stocks commonly called "black oils." These black oils include atmospheric tower bottoms

products, vacuum tower bottoms products (vacuum residuum), crude oil residuum, reduced crude oils, synthetic crde oils obtained from tar sands or oil shale, etc. Similarly, the present invention is applicable to the conversion of relatively heavy hydrocarbons such as those having initial boiling points above about 400° F. and end boiling points of about 100° F. With specific reference to the black oils, this class of relatively heavy hydrocarbons are characterized by having at least 10% by volume boiling above about 1050° F. Normally, in hydrogenating such feedstocks as herein mentioned there is, in addition to the hydrocracking reaction, the desulfurization reaction which converts sulfur compounds into hydrogen sulfide and the denitrogenation reaction which converts nitrogen compounds into ammonia.

Specific feedstocks which may be processed in accordance with this invention include a vacuum tower bottom product having a gravity of 7.1° API at 60° F., and containing 4.1% by weight sulfur and 23.7% by weight asphaltic compounds; a reduced crude oil having a gravity of 11° API at 60° F., and containing 10.1% by weight of asphaltic compounds and about 5.2% by weight sulfur; and a vacuum residuum having a gravity of about 8.8° API at 60° F., and containing 3.0% by weight sulfur and 4300 p.p.m. (parts per million by weight) of nitrogen, and having a 20.0% volumetric distillation point of 1055° F. Generally, the asphaltic compounds are found to be colloidally dispersed within the black oil, and when subjected to elevated temperature and pressure has a tendency to flocculate and/or polymerize, whereby the conversion thereof to more valuable products becomes extremely difficult.

In the processing of black oils the conversion conditions are those which are sufficient for the purpose of achieving both desulfurization and conversion of at least a portion of the feed hydrocarbons into lower boiling (or lower molecular weight) hydrocarbon products. Generally, these conversion conditions are significantly less severe than those being currently commercially employed in processing similar charge stocks. For example, with respect to black oil processing, the conversion conditions include a temperature from 700° F. to 800° F. and a pressure from 1000 p.s.i.g. to 3000 p.s.i.g. The temperature usually is measured at the inlet to the catalyst bed since the exothermic nature of the reaction will produce a considerably higher effluent temperature. For example, the effluent temperature, in the absence of quench, may be as high as 900° F. even though the inlet feed temperature was only about 725° F. Hydrogen is added to the reaction zone in an amount from 1,000 to 30,000 standard cubic feet per barrel, preferably, from about 2,000 to 10,000 s.c.f./b. at the selected operation pressure. The liquid hourly space velocity (volume of hydrocarbon per hour per volume of catalyst) may be selected over a relatively broad range but, preferably, will be within the range from about 0.25 to about 2.0.

The hydrogenation reaction is carried out in the presence of a catalyst. The catalyst is characterized as comprising a metallic component possessing hydrogenation activity. This metallic component is generally composited with a refractory inorganic oxide carrier material which may be of synthetic or natural origin. The precise composition and method of manufacturing the catalyst is not considered an essential element of the present invention; however, a siliceous carrier, such as 88% by weight of alumina and 12% by weight of silica, or 63% by weight alumina and 67% by weight silica, are generally preferred in use in the design to convert black oils into more valuable products. Suitable metallic components, having hydrogenation activity, are those selected from the group of metals of Group VI–B and VIII of the Periodic Table as indicated in the Periodic Chart of the Elements, Fisher Scientific Company, 1953. Thus, the catalytic composite may comprise one or more metallic components from the group consisting of molybdenum, tungsten, chromium, iron, cobalt, nickel, platinum, palladium, iridium, osmium, rhodium, ruthenium, and mixtures thereof. The concentration of the catalytically active metallic component or components is dictated by the particular metal chosen as well as the physical and chemical characteristics of the black oil charge stock. The metallic components of Group VI–B are generally present in an amount within the range of about 1.0% to about 20.0% by weight; the iron group metals in an amount from 0.2% to 10% by weight; and, the platinum group metals are preferably present in an amount from 0.1% to about 5% by weight; all of which are calculated as if the components existed within the finished catalytic composite as the elemental metal.

The refractory inorganic oxide carrier material may comprise alumina, silica, zirconia, magnesia, titania, boria, strontia, hafnia, and mixtures of two or more including silica-alumina, alumina-silica-boria phosphate, silica-zirconia, silica-magnesia, silica-titania, alumina-zirconia, alumina-magnesia, alumina-titania, magnesia-zirconia, silica-alumina-magnesia, silica-alumina-titania, silica-magnesia-zirconia, silica-alumina-boria, etc. It is preferred to utilize a carrier material containing at least a portion of silica and preferably a composite of alumina and silica, with alumina being of the greater proportion.

As previously noted, it was discovered in the practice of this invention that the measurement of the temperature in the first vapor stream from the hot separator is a particularly advantageous control point for the amount of quench necessary. It was further found that the predetermined temperature of this vapor stream from the high pressure separator should be maintained below a temperature of about 775° F. but, preferably, above about 700° F. It was found that at temperatures above about 775° F. the heavier normally liquid hydrocarbons are carried over into this vapor phase, thereby considerably contaminating the hydrogen gas stream which subsequently is to be recycled to the reaction zone. If a large amount of the heavier material is carried over into this vapor stream, the size and operating expense of condensing and thereby removing the hydrocarbons from the hydrogen gas would be significantly increased. In addition, it was found that the use of this vapor stream for the control point permitted the complete elimination of all other heat exchange equipment between the reactor vessel and the high pressure separator. Thus, the subsequently separated hydrogen gas is available for recycle at significantly higher pressures than would be the case for prior art schemes using indirect heat exchange means between the reactor vessel and high pressure separator. Obviously, savings in compressing cost can be realized. In other words, the practice of this invention permits the use of solely a direct quench stream, as herein defined, to control this important temperature.

On the other hand, if the temperature of the vapor stream from the high pressure separator is below about 700° F. ammonia salts resulting from the conversion of nitrogenous compounds contained in the feedstock would tend to contaminate the normally liquid hydrocarbon phase from the bottom of the high pressure separator. If such were allowed to happen, the conventional way of removing these ammonia salts would be by water washing; however, it is presently believed that if an attempt were made to water wash these relatively heavy converted hydrocarbons and emulsion would be formed by the hydrocarbon and the water wash which would be extremely difficult to break. Therefore, as more fully discussed hereinbelow, the preferred embodiment of this invention teaches that the control or a predetermined temperature level for the vapor stream leaving the high pressure separator should be less than about 775° F. and more than 700° F. However, depending upon the characteristics of the hydrocarbon feedstock and the conversion conditions chosen, reasonable exceptions to these temperature

limitations may be utilized with satisfactory operating results.

ILLUSTRATIVE DRAWING

Other operating conditions and the preferred operating techniques will be given in conjunction with the following description of one embodiment of the invention with specific reference to the drawing which is a diagrammatic representation of apparatus for practicing one embodiment of the invention.

For the purpose of referring to the drawing, it will be assumed that the method will be operated with the conversion of a reduced crude oil having a gravity of 16.6° API at 60° F., and an ASTM 65.0% volumetric distillation temperature of 1034° F. The reduced crude feedstock contains about 3.8% by weight sulfur, about 2,000 p.p.m. of nitrogen, about 6.5% by weight pentane-insoluble asphaltic materials, a Conradson carbon residue of about 8.0% by weight, and about 85 p.p.m. of metals, principally nickel and vanadium.

Now, with reference to the drawing, the reduced crude enters the method or process system through line **1**. It is admixed with makeup hydrogen of about 97.5 mol percent purity from an external source by line **2**. It has been found appropriate in some instances to add water to the reaction zone in admixture with the charge stock. When this is deemed advisable, the water is added via line **3**. Normally, however, the use of water is not necessary or desirable. The hydrogen-reduced crude oil mixture is further admixed with a hydrogen-rich recycle vapor stream (about 80.0 mol percent hydrogen) from line **4**. The total charge, after suitable heat exchange with various streams not shown, is passed through heater **5** to raise the temperature of the charge mixture to about 705° F. In the practice of this embodiment it is preferred that the heated mixture in line **6** be further admixed with a hot (750° F.) recycle stream from line **7** to produce a total reactor charge mixture of about 720° F. and a pressure of about 2,165 p.s.i.g.

The heated feedstock in admixture with hydrogen is now passed via line **6** into conversion reactor **8** which contains catalyst disposed therein as a fixed bed; such catalyst being a composite of 2.0% by weight nickel, 16.0% by weight molybdenum on a carrier material comprising 68.0% by weight alumina, 22.0% by weight borontrifluoride, and 10.0% by weight silica. The hydrocarbon phase contacts the catalyst at a liquid hourly space velocity of about 8 based on the original reduced crude oil, or about 2 based on the combined hydrocarbon feed.

The total conversion product effluent leaves reactor **8** via line **9** in admixture with a hereinafter specified quench stream which had been added to the effluent via line **35** at a temperature of from 50° F. to 150° F., typically at about 120° F. Therefore, in line **9** there is the total conversion product effluent admixed with the quench stream which had been added via line **35**. Prior to the introduction of the quench stream, the conversion product effluent is at a temperature of about 780° F. and a pressure of about 2,075 p.s.i.g. Sufficient quench is added via line **35** to lower the temperature of the effluent stream to less than 750° F., but, preferably, no lower than 700° F. prior to entering hot separator **10**. Due to pressure drop through the transfer line, primarily, the pressure within hot separator **10** is about 2,060 p.s.i.g. A first liquid stream is withdrawn from separator **10** through line **11** and a portion of this first liquid stream is diverted through the line **7** to combine with the heated mixture in line **6** as previously mentioned. The remaining portion of the first liquid stream continues through line **11** into hot flash zone **24**.

A first vapor stream is removed from hot separator **10** through line **12**. The temperature of this first vapor stream is measured by temperature recording control device (TRC) **36** which opens or closes control valve **37** in accordance with the deviation of the measured temperature from a predetermined temperature (say, 745° F.) for this first vapor stream. Thus, if the measured temperature in line **12** is 760° F., TRC **36** would open control valve **37** thereby increasing the flow of liquid quench in line **35** in an amount sufficient to maintain the ultimate temperature of the vapor stream in line **12** at its predetermined level of, say, 745° F. After passing the temperature measurement point, the first vapor stream passes through condenser **13** whereby the temperature is lowered to about 120° F., with the pressure now being about 2,005 p.s.i.g. again due to the pressure drop through the system.

The various streams flowing into and out of hot separator **10** may have the following illustrative composition (exclusive of quench material):

	Line No.		
	9	11	12
Component, mols/hour:			
Water	19	--------	19
Ammonia	29	--------	29
Hydrogen Sulfide	2,559	185	2,374
Hydrogen	19,275	911	19,364
Methane	2,635	143	2,492
Ethane	206	22	184
Propane	176	20	156
Iso-butane	32	4	28
n-Butane	69	9	60
Iso-pentane	20	3	17
n-Pentane	18	3	15
C_6, 380° F	203	50	153
380° F.–650° F	360	199	161
650° F. +	2,299	2,139	160

It should be noted that the 19 mols/hour of water in the reaction zone effluent is water of saturation in the recycle hydrogen gas stream and/or is water present in the fresh hydrogen added to the system by means of line **2** and/or water carried in with the feed hydrocarbons.

The cooled first vapor stream passes through line **14** where, preferably, it is admixed with a portion of a fourth liquid stream in line **23** hereinafter described, and the resulting admixture is introduced into cold separator **15**. A second vapor stream containing about 80.0 mol percent hydrogen is removed via line **16**, is raised to a pressure of about 2,245 p.s.i.g. via compressor **17**, and is introduced through line **4** to combine with the feedstock and makeup hydrogen in line **1**, as hereinabove described. As previously mentioned, if water is added to the feedstock via line **3** then the water may be removed from the system via line **34** as indicated.

In conjunction with the material balance around hot separator **10**, the vatrious streams into and out of cold separator **15** may have the following illustrative composition:

	Line No.		
	14	16	18
Component, mols/hour:			
Water	[1] 991	19	0
Ammonia	29	0	0
Hydrogen Sulfide	2,654	1,957	697
Hydrogen	18,371	18,206	165
Methane	2,509	2,372	137
Ethane	199	158	41
Propane	187	128	59
Iso-butane	38	21	17
n-Butane	88	44	44
Iso-pentane	30	10	20
n-Pentane	29	9	20
C_6, 380° F	483	20	463
380° F.–650° F	581	0	581
650° F.+	602	0	602

[1] 972 mols/hour of water injection for ammonia removal. This, along with the 29 mols/hour of ammonia are removed via line 34.

Thus, the liquid quench stream (line **18**) comprises hydrocarbons boiling for the most part below 650° F. (about 78 mol percent 650° F.-hydrocarbons).

The first liquid stream in line **11** enters hot flash zone **24** at a temperature of about 745° F. and is at a substantially reduced pressure of from 100 p.s.i.g. to 500 p.s.i.g., typically about 220 p.s.i.g. A third liquid stream is removed via line **27** to be combined with a fourth liquid stream, hereinafter described, as the major product stream.

A third vapor stream is removed through line **25**, is cooled and condensed to about 105° F. in condenser **26**,

and, then passed into cold flash separator **20** through line **19**; however, it is to be noted that the cooled third vapor stream is, preferably, combined with a portion of second liquid stream in line **18** from cold separator **15**. The total material entering cold flash separator **20** via line **19** is at a pressure of about 200 p.s.i.g. and a temperature of about 105° F.

Referring again to cold separator **15**, the second liquid stream in line **18** is utilized, at least in part, as the quench for the reactor effluent, as hereinabove set forth. Thus, in the practice of this invention, an amount of second liquid stream responsive to the measured temperature in line **12** by TRC **36** is passed through control valve **37** sufficient to maintain the predetermined temperature of, say, 745° F. in line **12** prior to condenser **13**.

A fourth vapor stream comprising, for example, 97.5 mol percent propane and lighter normally gaseous components is removed from separator **20** via line **21**. Since this material contains a considerable quantity of hydrogen sulfide, it is generally subjected to a suitable treating process prior to being vented and/or being burned as flue gas. The particular economic aspects to be considered will dictate when the fourth vapor stream (line **21**) is suitably treated to recover the small quantities of C_4+ normally liquid hydrocarbons contained therein. A fourth liquid stream is removed from cold flash zone **20** via line **22** and a portion thereof is diverted through line **23** to be combined with the cold first vapor stream in line **14** thereby forming the total feed stream to cold separator **15**. The remaining amount of the fourth liquid stream is combined with the third liquid stream in line **27** and passed to heater **28**, and then, via line **29** into distillation tower **30**. It is to be understood that the third liquid stream in line **27** is combined with the unrecycled portion of the fourth liquid stream in line **22** for illustrative purposes only. For reasons peculiar to the particular operation involved, these streams may be separately fractionated to recover desired converted hydrocarbons therefrom.

Distillation column **30** will be operated at conditions of temperature and pressure sufficient to separate the desired fractions of converted hydrocarbons. The particular operating conditions will be known to those skilled in the art from general knowledge and from the teachings presented herein. However, for illustrative purposes, a gasoline boiling range material having an end boiling point of about 380° F. is removed from column **30** via line **31**. A middle distillate fraction (380° F. to 650° F.) is also removed via line **32**, and, finally, since the primary object of this example was to maximize the production of fuel oil (650° F.+) having a sulfur concentration not greater than 1.0% by weight, a converted hydrocarbon bottoms product is removed from fractionator **30** via line **33**.

Therefore, it can be seen from the above specific and illustrative embodiment that the present invention provides a method for hydrogenating (hydrocracking) a relatively heavy hydrocarbon feedstock in a facile and economical manner. The use of a relatively light hydrocarbon liquid stream as quench (line **35**) is particularly advantageous in that it is cooled and at a pressure substantially sufficient for introduction into the reactor effluent without significant additional high pressure pumping. The use of this stream also permits the complete elimination of heat exchange equipment in the transfer line between reactor **8** and hot separator **10** so that maximum pressure may be maintained through the separation steps in such a manner that the recovered hydrogen-containing stream (line **16**) may be advantageously reused in the process.

PREFERRED EMBODIMENT

Thus, from the description presented hereinabove, the preferred embodiment of the invention provides a method for hydrogenating a sulfur-containing hydrocarbon which comprises: (a) introducing said feedstock at an inlet temperature from 700° F. to 800° F. into a reactor vessel containing hydrogenating catalyst disposed as a fixed bed therein, maintained under hydrogenating conditions including the presence of hydrogen and a relatively high pressure; (b) withdrawing from said vessel an effluent stream containing hydrogenated hydrocarbons; (c) passing said effluent stream into a first separation zone under substantially the same pressure as maintained in said reactor vessel to produce a first vapor stream and a first liquid stream containing hydrogenated hydrocarbons; (d) measuring the temperature of said first vapor stream; (e) introducing hereinafter specified liquid quench stream at a temperature from 50° F. to 150° F. directly into the downstream side of said catalyst bed in an amount responsive to said temperature measurement sufficient to maintain a predetermined temperature of said first vapor stream; (f) cooling said first vapor stream to a temperature from 50° F. to 150° F.; (g) separating the cooled vapor stream in a second separation zone at substantially the same pressure as said first separation zone under conditions sufficient to provide a second vapor stream comprising hydrogen and a second liquid stream containing hydrogenated hydrocarbon; (h) passing at least a portion of said second liquid stream as quench into said downstream side as specified hereinabove in step (e); (i) recycling said second vapor stream to said reactor vessel; (j) recycling a portion of said first liquid stream to combine with said feedstock in step (a); and (k) recovering hydrogenated hydrocarbons in high concentration having reduced sulfur content.

A distinctly preferred embodiment would include the method wherein said feedstock boils within the range from 400° F. to 1100° F.

The invention claimed:

1. Method for converting hydrocarbons which comprises introducing feed hydrocarbons into a catalytic reaction zone maintained under conversion conditions including the presence of hydrogen gas; passing the total effluent from said zone into a first separation zone under conditions sufficient to produce a first vapor stream and a first liquid stream containing converted hydrocarbons; measuring the temperature of said first vapor stream; introducing hereinafter specified quench stream directly into the downstream side of said reaction zone in an amount sufficient to maintain a predetermined temperature of said first vapor stream responsive to said temperature measurement; cooling said first vapor stream to a temperature within the range from 50° F. to 150° F.; separating the cooled vapor stream in a second separation zone under conditions sufficient to provide a second vapor stream comprising hydrogen and a second liquid stream containing converted hydrocarbons; passing at least a portion of said second liquid stream as quench into said downstream side as specified hereinabove; and, recovering converted hydrocarbons in high concentration.

2. Method according to claim **1** wherein said conversion conditions are hydrogenating conditions and said predetermined temperature is less than about 775° F.

3. Method according to claim **2** wherein said second vapor stream is recycled to the hydrogenation reaction zone.

4. Method according to claim **2** wherein said predetermined temperature is more than 700° F.

5. Method for hydrogenating a sulfur-containing hydrocarbon feedstock which comprises the steps of:

(a) introducing said feedstock at an inlet temperature from 700° F. to 800° F. into a reactor vessel containing hydrogenating catalyst disposed as a fixed bed therein maintained under hydrogenating conditions including the presence of hydrogen and a relatively high pressure;

(b) withdrawing from said vessel an effluent stream containing hydrogenated hydrocarbons;

(c) passing said effluent stream into a first separation zone under substantially the same pressure as maintained in said reactor vessel to produce a first vapor stream and a first liquid stream containing hydrogenated hydrocarbons;

(d) measuring the temperature of said first vapor stream;

(e) introducing hereinafter specified liquid quench stream at a temperature from 50° F. to 150° F. directly into the downstream side of said catalyst bed in an amount responsive to said temperature measurement sufficient to maintain a predetermined temperature of said first vapor stream;

(f) cooling said first vapor stream to a temperature from 50° F. to 150° F.;

(g) separating the cooled vapor stream in a second separation zone at substantially the same pressure as said first separation zone under conditions sufficient to provide a second vapor stream comprising hydrogen and a second liquid stream containing hydrogenated hydrocarbons;

(h) passing at least a portion of said second liquid stream as quench into downstream side as specified hereinabove in step (e);

(i) recycling said second vapor stream to said reactor vessel;

(j) recycling a portion of said first liquid stream to combine with said feedstock in step (a); and

(k) recovering hydrogenated hydrocarbons in high concentration having reduced sulfur content.

6. Method according to claim 5 wherein said relatively high pressure is more than 1000 p.s.i.g. and said predetermined temperature is less than about 775° F.

7. Method according to claim 6 wherein said relatively high pressure is less than 3000 p.s.i.g. and said predetermined temperature is more than 700° F.

8. Method according to claim 7 wherein said feedstock is characterized by having at least 10% by volume boiling above 1050° F.

9. Method according to claim 5 wherein said feedstock boils within the range from 400° F. to 1100° F.

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U.S. Cl. X.R.

208—100, 112, 209, 210; 260—672