

July 13, 1971

D. M. BOYD
CONTROL SYSTEM

3,592,606

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2 Sheets-Sheet 1

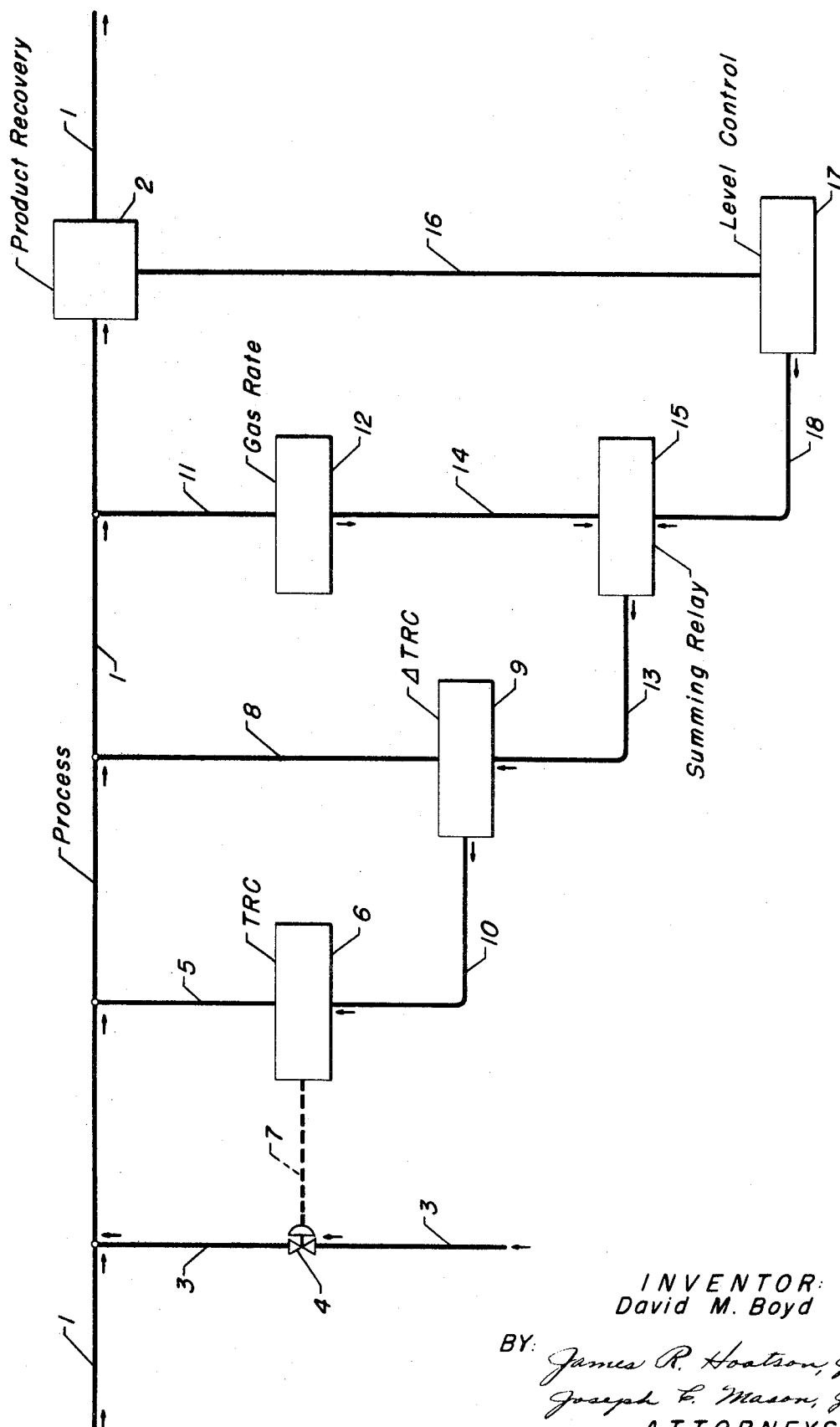


Figure 1

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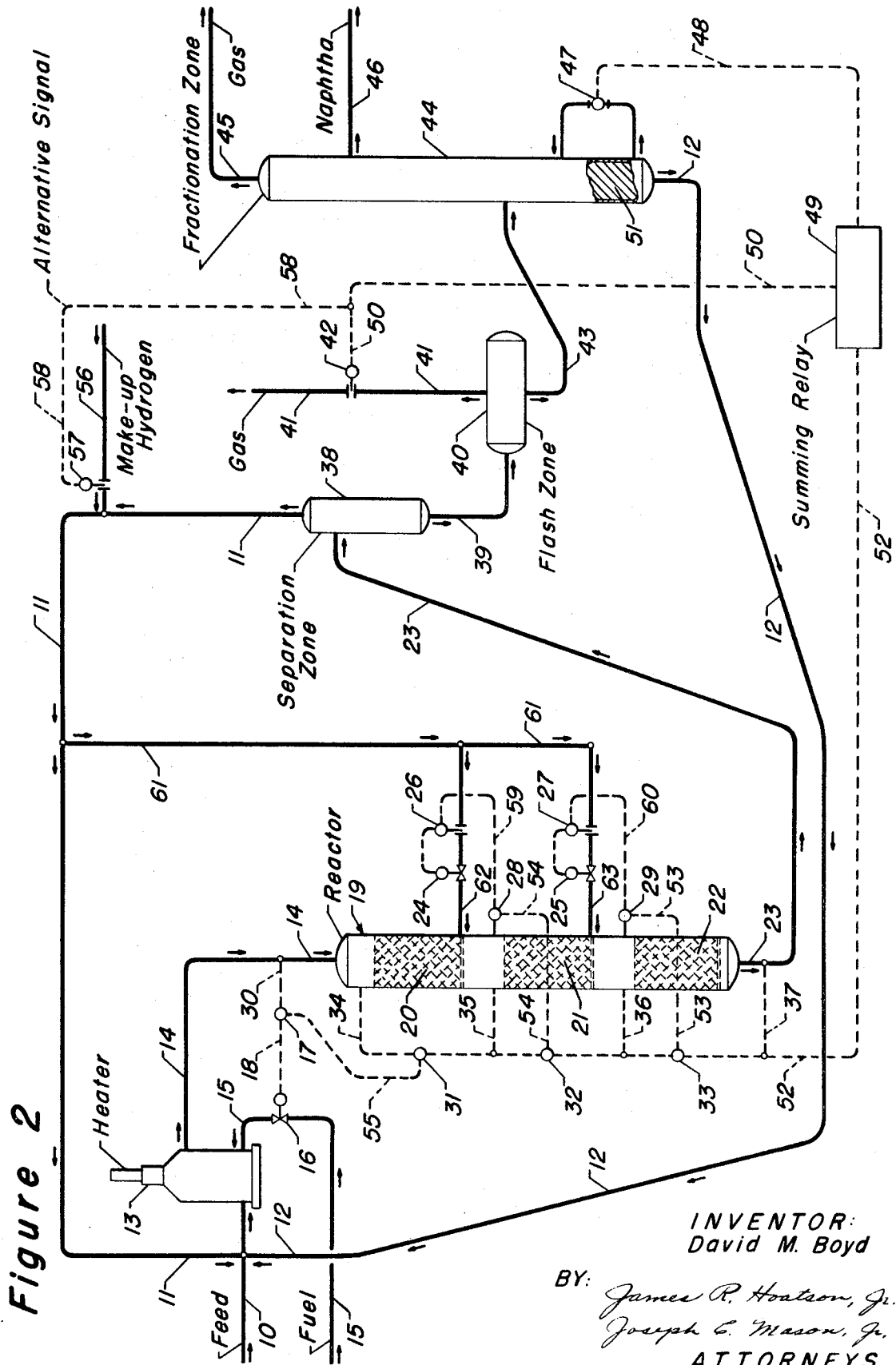
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CONTROL SYSTEM

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3 Claims

ABSTRACT OF THE DISCLOSURE

Control system for a hydrocracking reaction zone operating by temperature control on the feed inlet, reset by temperature differential across the catalyst beds. The desired temperature differential is determined by a combination fractionator-level control signal and gas make flow control signal.

BACKGROUND OF THE INVENTION

This invention relates to a control system. It also relates to a control system for a process conversion operation. It specifically relates to a control system for regulating a hydrocracking reaction zone. It particularly relates to a method for controlling a process responsive to slow time factor variables.

In the chemical processing industry today there is a need for ever increasing efficiency in the operation of process units. This increased efficiency has in a large measure been achieved through sophisticated instrumentation techniques. However, it has been found that in most processes there are a variety of slow time factor variables and fast time factor variables. In an effort to achieve stability of operation, the prior art has used a combination of these variables in an effort to achieve desired control of a given process. Basically, these factor variables operate against one another. Almost without exception a given process is influenced to a greater degree by slow time factor variables. However, the delay time in attempting to operate with the slow time factor variables aggravates the control problem to such an extent that instability or "swinging" of the process unit is the result.

Accordingly, it would be desirable to develop a control system which utilizes a unique combination of slow time and fast time factor variables in order to achieve the desired stability of the process unit.

Recently, the petroleum industry has attempted to further upgrade the liquid product yield from a barrel of crude oil by improvements in the hydrocracking reaction. Basically, hydrocracking or destructive hydrogenation effects definite changes in the molecular structure of hydrocarbons. Hydrocracking, may, therefore, be designated as cracking under hydrogenation conditions in such a manner that the lower boiling hydrocarbon products resulting therefrom are substantially more saturated than when hydrogen is not present in the reaction zone.

As presently practiced, the hydrocracking reaction involves contacting a fluid mixture to be converted with a suitable catalyst in the presence of hydrogen. Since the reaction is basically one which separates large molecules into smaller molecules, it is essentially exothermic in nature. In addition, since the hydrocracking reaction has not yet been shown to be perfectly selective, there is produced from the reaction zone a large quantity of normally gaseous hydrocarbons as well as the desired normally liquid hydrocarbons which have been upgraded in quality. In addition, there is also produced a residue of heavier materials which are ultimately separated from the reaction zone effluent and preferably returned or recycled to the reaction zone for further conversion. In essence, it is the desire of most hydrocracking reactions to achieve a

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100% conversion of the feed hydrocarbons into lighter and/or more valuable hydrocarbons. In other words, it is the practice of the prior art of hydrocracking to return the residual material entirely to the reaction zone, i.e. recycled to extinction.

It is evident to those skilled in the art that there are a number of process variables which influence the hydrocracking reaction. Illustrative of these variables include the inlet feed temperature, the differential temperature rise across the reaction zone, the light hydrocarbon gas make, the hydrogen consumption rate, etc. With a realization that the permutations and combinations of process variables are almost limitless, it is the desire of the art to achieve optimum control of the hydrocracking reaction in a facile and economical manner.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a control system for a fluid mixture conversion system.

It is another object of this invention to provide a control system for a fluid mixture conversion system utilizing a combination of slow time factor variables and fast time factor variables.

It is a specific object of this invention to provide a control system for a hydrocracking reaction zone which operates in a facile and economical manner.

Therefore, the present invention provides in a specific embodiment a control system for a hydrocracking reaction zone operating by temperature control on the feed inlet which is reset by temperature differential control across the catalyst bed. The desired temperature differential is determined by a combination of fractionator level control signal and gas make flow control signal. Alternatively, in lieu of the gas make flow control signal there may be utilized the hydrogen make-up flow control signal.

Broadly, the present invention provides in a fluid mixture conversion system wherein a fluid mixture to be converted is introduced through a first conduit into a conversion zone maintained under conversion conditions, conversion zone effluent containing normally liquid and normally gaseous components is passed into a separation zone, normally gaseous converted components are removed from the separation zone via a second conduit, normally liquid components are passed from the separation zone into a fractionation column, conversion products are removed from the upper portion of the fractionation column, a level of unconverted material is maintained in the lower portion of said fractionation column, and said unconverted material is returned to the conversion zone; a control system for maintaining the level of conversion of the fluid mixture at a predetermined value which comprises: (a) first means to establish a first signal functionally representative of the temperature of the fluid mixture in said first conduit, said first signal operatively connected to control means for heat input to said fluid mixture; (b) second means to establish a second signal representing the temperature differential of fluid into and out of said conversion zone, said second signal operatively connected to said first means to reset said first signal in a manner sufficient to maintain said differential temperature at a hereinafter specified value; (c) third means for establishing a third signal representative of the rate of flow of said gaseous components in the second conduit; (d) fourth means for establishing a fourth signal representing said liquid level in the lower portion of the fractionation column; and, (e) fifth means for summing said third and fourth signals thereby producing a fifth signal representative of the desired value of said differential temperature, said fifth signal operatively connected to said second means to reset the second signal.

Another broad embodiment of the invention provides in a fluid mixture conversion system wherein a fluid mixture to be converted is introduced through a first conduit into a conversion zone maintained under conversion conditions including the presence of a gaseous reactant introduced through a second conduit, conversion zone effluent containing normally liquid and normally gaseous components is passed into a separation zone, normally gaseous components are removed from the separation zone, normally liquid components are removed from the separation zone and passed into a fractionation column, conversion products are removed from the column as distillate streams, a level of unconverted material is maintained in the bottom of the column, and unconverted material is returned to the conversion zone; a control system for maintaining the level of conversion of the fluid mixture at a predetermined value which comprises: (a) first means to establish a first signal functionally representative of the temperature of the fluid mixture in said first conduit, said first signal operatively connected to control means for heat input of said fluid mixture; (b) second means to establish a second signal representing the temperature differential of fluid into and out of said conversion zone, said second signal operatively connected to said first means to reset said first signal in a manner sufficient to maintain said differential temperature at a hereinafter specified value; (c) third means for establishing a third signal representative of the rate of flow of said gaseous reactant in the second conduit; (d) fourth means for establishing a fourth signal representing said liquid level in the bottom of the fractionating column; and, (e) fifth means for summing said third and fourth signals thereby producing a fifth signal representative of the desired value of said differential temperature, said fifth signal operatively connected to said second means to reset the second signal.

Specific embodiments of this invention include the control systems hereinabove wherein said gas make flow rate and said gaseous reactant flow rate means consist of proportional-derivative control means.

DETAILED DESCRIPTION OF THE INVENTION

Even though this invention will be described with reference to a hydrocracking reaction, it will be evident to those skilled in the art that it has broad application to conversion processes in general which embody at least the following process variables: inlet temperature to the reaction zone, temperature change across the reaction zone, the production of normally gaseous components, and the utilization of a fractionating column to separate and recover desired conversion products. In addition, the invention has broad application to those processes which have the above mentioned variables plus a gaseous reactant as part of the feed to the conversion zone. Illustrative of other processes which may utilize the broad embodiments of this invention include catalytic reforming, catalytic cracking, ethylbenzene dehydrogenation to produce styrene, hydrodesulfurization, and the like.

Furthermore, the conversion zone, preferably, will contain catalytic compositions which influence or enhance the conversion reaction desired. In the practice of this invention the catalytic masses are desirably contained in fixed beds either as a single bed or as a plurality of fixed catalyst beds in a single vessel. If a plurality of catalyst beds are desirable, these may, of course, be contained in separate vessels. In the process referred to herein, the plurality of catalyst beds may vary from one to six, with the usual number of catalyst beds being three. Still further, the conversion reactions may either be endothermic or exothermic in nature. As previously mentioned, for the hydrocracking reaction the exothermic nature of the reaction may demand the utilization of quench streams between catalyst beds in order to control the reaction at its desired level. Alternatively, for the endothermic reactions, the effluent between the intermediate catalyst beds may be reheated by any suitable means in

order to maintain each catalyst bed at its proper conversion temperature.

As used herein, the term "level of conversion" is intended to embody the desired end result from subjecting a fluid mixture to the conversion system. For example, in the hydrocracking reaction, the level of conversion is desirably 100%; that is, the feed material is converted 100% into lighter boiling products. Similarly, in the catalytic reforming operation, the level of conversion is denoted as the percentage of hydrocarbons having a desired octane number relative to the feed hydrocarbons subjected to the platinum catalyst reaction zone. Also, as used herein, the term "gaseous reactant" is intended to include all those normally gaseous components which are at least in part consumed by the reaction mechanism. This, by its very nature, excludes the utilization of an inert diluent which is sometimes used in chemical processing for various reasons. Since it is an unusual chemical reaction which is 100% efficient with respect to the gaseous reactant, there will usually be in the effluent from the conversion zone, a significant portion of, for example, the gaseous reactants which have not been consumed. This unconverted portion of the gaseous reactant is separated and recycled to the reaction zone. Accordingly, as used herein, the term "gas make flow" or words of similar import are intended to exclude the flow of unconsumed gaseous reactant which is present in the effluent from the conversion zone. Of course, in most of the processes referred to herein, the gaseous reactant comprises hydrogen.

As will become evident from the description presented herein, the various components of the control system are well known to those skilled in the art and from general knowledge. The various materials, transducers, square root means, multipliers, controllers, accumulators, etc. are available commercially from any number of reputable manufacturers.

As previously mentioned, the present invention has specific application to the control of a hydrocracking reaction. Suitable charge stocks to hydrocracking processes are considered to include kerosene fractions, gas oil and white oil stocks, cycle stocks, fuel oil stocks, reduced crudes, the various high boiling bottoms recovered from the fractionating columns generally integrated within catalytic cracking operations and referred to as heavy recycle stocks, and other sources of hydrocarbons having a depreciated market demand due to the high boiling points of these hydrocarbons accompanied by the usual presence of asphaltic and other heavy hydrocarbonaceous residues. The present invention is particularly directed toward processing the heavier of the aforementioned feedstocks; that is, those heavy hydrocarbons having an initial boiling point of about 450° F. and an end boiling point of about 1000° F. or more.

In general, the hydrocracking reaction utilizes a conventional hydrocracking catalyst which may be an iron-group metallic component composited on a siliceous carrier material, such as alumina and silica. The hydrocracking catalyst may also comprise an iron group metallic component promoted by a Group VI-A metal, such as molybdenum, chromium, and/or tungsten. Other hydrocracking catalysts known to those skilled in the art may also be satisfactorily used in the practice of this invention and, in particular, satisfactory catalysts will include those which contain at least one metallic component selected from the metals of Groups VI-A and VIII of the Periodic Table. The active metallic components are generally employed in an amount from about 0.01% to about 20.0% by weight of the total catalyst.

Operating conditions for the hydrocracking reaction include a temperature from 400° F. to 900° F., a pressure from 500 p.s.i.g. to 5,000 p.s.i.g., liquid hourly space velocity (v./v./hour) from 0.5 to 15, and hydrogen in an amount from 500 to 15,000 standard cubic feet of hydrogen per barrel of hydrocarbon.

The process conditions in the hydrocracking conversion zone are preferably adjusted so as to provide a 100% conversion of the feedstock to lighter boiling hydrocarbons, such as gasoline, per pass through the reaction zone. On the other hand, the level of conversion may be adjusted so as to provide from 30% to 70% conversion of the feedstock to gasoline or naphtha per pass. Those skilled in the art familiar with the techniques of hydrocracking understand what is meant by the term "level of conversion" and use of the term herein embodies conventional definition.

The invention may be more fully understood with reference to the accompanying drawing which illustrates in FIG. 1 a schematic representation of a general conversion process and its method of control and in FIG. 2 the specific application of this invention to the hydrocracking of gas oil stocks to produce an upgraded naphtha material.

DESCRIPTION OF THE DRAWINGS

Referring now to FIG. 1, in line 1 is a schematic representation of a conversion process in which a fluid mixture is converted by a sequence of operations illustrated by the various points along line 1 resulting in a conversion product being collected in zone 2. Line 3 contains a means for varying a condition, such as the fuel input to a fired furnace which supplies heat to the fluid mixture in line 1. This means contains valve or other means 4 which controls the extent to which the heat input control means is being employed.

Line 5 carries a determination of the temperature of the fluid mixture being introduced into the conversion zone to temperature recorder controller (TRC) 6 which acts responsive to the condition through line 7 on valve 4, thereby maintaining the temperature at the set point at which TRC 6 is set.

Line 8 is a later stage in the process and transmits a determination of the temperature differential across the conversion zone into controller delta temperature recorder controller (Δ TRC) 9. The Δ TRC determination is a longer time factor variable than the variable controlled by TRC 6. Δ TRC 9 receives its signal via line 8 and attempts to maintain the temperature differential at a set point by acting through means 10 upon TRC 6 to change its set point so that the temperature sought to be established is established at a level more consistent with the desired temperature differential across the conversion zone.

In accordance with one embodiment of this invention, line 11 carries a determination of the normally gaseous component flow rate which has been separated from the effluent of the conversion zone. This flow rate is transmitted into flow controller 12 which, in accordance with the practice of this invention, must be a proportional-derivative control means; that is, it is essential that controller 12 not contain the integral function normally associated with flow rate controllers.

Finally, the product recovery zone 2 includes a fractionating column which senses by line 16 the level of unconverted material being maintained in the lower portion of the fractionating column. This level determination is passed via line 16 into level control means 17 which thereby produces an output signal representative of the level of such material which is transmitted via line 18 as one input signal to summing amplifier 15. The other input signal to summing amplifier or relay 15 is the signal generated by flow control means 12, such signal being transmitted from controller 12 via line 14 into amplifier 15.

Summing amplifier 15 performs the additive function on signals in line 14 and 18 thereby producing an output signal which is representative of the desired temperature differential which is to be maintained across the conversion zone. This output signal is transmitted via line 13 to Δ TRC 9 to change its set point so that the TRC condition it seeks to establish is established at a level more con-

sistent with the temperature differential demanded by the output signal from summing relay 15. In cascade fashion the change in Δ TRC 9 reflects a change in TRC 6 which activates an appropriate change in heat input control means represented by valve 4 in line 3.

Alternatively, the above control system will operate satisfactorily by including in flow controller 12 a determination of a gaseous reactant make-up stream into line 1 prior to the conversion zone. It is important to note that the make-up gaseous reactant flow determination is in lieu of a gas make flow determination. The other functions of the various components remain substantially the same.

It is to be noted that the level of conversion for the conversion system is basically determined by the amount of unconverted material which is accumulated in the lower portion of the product recovery fractionating column. However, the use of level controller 17 alone is not satisfactory since the time delay between the transmission of a signal from level control means 17 to heat input means at line 3 is too long to effectuate stable control of the process. It should also be noted that the utilization of gas rate controller 12 in either of the described embodiments is also not satisfactory alone. For example, the gas make composition may change, particularly with respect to its gravity, and this kind of change would automatically change its flow indication thereby giving an untrue indication that something needed adjusting in the conversion zone. Furthermore, the feed composition may change which would result in a distinct change in both the gas make and in the gaseous reactant demand. Therefore, the process cannot be satisfactorily stabilized by relying on either one of these gas flow rates.

Therefore, the essence of the present invention is embodied in the discovery that stability of the process could be achieved by combining a slow time factor variable, such as level control, with an intermediate time factor variable, such as gas flow rate, to reset the fast time flow control variable which is the conversion zone inlet temperature.

Referring now to FIG. 2, a suitable hydrocarbon feedstock to be converted, such as a gas oil fraction boiling between about 470° F. and 900° F. is introduced into the system via line 10. A gaseous reactant comprising hydrogen is also admixed with the feed stream from line 11. Still further a recycle stream comprising hereinafter specified unconverted material is also admixed with the feed stream from line 12. This total feed mixture passes through heater 13 in line 14 into reactor 19. For purposes of illustration, reactor 19 contains catalyst beds 20, 21, and 22 of the type referred to hereinabove.

Heater 13 is controlled by the flow of fuel in line 15 and flow control valve 16. The inlet temperature to reactor 19 is measured by TRC 17 which is connected via circuit 30 and which controls valve 16 via circuit 18.

In addition, there is placed across catalyst beds 20, 21, and 22, Δ TRC 31, 32, and 33, respectively. Δ TRC 31 senses the temperature across catalyst bed 20 via circuits 34 and 35. The operation of Δ TRC 31 is on TRC 17 via lead 55 in the manner previously discussed with reference to FIG. 1. In addition, hydrogen gas is utilized as a quench between each catalyst bed and is introduced into the system via lines 61, 62, and 63. The amount of quench gas is controlled by flow controller 26 which activates flow control valve 24 and flow controller 27 which activates control valve 25. In each instance, flow controller 26 is set by TRC 28 which is an indication of the temperature of the effluent leaving catalyst bed 20. This control is achieved by the connecting lead 52. Similarly, flow controller 27 is set by TRC 29 which senses the temperature of the effluent leaving catalyst bed 21. This latter control is achieved by connecting lead 60.

To achieve the control stability of the present invention it is to be noted that Δ TRC 32 resets TRC 28 via connecting lead 54. In similar manner, Δ TRC 33 resets TRC 29 via connecting lead 53.

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Thus, by operating in this manner, the temperature differential across each catalyst bed is maintained at a hereinafter described predetermined differential temperature level.

Referring again to the process flow, the total effluent from reactor 19 is withdrawn via line 23 and passed into separation zone 38 which is maintained under conditions sufficient to separate the unconverted hydrogen gas which is returned to the conversion zone via line 11 utilizing, preferably, compressor means (not shown) in the manner previously discussed. Make-up hydrogen as needed is introduced into the system via line 56 which has flow controller 57 appropriately placed in its conduit. The remainder of the effluent stream which has been separated in separation zone 38 and which comprises normally gaseous hydrocarbons and normally liquid hydrocarbons is passed via line 39 into flash zone 40.

Flash zone 40 is maintained under conditions sufficient to flash off in line 41 normally gaseous hydrocarbons such as methane, ethane, and propane. It is preferred that no substantial amount of butane be flashed off in line 41. The amount of this gas make is sensed by flow controller 42 which is in conduit 41.

The remaining portion of the effluent which now comprises primarily normally liquid hydrocarbons, but which may contain a significant portion of C_4 hydrocarbons, is withdrawn via line 43. If desired, the material may be passed into a conventional debutanizer column for the separation and recovery of C_4 hydrocarbons (not shown). The product recovery column is shown as column 44 and takes as its feed the material from flash zone 40 via line 43. The desired converted hydrocarbons, such as naphtha, which is removed via line 46 and/or normally gaseous hydrocarbons which are removed via line 45. Therefore, the converted products are removed as distillate streams from fractionation zone 44. A level of unconverted hydrocarbons is maintained in the bottom of fractionation zone 44 and is designated as point 51. Level control means 47 is utilized to sense and determine the level of unconverted material present in column 44. In the preferred embodiment of the invention the unconverted hydrocarbons are withdrawn from column 44 and passed via line 12 into reactor 19 in the manner previously described.

Returning now to the essence of the inventive control system of this invention, it is to be noted that the signal generated by flow controller 42 is passed via line 50 into summing relay 49. Similarly, the signal generated by level indicating means 47 is passed via lead 48 into summing relay 49. Summing relay 49 comprises the signals from 48 and 50 and produces an output signal which is passed via line 52 into Δ TRC's 31, 32, and 33, respectively.

Alternatively, the signal generated by flow control 57 which is representative of the make-up hydrogen rate is passed via line 58 and 50 into summing relay 49. In such event, no signal is used from flow controller 42.

Therefore, it is to be noted that the output signal from summing relay 49 is representative of the desired differential temperature which is to be maintained across the respective catalyst beds.

In operation, therefore, if the level in the bottom of fractionating column 44 begins to increase the signal from controller 47 would demand that the severity of the hydrocracking reaction be increased. Complementing this signal for increased severity is in one embodiment the amount of gas which is produced from this increased severity represented by the signal generated from flow controller 42. Therefore, the combined signals from controller 42 and 47 is in effect a compromise on the demands for increased severity which is ultimately represented by increased differential temperature across each catalyst bed which in turn is set between inlet temperatures to each catalyst bed represented by TRC's 17, 28, and 29, respectively.

Should the level of unconverted material in column 44 begin to decline, the reverse effect would take place,

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thereby calling for a reduction in the severity of reaction.

In other words, as an example, assume that level controller 47 decided that it needed a 4° F. more differential temperature in order to properly maintain its level in column 44. Control 47 would then send this signal to the differential temperature instruments 31, 32, and 33, which would increase appropriately the differential temperature across the catalyst beds. However, in a short length of time the flash gas rate of flow in line 41 or the hydrogen make-up rate in line 56 would significantly increase. The signal generated by controller 42 representing this flow increase or, alternatively, the signal generated by controller 57 would demand that the system decrease from the 4° F. ΔT originally desired by controller 47 to, for example a 2° F. ΔT . In due time, the level in column 44 would level to such an extent that level controller 47 would be satisfied by only a 2° F. increase in ΔT .

PREFERRED EMBODIMENT

In view of the description of the invention presented thus far, the present invention provides as its preferred embodiment that in a hydrocarbon conversion system wherein a hydrocarbon to be converted is admixed with a gaseous reactant thereby producing a conversion zone feed mixture; the feed mixture is passed at conversion temperature through a first conduit into a conversion zone comprising a plurality of fixed catalyst beds; the effluent from each catalyst bed except the last bed is contacted with additional gaseous reactant being introduced through at least a second conduit; the conversion zone effluent is removed from the last catalyst bed and separated in a separation zone into a normally liquid hydrocarbon fraction, normally gaseous reactant fraction, and normally gaseous hydrocarbon fraction; the normally gaseous hydrocarbon fraction is withdrawn from the separation zone via a third conduit; the normally liquid hydrocarbon fraction is withdrawn from the separation zone and passed into a fractionation column; converted hydrocarbon products are removed from the fractionation column as distillate streams; a level of unconverted hydrocarbons is maintained in the bottom of the column; the unconverted hydrocarbons are returned to the conversion zone in admixture with said feed mixture; and, make-up gaseous reactant is added to the system via a fourth conduit; a control system for maintaining the hydrocarbon conversion at 100% by volume of the hydrocarbon feed mixture which comprises: (a) first means to establish a first signal functionally representative of the temperature of the feed mixture in said first conduit, said first signal operatively connected to control means for heat input to said feed mixture; (b) second means to establish a second signal representing the temperature differential of hydrocarbons into and out of the first bed of said plurality of catalyst beds, said second signal operatively connected to said first means to reset said first signal in a manner sufficient to maintain the temperature differential across said first bed at a hereinafter specified value; (c) at least third means to establish at least a third signal representing the temperature differential of hydrocarbons into and out of each succeeding catalyst bed in said plurality of beds; (d) at least fourth means to establish at least a fourth signal representing the rate of flow of additional gaseous reactant in said second conduit, said fourth signal being responsive to said third signal in a manner sufficient to maintain the temperature differential across the next succeeding catalyst bed at said specified value; (e) fifth means to establish a fifth signal representative of the rate of flow of said make-up gaseous reactant in said fourth conduit; (f) sixth means for establishing a sixth signal representing said liquid level in the bottom of the fractionating column; and, (g) seventh means for summing said fifth and sixth signals thereby producing a seventh signal representative of the desired value of each said differential temperature, said seventh signal operatively connected to said second means, said third means, and

any other said means representing catalyst bed temperature differential in a manner to reset each said differential temperature signal.

I claim:

1. In a hydrocarbon conversion system wherein a hydrocarbon to be converted is admixed with a gaseous reactant thereby producing a conversion zone feed mixture; the feed mixture is passed at conversion temperature through a first conduit into a conversion zone comprising a plurality of fixed catalyst beds; the effluent from each catalyst bed except the last bed is contacted with additional gaseous reactant being introduced through at least a second conduit; the conversion zone effluent is removed from the last catalyst bed and separated in a separation zone into a normally liquid hydrocarbon fraction, normally gaseous reactant fraction, and normally gaseous hydrocarbon fraction; the normally gaseous hydrocarbon fraction is withdrawn from the separation zone via a third conduit; the normally liquid hydrocarbon fraction is withdrawn from the separation zone and passed into a fractionation column; converted hydrocarbon products are removed from the fractionation column as distillate streams; a level of unconverted hydrocarbons is maintained in the bottom of the column; the unconverted hydrocarbons are returned to the conversion zone in admixture with said feed mixture; and, make-up gaseous reactant is added to the system via a fourth conduit; a control system for maintaining the hydrocarbon conversion at 100% by volume of the hydrocarbon feed mixture which comprises:

(a) first means to establish a first signal functionally representative of the temperature of the feed mixture in said first conduit, said first signal operatively connected to control means for heat input to said feed mixture;

(b) second means to establish a second signal representing the temperature differential of hydrocarbons into and out of the first bed of said plurality of catalyst beds, said second signal operatively connected to said first means to reset said first signal in a manner sufficient to maintain the temperature differential across said first bed at a hereinafter specified value;

(c) at least third means to establish at least a third signal representing the temperature differential of hydrocarbons into and out of each succeeding catalyst bed in said plurality of beds;

(d) at least fourth means to establish at least a fourth signal representing the rate of flow of additional gaseous reactant in said second conduit, said fourth signal being responsive to said third signal in a manner sufficient to maintain the temperature differential across the next succeeding catalyst bed at said specified value;

(e) fifth means having proportional-derivative control to establish a fifth signal representative of the derivative of rate of flow of said make-up gaseous reactant in said fourth conduit;

(f) sixth means for establishing a sixth signal representing said liquid level in the bottom of the fractionating column; and,

(g) seventh means for summing said fifth and sixth signals thereby producing a seventh signal representative of the desired value of each said differential temperature, said second means, said third means, and any other said means representing catalyst bed temperature differential in a manner to reset each said differential temperature signal.

2. Control system according to claim 1 wherein said conversion zone comprises an exothermic catalytic hydrocracking reaction zone, said gaseous reactant comprises hydrogen, and said plurality of beds comprises from 2 to 6 beds.

3. Control system according to claim 1 wherein said control means for heat input to said feed mixture comprises flow control means on the fuel flow to a fired furnace.

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U.S. Cl. X.R.

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