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[54] **INTEGRATED PRODUCTION OF OLEFINS AND COKE**

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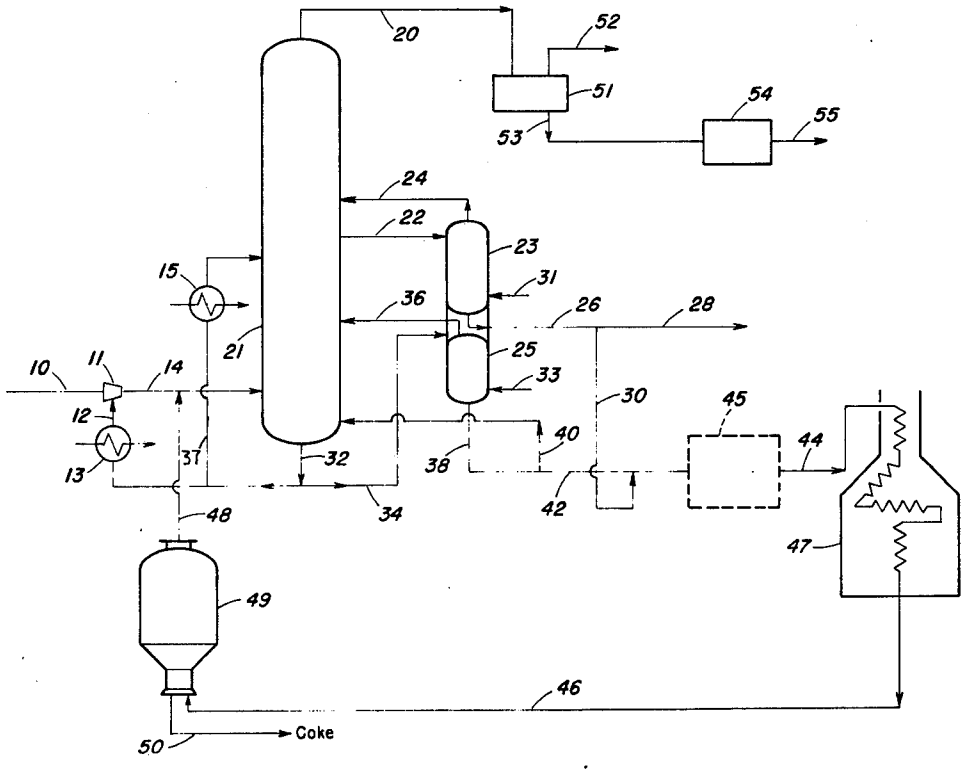
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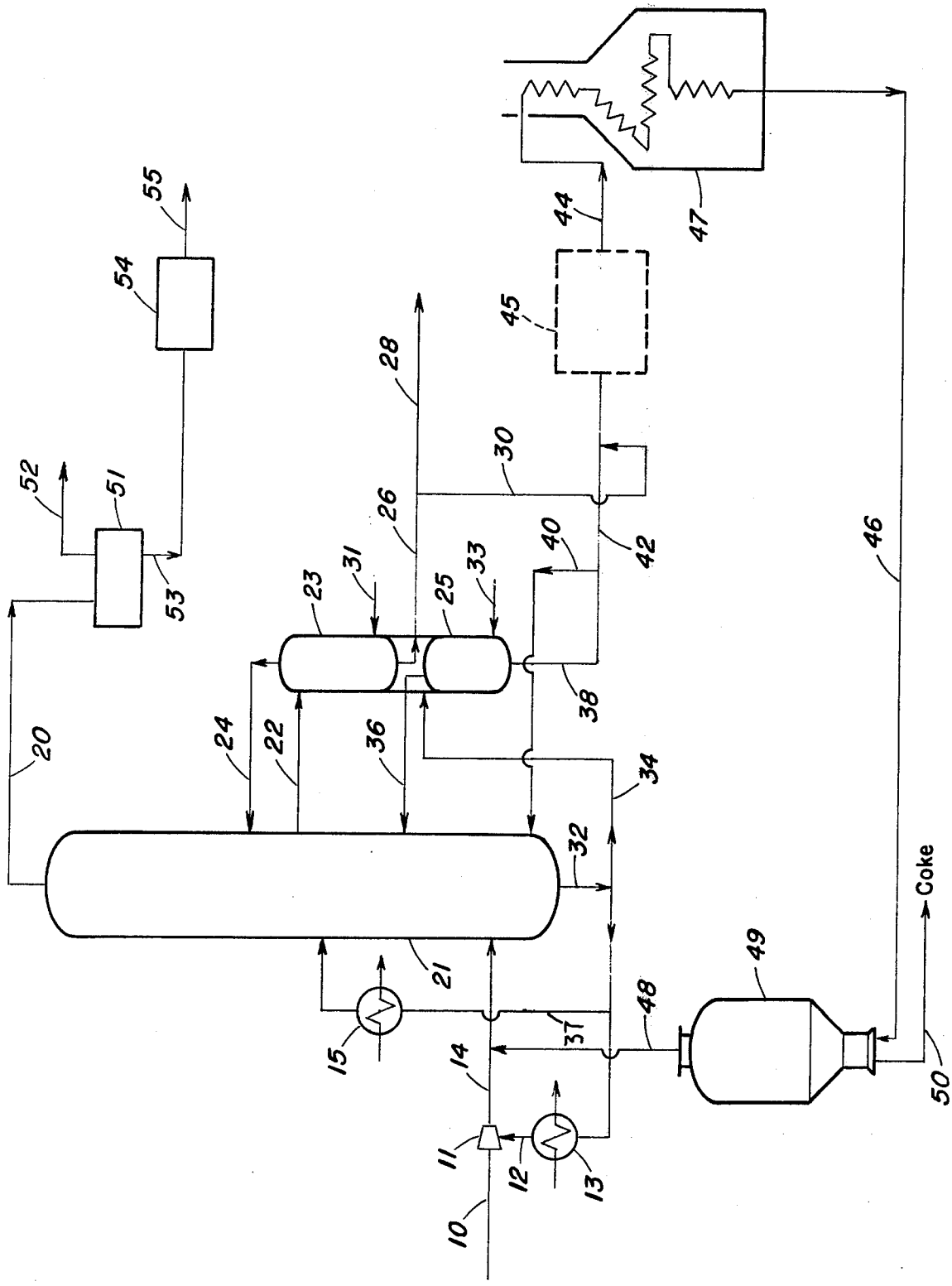
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[57] **ABSTRACT**

An integrated process for production of olefins and coke from an effluent from a pyrolysis furnace, in which a common fractionator is used to both fractionate the pyrolysis products and prefractionate hydrocarbon fractions for introduction into a coking apparatus. Coke drum overhead vapors are introduced into the pyrolysis effluent to serve as flux for a circulating quench fluid stream.

8 Claims, 1 Drawing Figure




Coke

INTEGRATED PRODUCTION OF OLEFINS AND COKE

This invention provides a method for integration of facilities for producing olefins from a pyrolysis heater effluent with facilities for producing coke from a similar effluent by delayed coking. The most common method in use today for production of olefins from hydrocarbon fractions is pyrolysis of the hydrocarbon fraction (which may range from a light fraction such as ethane, to heavier fractions such as gas oil) in a tubular heater. Pyrolysis processes of this type produce a gaseous effluent, usually having a temperature of 1,400°F or above, and which must be cooled for further processing. In many cases, more than one cooling, or quenching step, is required. Usually the first of these steps is conducted by passing the pyrolysis effluent gases into a heat exchanger, where the gases are cooled by indirect heat exchange with water, and the water is vaporized to steam. Generally, the subsequent quenching step consists of contacting the cooled gases (which are generally at temperatures of 700°F to 1,000°F) with a quenching fluid, usually consisting of a heavy hydrocarbon fraction obtained downstream of the quenching operation to further cool the gaseous effluent and condense a portion of it. The effluent is then fractionated in one or more fractionating towers into appropriate cuts, generally a light overhead cut, a middle distillate, and a bottoms, or heavy fraction. Traditionally, the bottoms fraction is recirculated for use as the quench fluid. A small portion of this recirculated stream, after being steam stripped, is withdrawn as the net fuel oil product.

The heat transferred to the quench oil from the cracked gas can be recovered by generating steam, preheating boiler feed water, or heating various process streams. During operation, the circulating quench oil viscosity increases markedly due to buildup of degradation products resulting from an insufficient purge. In order to maintain the proper viscosity and pumpability of the quench oil, an external flux oil is introduced into the quench circuit in customary practice if the net withdrawal of fuel oil is insufficient as a purge. This flux oil also permits a sufficiently high temperature to be maintained in the fractionating tower bottoms so that a higher pressure steam can be generated in the quench oil circuit. Without addition of flux oil, a lower circulating oil temperature must be maintained. In naphtha pyrolysis, this results in a low pressure steam generated from quench oil (e.g., 40–50 psig as opposed to 110–125 psig). The use of a flux oil thus permits this gasoline fractionator to be operated at a higher bottoms temperature, i.e., about 30°–40°F higher than without this addition of flux oil. The flux oil employed is preferably aromatic in nature, and may be, for example, catalytic cycle stock or heavy distillate from refinery thermal processing operations. Since at least part of the flux oil ends up in the pyrolysis fuel oil, i.e., the heaviest fraction obtained, it is downgraded in value. This loss in value of the flux stock can be quite significant.

In plants for production of olefins by pyrolysis of gas oil, as opposed to plants for pyrolysis of naphtha, the circulating quench oil is more effectively purged, since the net fuel oil produced by pyrolysis of gas oil is several times that for naphtha. The circulating quench oil rate, however, is considerably larger for a gas oil pyrolysis plant than for a similar plant for pyrolysis of naphtha, and intermittent use of flux oil is often required. Gas oil pyrolysis plants will generally have higher temperatures in the fractionator bottoms than naphtha pyrolysis plants, and thus serve to generate higher pressure steam from that heat content of the circulating quench oil.

Generally speaking, plants for production of coke are entirely separate from plants for production of olefins. However, it has been a common practice to produce coke from the heavy and/or middle boiling range fractions obtained from numerous petroleum refining and/or petrochemical production operations, such as vacuum bottoms, hydro-visbreaking residues, fuel oils, etc. In general, these feeds are introduced into a prefractionator, in which the desirable coke producing fractions are isolated, and lighter components, which either do not serve to produce coke or may be detrimental in its production, are separated. According to the technology employed, and the nature of the feedstock, one or more grades of coke can be produced, for example, metallurgical grade coke, amorphous coke for electrodes in aluminum manufacture, and a type of coke known variously as premium coke, needle coke, or graphitizable electrode grade coke. In general, these cokes are produced by a delayed coking process, in which the feedstock is introduced into a preheater in which it is heated to a certain temperature, generally from about 900°F to about 950°F, and the heated materials quickly introduced into one or more coke drums for production of coke. Vapors produced in the coke drums are drawn out as overhead and generally are returned to the prefractionating column. In U.S. Pat. No. 3,687,840 it has been disclosed that pyrolysis fuel oils can be rendered suitable as delayed coke feedstocks by subjecting the fuel oil to a pretreating step, in which sulfur is added prior to introducing the fuel oil into the coking heater.

It is an object of the present invention to provide a process for integrating an olefins production plant with a plant for producing coke from residues obtained during olefins production, such as pyrolysis fuel oil. It is a further object of this invention to produce integrated operations of this nature in which no externally supplied flux oil is required for the cracked gas quench fluid. Another object of the present invention is to provide a process for integrated production of olefins and coke from a gas oil feedstock. Yet another object of the present invention is to provide an integrated operation of any of these types in which a common fractionating system is used for fractionating the products of pyrolysis and prefractionating the feed to the coke production step.

SUMMARY OF THE INVENTION

In general the invention comprises a process for production of olefins and coke from a hydrocarbon feedstock comprising the steps of:

a. cracking the hydrocarbon feedstock to produce a gaseous effluent;

b. quenching the gaseous effluent by contacting it with a hydrocarbon quench fluid;

c. introducing coke drum vapors into the quenched gaseous effluent from step (*b*);

d. separating the product of (*c*) into (i) an overhead fraction comprisig gasoline and lighter hydrocarbons, (ii) a middle fraction having a boiling range

of about 360°F to about 600°F, and (iii) a bottoms fraction having a boiling range of above about 600°F;

e. recycling the bottoms fraction of (*d*) to serve as the hydrocarbon quench fluid in step (*b*);

f. recovering olefins from the overhead fraction of (*d*);

g. subjecting another portion of the bottoms fraction of (*d*) to a delayed coking operation including coke drums; and

h. introducing overhead vapors from the coke drums into step (*c*).

DETAILED DESCRIPTION OF THE INVENTION

The invention can be more clearly understood from the following description and the FIGURE, which depicts a flow diagram of a process for carrying out the invention.

A gaseous effluent from a cracking heater (not shown) which has been previously quenched, for example, by passage through an indirect heat exchanger by heat exchange with water, is conducted through line **10** to quench vessel **11**, where it is contacted by a hydrocarbon quench fluid, hereinafter described, introduced through line **12**. The quenched gaseous effluent plus quench liquid proceeds through line **14**, being mixed with coke drum overhead vapors from line **48** from a coke drum source as specified hereinafter, and the combined mixture in line **14** is introduced into gasoline fractionator **21**.

Three major fractions are recovered from the gasoline fractionator. An overheat fraction, comprising gasoline and lighter, lower boiling hydrocarbons (including olefins) is removed in line **20**. A side stream comprising primarily a middle distillate boiling in the range of about 360°F to 600°F is removed in line **22**, and a bottoms or heavy fuel oil fraction, comprising mainly hydrocarbons boiling above 600°F is removed in line **32**.

The overhead fraction in line **20** is further processed downstream to recover olefins, such as ethylene, propylene, etc. and pyrolysis gasoline. For example, the overhead product in line **20** may be subsequently cooled in section **51**, and lighter hydrocarbons including olefins removed in line **52**, while a pyrolysis gasoline is removed in line **53** and hydrotreated in unit **54** by any of the numerous techniques available to produce a stable aromatic gasoline or gasoline blending components.

The contents of the side stream withdrawn in line **22** are stripped in vessel **23** by steam introduced through line **31**, with the lighter hydrocarbons (boiling below about 400°F), returned to the fractionator in line **24** and a fraction boiling between 360°F and about 600°F withdrawn from the bottom of the stripper in line **26**. The greater part of this fraction is recovered in line **28** for further use, for example as feed for a carbon black process, and a smaller portion is introduced through line **30** into the feed to the coking unit as hereinafter described.

The heavier fractions withdrawn from the bottom in line **32** are divided into three portions. One portion is returned to the gasoline fractionator **21** in line **37**, being used to supply heating to various process streams in heat exchanger or exchangers **15**. A second portion is conducted through one or more heat exchangers **13**, in which it may be utilized to convert process water to 100–200 psig pressure steam (depending on this pyrolysis feedstock) and then used in line **12** as the quench fluid for the gaseous effluent from line **10**. A third portion of the bottoms or fuel oil fraction is conducted by a line **34** into stripper **25** and stripped by countercurrent contact with steam introduced through line **33**. Lighter boiling hydrocarbons are returned to the gasoline fractionator via line **36**. The bottoms from stripper **25** are withdrawn in line **38**, a portion thereof returned to the gasoline fractionator in line **40**, and the remainder passed via lines **42** and **44** into a delayed coking unit. A portion of the middle range distillate may be introduced to this line from line **30**. The coking feed is passed through a coking heater **47**, in which it is heated to a temperature of between about 900°F and about 950°F, then quickly passed in line **46** to coke drum or drums **49**, in which coke is formed. The coke is eventually removed via line **50**. In coke drums **49**, vapors are generated, ranging from hydrogen and light hydrocarbons such as methane, up to hydrocarbons boiling in the gas oil range. These are removed from the coke drums via line **48** and introduced into the quenched gaseous effluent in line **14** prior to its introduction into gasoline fractionator **21**. As described hereinafter, the introduction of these coke drum vapors into the quenched gaseous effluent eliminates the need for an externally supplied flux oil in the quench liquid circulation system.

The injection of coke drum overhead vapors from line **48** into the cracked gaseous effluent in line **14** has several advantages. First, it permits the fractionation of the coke drum overhead product to be conducted in the same equipment as is used for fractionation of products from the pyrolysis unit. Consequently, no additional units are needed for downstream processing of the coke drum overhead products; these are processed together with the pyrolysis products in the various downstream units for olefins recovery, gasoline recovery, middle distillate treatment, etc. This is particularly important with the downstream processing of the lighter coker products, as the overall olefins production from the plant can be thus increased without requiring separate equipment to recover such olefins from the coke drum overhead. Similarly, coker gasoline in the coke drum overhead can be processed together with pyrolysis gasoline in units **54** etc. The gasoline components of the coke drum overhead are highly aromatic and thus quite valuable for gasoline blending. Secondly, the injection of the coke drum overhead vapors into the cracked gaseous effluent serves to replace the requirement for an external flux oil for the circulating quench liquid, as the gas oil and other heavier fractions in the coke drum vapors functions as flux oils. Additionally, processing a portion of the bottoms (i.e., fuel oil) through the coking heater results in conversion of unstable products from quenching into coke, thus eliminating the potential build-up of such components in the circulating quench oil system, especially when a high recycle rate of fuel oil through the coking unit is maintained.

The inclusion of coke drum overhead products in the stream to be fractionated may also increase the amount of the 360°–600°F distillate fraction recovered in lines **26** and **28**. This combined distillate fraction, being highly aromatic, should make an excellent carbon black feedstock. Alternatively this distillate could be upgraded by hydrotreating to improve color and stabil-

ity characteristics. The hydrotreated distillate would then be suitable for blending for No. 2 fuel oils.

A portion of this 360°–600°F distillate is upgraded to gasoline and lighter components in being passed via lines **30** and **44** through the coking heater, thus further increasing the yield of valuable gasoline products in the overhead line **20.** The balance of this distillate remains essentially unconverted and thus builds up a recycle in the fractionator/coker circuit.

The fuel oil passed through the delayed coking unit can be either converted to metallurgical or amorphous coke, or to premium grade electrode coke, according to the type of product desired. When converting pyrolysis residues to coke, the feed in line **42** should be conducted through a soaking drum and other apparatus, generally indicated as **45,** which is more fully described in U.S. Pat. No. 3,687,840 assigned to The Lummus Company, and which is incorporated herein by reference.

The invention hereindescribed can be applied to processing of effluents obtained by cracking hydrocarbons ranging from light hydrocarbons such as ethane, propane and mixtures thereof, to heavier hydrocarbons such as naphtha or gas oils. However, it is most suitable in connection with treatment of effluents resulting from cracking of heavier hydrocarbons, particularly gas oils, as these heavier hydrocarbons, when cracked, produce greater amounts of fuel oils. On the other hand, it should be pointed out that it is not necessary to produce large amounts of coke for this invention to be useful, since, in any case, the improvement in quality of the distillate and gasoline fractions resulting from the inclusion of substances from the coke drum overhead, and the elimination of separate downstream processing units for the coke drum overhead vapors, are in themselves quite advantageous.

The following example is included to illustrate the application of the invention to the integration of a plant producing about 320,000 metric tons per year (MTA) ethylene from atmospheric gas oil and naphtha feedstocks (gas oil: naphtha, 60/40 by weight) with a delayed coking facility.

The feedstock is subjected to pyrolysis and the gaseous effluent from the pyrolysis heater, optionally partially quenched by indirect heat exchange with water, is contacted in quench vessel **11** with the circulating pyrolysis fuel oil from line **12.** The mixture of quenched pyrolysis effluent is combined with coke drum overhead vapors (at about 890°F) from line **48** and introduced into gasoline fractionator **21** operating at an overhead temperature of about 230°F and a bottoms temperature of about 440°–450°F. The overhead fraction is withdrawn through line **20** and further processed to recover ethylene, other light hydrocarbons and pyrolysis gasoline. Middle distillate is removed in sidestream **22** and stripped, and the lighter portion (ca. 300°–360°F) returned to the fractionator. About 94,600 MTA of this fraction (pyrolysis gas oil) is recovered as such, and the remainder, amounting to 173,600 MTA is introduced into the coker feed in line **30.** The pyrolysis fuel oil (600°F+ bottoms fraction) is divided into three parts, with about 347,200 MTA fed to the coker. The combination of pyrolysis gas and pyrolysis fuel oil simulates a full-range pyrolysis fuel oil (400°F+ boiling range) but, as mentioned above, the bottoms fraction (600°F+) can be coked alone. About 48,600 MTA green coke is produced.

The operation in this manner will result in the production of about 1,100 MTA additional ethylene over that produced in the ethylene plant without integration. Part of this additional ethylene is recovered from this coke drum vapors per se, another part results from recycling and pyrolysis of ethane from the coke drum vapors. The pyrolysis gasoline production of the plant is about 308,000 MTA. This is about 8–8½% higher than that of the unintegrated ethylene plant. An additional amount of about 1,000 MTA of LPG is also produced. The pyrolysis gas oil (360°–600°F distillate) production is not quantitatively increased but the quality, in terms of color and oxidation stability is greatly improved by cracking in the coke drums and production of coke from unstable constituents.

While the above description of the invention has included a number of specific limitations, it should be noted that variations in the exact manner of carrying out the invention may be obvious to those skilled in the art, and therefore the invention is not to be considered limited to specific processing conditions and/or steps described hereinabove, but only by the scope of the claims appended hereto.

We claim:

1. A process for production of olefins and coke from a hydrocarbon feedstock comprising:

a. cracking the hydrocarbon in the presence of steam to produce a gaseous effluent;

b. quenching the gaseous effluent by contacting it with a hydrocarbon quench fluid;

c. introducing coke drum vapors into the quenched gaseous effluent from step (b);

d. separating the product of (c) into (i) an overhead fraction comprising gasoline and lighter hydrocarbons, (ii) a middle fraction having a boiling range of about 360° F to about 600° F, and (iii) a bottoms fraction having a boiling range of above about 600° F;

e. recycling a portion of the bottoms fraction of (d) to serve as the hydrocarbon quench fluid in step (b);

f. recovering olefins from the overhead fraction of (d);

g. subjecting another portion of the bottoms fraction of (d) to a delayed coking operation, including coke drums; and

h. introducing overhead vapors from the coke drums into step (c).

2. A process according to claim **1** further comprising recovering the middle fraction from step (d).

3. A process according to claim **1** in which a portion of the middle fraction from step (d) is combined with the portion of the bottoms fraction subjected to delayed coking in step (g).

4. A process according to claim **1** further comprising recovering a gasoline fraction from the overhead fraction of step (d).

5. A process according to claim **1** in which the bottoms fraction of (d) recycled to serve as the hydrocarbon quench fluid is additionally used to generate steam by indirect heat exchange with water.

6. A process according to claim **1** wherein the hydrocarbon feedstock comprises a gas oil.

7. A process according to claim **1** wherein the hydrocarbon feedstock comprises a naphtha.

8. A process according to claim **1** wherein premium electrode grade coke is produced.

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