comprise, *e.g.*, a primary fractionator. Generally, a cooling stage, typically either a direct quench or indirect heat exchange is located between the pyrolysis furnace and the separation stage.

[0064] Cooling the second mixture **105** downstream of the pyrolysis furnace **102** is performed by a system **110** comprising one or more transfer line heat exchangers ("TLE"). For example, the transfer line heat exchangers can cool the second mixture to about 650ºC, in order to efficiently generate super-high pressure steam **108** which can be utilized by the process or conducted away. When a TLE is used, the second mixture is a cooled second mixture **105'**. Note that in some embodiments, system **110** is not used. The second mixture **105** (or cooled second mixture **105'**) can be subjected to direct quench to form a third mixture **119** (*e.g.*, a quenched mixture) at a quench point **220** typically between the furnace outlet **103** of the pyrolysis furnace **102** and the separation stage (discussed below). The quench can be accomplished by contacting the second mixture with a quench oil composition, in lieu of, or in addition to the treatment with transfer line exchangers. Where employed in conjunction with at least one transfer line exchanger, the quench oil **215** is introduced at a point downstream of the transfer line exchanger(s). In this embodiment, the quench oil composition **215** comprises the mid-cut flowing through outlet **213** from the hydrotreatment process **200** (*e.g.*, SATC process). In other embodiments, the quench oil composition comprises one or more of a solvent stream produced during a hydrotreatment process (*e.g.*, a hydroprocessed tar and/or a TLP). As stated above, the hydroprocessed tar and TLP are produced during the SATC process **201**. The quench oil composition optionally includes other liquid quench oils, such as those obtained by a downstream quench oil knock-out drum, pyrolysis fuel oil and water, which can be obtained from conventional sources, *e.g.*, condensed dilution steam.

[0065] In certain embodiments, the side product flowing through side product line **175** can be added to the effluent flowing from the pyrolysis furnace and or TLE at mixing point **120**. The side product of product line **175** generally has a normal boiling point range of about 93°C (200°F) to 538°C (1000°F), e.g., 121°C (250°F) to 427°C (800°F), such as 149°C (300°F) to 371°C (700°F). In aspects where SCT is separated upstream of the primary fractionator (not shown) and conducted away for SCT processing in an SATC process, the primary fractionator bottoms **135** typically has a normal boiling point range of about 93°C (200°F) to 538°C (1000°F), e.g., 121°C (250°F) to 427°C (800°F), such as 149°C (300°F) to 371°C (700°F). Those skilled in the art will appreciate that side product line **175** of Fig. **2** is not a conventional quench oil cut, and as such it differs from side product line **175** of Fig. **1.** The side product cut

of **175** of Fig. **2** comprises (i) at least a portion of the recycled side product cut introduced into the cooled pyrolysis effluent at location **120,** and (i) that portion of the quench oil composition that is (a) introduced into the partially-quenched pyrolysis effluent at location **220** and (b) is in an appropriate boiling point range for removal from the primary fractionator **125** at location **170**. The adding of the side product flowing through side product line **175** to the effluent flowing from the pyrolysis furnace and or TLE at mixing point **120** can be performed when process begins, that is, during the time the hydrotreatment process (*e.g.*, the SATC process) is generating the desired quench oil composition. In some embodiments, the steam cracking process includes a control valve **240** that can be actuated to direct the side product stream to line **245**, such that side product stream is no longer flowing to mixing point **120**.

[0066] A separation stage can be utilized downstream of the pyrolysis furnace **102** and downstream of the cooling system **110** (*e.g.*, transfer line exchanger) and/or quench point **120** for separating from the third mixture **119** (*e.g.*, the quenched mixture) one or more of light olefin, side product, SCN, SCGO, SCT, or water. Various separation apparatus may be utilized such as a primary fractionator **125**. Optional separation equipment can be utilized in the separation stage, *e.g.*, one or more flash drums, fractionators, water-quench towers, indirect condensers, etc., such as those described in U.S. Pat. No. 8,083,931. In the separation stage, a fourth mixture **130** (e.g., a tar stream) can be separated from the other components in the fractionator, with the fourth mixture **130** comprising ≥10.0 wt. % of the third mixture's TH based on the weight of the third mixture's TH. When the pyrolysis process is steam cracking, the fourth mixture **130** (the primary fractionator bottoms) generally comprises SCT, which is obtained, *e.g.*, from an SCGO stream and/or a bottoms stream of the steam cracker's primary fractionator, from flash-drum bottoms (*e.g.*, the bottoms of one or more flash drums located downstream of the pyrolysis furnace and upstream of the primary fractionator), or a combination thereof. The fourth mixture **130** flows from the primary fractionator **125** through outlet **135** via pump **136** to the SATC process inlet **237** to undergo a SATC process.

[0067] The primary fractionator **125** also contains outlets for other components flowing through the primary fractionator. For example, hydrocarbons in the SCN boiling range are conducted away from the primary fractionator **125** via SCN outlet **140** and pump **142** through SCN line **145**; hydrocarbons in the SCGO boiling range are conducted away from the primary fractionator **125** via SCGO outlet **150** and pump **152** through SCGO line **155**; water can be removed from the primary fractionator **125** via water outlet **160** and pump **162** through water

CLAIMS:

We claim:

1. A method for decreasing reactor fouling in a steam cracking process comprising:

steam cracking a hydrocarbon feed to obtain a quench oil composition comprising a concentration of donatable hydrogen of 0.5 wt. % or more based on a total weight percent of the quench oil composition;

adding the quench oil composition to a steam cracker effluent flowing from a pyrolysis furnace to form a mixture;

separating a steam cracker tar from the mixture;

hydroprocessing at least a portion of the separated steam cracker tar in a first hydroprocessing zone under catalytic hydroprocessing conditions to convert at least a portion of the feedstock to a first hydroprocessed product;

separating from the first hydroprocessed product one or more of:

(i) an overhead stream comprising ≥ about 1.0 wt. % of the first hydroprocessed product;

(ii) a mid-cut stream comprising ≥ about 20 wt. % of the first hydroprocessed product; and

(iii) a bottoms stream comprising ≥ about 20 wt. % of the first hydroprocessed product; wherein the quench oil includes one or more of at least a portion of the overhead stream, at least a portion of the mid-cut stream, and at least a portion of the bottoms stream; and

hydroprocessing at least a portion of the bottoms stream in a second hydroprocessing zone under second catalytic hydroprocessing conditions to convert at least a portion of the bottoms stream to a second hydroprocessed product, wherein the second hydroprocessed product has a sulfur content of 1.5 wt. % or less based on the total weight of the second hydroprocessed product.

2. The method of claim 1, further wherein the steam cracker effluent is cooled in at least one transfer line exchanger before the quench oil composition is added to the steam cracker effluent.

3. The method of claim 2, wherein the steam cracker tar is separated from the steam cracker effluent as a bottoms stream from a tar knock out drum and/or as a bottoms stream from a primary fractionator.

4. The method of any of claims 1 to 3, wherein the quench oil composition has a normal boiling point range of from 50ºF to 1400ºF.

5. The method of claim 4, wherein the quench oil composition has a normal boiling point range of from 100ºF to 1400ºF.

6. The method of claim 5, wherein the quench oil composition has a boiling point of from 300ºF to 700ºF.

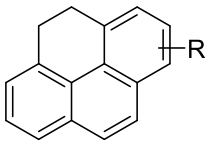
7. The method of any of claims 1 to 6, wherein the quench oil composition comprises a hydroprocessed tar.

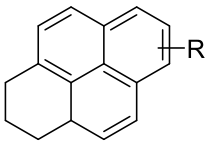
8. The method of any of claims 1 to 6, wherein the quench oil composition comprises total liquid products from one or more of the first hydroprocessing zone and the second hydroprocessing zone.

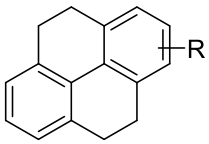
9. The method of any of claims 1 to 8, further comprising heating the feedstock before hydroprocessing the feedstock in the first hydroprocessing zone.

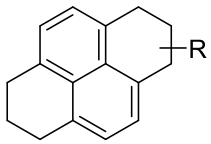
10. The method of any of claims 1 to 9, wherein the concentration of donatable hydrogen is 1.5 wt. % or more based on the total weight percent of the quench oil composition.

11. The method of any of claims 1 to 10, wherein the quench oil composition comprises one or more compound classes of the formula

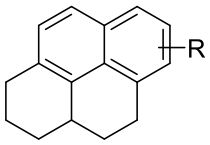


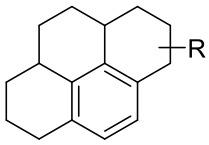
(I-1), 

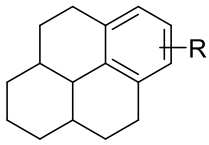
(I-2), 

(I-3), 

, (I-4),



(I-5), 

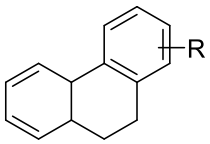
(I-6), and 

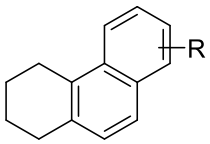
(I-7),

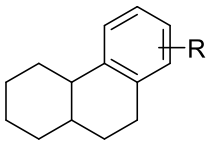
wherein:

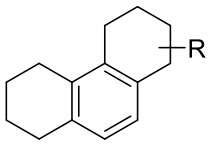
R is one or more R groups, wherein each R group is a C_1 to C_{10} alkyl radical.

12. The method of any of claims 1 to 11, wherein the quench oil composition comprises one or more compound classes of the formula



(II-1), 

(II-2), 

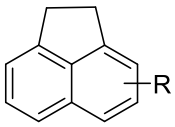
(II-3), and 

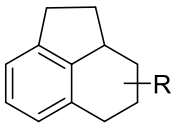
(II-4),

wherein:

R is one or more R groups, wherein each R group is a C_1 to C_{10} alkyl radical.

13. The method of any of claims 1 to 12, wherein the quench oil composition comprises one or more compound classes of the formula



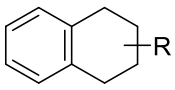
(III-1) and 

(III-2),

wherein:

R is one or more R groups, wherein each R group is a C_1 to C_{10} alkyl radical.

14. The method of any of claims 1 to 13, wherein the quench oil composition comprises one or more compound classes of the formula



(IV-1),

wherein:

R is one or more R groups, wherein each R group is a C_1 to C_{10} alkyl radical.

15. The method of any of claims 11 to 14, wherein a weight percent of each compound class in the quench oil composition is:

Compound Class Formula	weight %	Compound Class Formula	weight %
I-1	9.0% or less	II-1	25.0% or less
I-2	3.0% or less	II-2	30.0% or less
I-3	3.0% or less	II-3	30.0% or less
I-4	19.0% or less	II-4	30.0% or less
I-5	9.0% or less	III-1	30.0% or less
I-6	20.0% or less	III-2	30.0% or less
I-7	18.0% or less	IV-1	50.0% or less

based on a total weight percent of the quench oil composition.

16. The method of any of claims 11 to 14, wherein a weight percent of each compound class in the quench oil composition is:

Compound Class Formula	weight %	Compound Class Formula	weight %
I-1	4.5% or less	II-1	12.0% or less
I-2	1.5% or less	II-2	15.0% or less
I-3	1.5% or less	II-3	15.0% or less
I-4	10.0% or less	II-4	15.0% or less
I-5	4.5% or less	III-1	15.0% or less
I-6	10.0% or less	III-2	15.0% or less
I-7	9.0% or less	IV-1	25.0% or less

based on the total weight percent of the quench oil composition.

17. A steam cracking process, comprising:

(a) steam cracking a hydrocarbon feed to produce a steam cracker effluent;

(b) adding a quench oil composition to the steam cracker effluent to produce a quenched mixture, wherein the quench oil composition comprises a concentration of donatable hydrogen of 0.5 wt. % or more based on a total weight percent of the quench oil composition;

(c) separating steam cracker tar from the quenched mixture;

(d) hydroprocessing at least a portion of the separated steam cracker tar in a first hydroprocessing zone under catalytic hydroprocessing conditions to produce a first hydroprocessor product comprising hydroprocessed steam cracker tar;

(e) separating at least a portion of the hydroprocessed steam cracker tar from the first hydroprocessor product; and

(f) separating from the first hydroprocessor product

(i) an overhead stream comprising ≥ about 1.0 wt. % of the first hydroprocessed product;

(ii) a liquid-phase mid-cut stream comprising ≥ about 20 wt. % of the first hydroprocessed product; and

(iii) a bottoms stream comprising ≥ about 20 wt. % of the first hydroprocessed product;

(g) dividing the mid-cut stream into at least first and second portions;

(h) transferring the first portion to step (d), wherein the catalytic hydroprocessing conditions include combining at least a portion of the separated steam cracker tar with at least a portion of the transferred first portion; and transferring the second portion to step (b), wherein the quench oil composition comprises at least a portion of the transferred second portion.