BRIEF DESCRIPTION OF THE DRAWINGS

[0009] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0010] FIG. 1 depicts a schematic of an illustrative system for removing one or more contaminants from a refinery gas and/or a pre-treated refinery gas recovered from a refinery facility, according to one or more embodiments described.

[0011] FIG. 2 depicts a schematic of an illustrative pre-treatment stage for pre-treating a refinery gas and recovering a fuel gas and a pre-treated refinery gas therefrom, according to one or more embodiments described.

[0012] FIG. 3 depicts a schematic of another illustrative pre-treatment stage for pre-treating a refinery gas to remove at least a portion of any nitrogen oxide and/or at least a portion of any molecular oxygen, according to one or more embodiments described.

[0013] FIG. 4 depicts another illustrative pre-treatment stage for pre-treating a refinery gas by removing at least a portion of any carbonyl sulfide therefrom, according to one or more embodiments described.

DETAILED DESCRIPTION

[0014] It is to be understood that the following disclosure describes several exemplary embodiments for implementing different features, structures, and/or functions of the invention. Exemplary embodiments of components, arrangements, and configurations are described below to simplify the present disclosure; however, these exemplary embodiments are provided merely as examples and are not intended to limit the scope of the invention. Additionally, the present disclosure may repeat reference numerals and/or letters in the various exemplary embodiments and across the Figures provided herein. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various exemplary embodiments and/or configurations discussed in the Figures. Moreover, the exemplary embodiments presented below can be combined in any combination of ways, *i.e.*, any element from one exemplary embodiment can be used in any other exemplary embodiment, without departing from the scope of the disclosure.

[0015] The indefinite article “a” or “an”, as used herein, means “at least one” unless specified to the contrary or the context clearly indicates otherwise. Thus, embodiments using “a

[0031] As shown, the refinery gas via line 102 and/or the pre-treated refinery gas via line 105 can be combined with the compressed process gas in line 132 between the first compression stage 131 and the second compression stage 133 to produce a mixture of the process gas and the refinery gas and/or the pre-treated refinery gas or simply a combined gas in line 132. The combined gas via line 132 can be introduced into the second stage 133 of the multi-stage compressor to produce a compressed combined gas via line 134 that can include the process gas and the refinery gas and/or the pre-treated refinery gas that can be conducted away from the multi-stage compressor 130.

[0032] The compressed combined gas via line 134 can be introduced into an amine tower 135 for purification, e.g., by removing hydrogen sulfide and/or other acidic gases. The amine tower can also receive a lean solution of one or more light amines via line 122. At least a portion of any acid gases in the combined gas can be transferred to the lean amine solution to produce a rich amine solution that can be conducted away via line 106. A treated combined gas via line 137 can be introduced into a caustic tower 138 for additional treatment, such as with an aqueous hydroxide solution, e.g., sodium hydroxide, to further reduce the content of any acidic gases in the combined gas. An upgraded combined gas can be conducted away via line 139 from the caustic tower 138.

[0033] The upgraded combined gas via line 139 can be introduced into a separation stage 140 that can separate a bottoms stream via line 141 and an overhead stream via line 142. The bottoms stream can include C_{3+} hydrocarbons and the overhead stream can include molecular hydrogen, C_1-C_2 hydrocarbons, and some C_{3+} hydrocarbons. It should be understood that the invention is not limited to the embodiment illustrated by FIG. 1. As such, this description should not be interpreted as excluding other embodiments within the broad scope of the invention, such as embodiments in which (i) the overhead stream in line 142 includes methane and molecular hydrogen and the bottoms stream in line 141 includes C_{2+} hydrocarbons or (ii) the overhead stream in line 142 includes molecular hydrogen and C_{3-} hydrocarbons and the bottoms stream in line 141 includes C_{4+} hydrocarbons. Accordingly, those skilled in the art will appreciate that various separations and upgrading process configurations can be arranged in many different configurations within the scope of the present invention in addition to the embodiment illustrated by FIG. 1.

[0034] The bottoms stream via line 141 can be introduced into a separation stage 113 that can separate a bottoms stream via line 143 and an overhead stream via line 144. The bottoms stream in line 143 can include C_{4+} hydrocarbons and the overhead stream in line 144 can include C_3 hydrocarbons. The bottoms stream via line 143 can be introduced into a separation

sorbent rich in carbonyl sulfide to produce a regenerated sorbent and a desorb effluent that can include one or more sulfur based contaminants that can be recovered via line 180. The regenerating gas can be or can include, but is not limited to, one or more C_1-C_4 alkanes. In some embodiments, the regenerating gas in line 159 can be recovered from the combined gas in the recovery facility 114. For example, the regenerating gas can include methane in line 178, ethane in line 176, propane in line 158, and/or butane in line 147 separated from the combined gas. In some embodiments, the regenerating gas can contain < 5 mol% of any alkenes. In some embodiments, at least a portion of the desorb effluent can be combined with a hydrocarbon feed in line 111 or a heated hydrocarbon feed in line 117 and introduced into the steam cracker 115.

[0038] In some embodiments, the compressed combined gas in line 134, the treated combined gas in line 137, and/or the upgraded combined gas in line 139 may include water vapor. At least a portion of the water can be removed by condensing, by sorption, or otherwise removing at least a portion of the water and separating and a dried gas therefrom. In some embodiments, at least a portion of the purified stream in line 167 can be introduced via line 190 into a dehydrator 192 to remove at least a portion of the water vapor to provide a dried stream via line 194 that can be introduced via line 167 into the separation stage 168. The dehydrator 192 can be located at any suitable position within the recovery facilities 114. For example, the overhead stream in line 142 could be introduced into the dehydrator 190 with the dried stream via line 194 being introduced into the carbonyl sulfide removal bed 162. In another example, the upgraded combined gas in line 139 could be introduced into the dehydrator 190 with the dried stream via line 194 being introduced into the separation stage 140. In addition to or in lieu of the dehydrator 190, water can be removed via one or more other ways such as during compression of the overhead in line 142 via the compressor 160.

[0039] The stream in line 173 can be introduced into separation stage 174 that can separate therefrom at least (i) ethylene via line 175 and (ii) ethane via line 176. The ethane can be recycled to the steam cracker 116 for cracking, used in a refinery process, e.g., sent to refinery 101 for processing, and/or recovered as a product. Additional separations can optionally be carried out. For example, a separator 177 can be used to separate from the stream in line 169 into (i) methane via line 178 and (ii) molecular hydrogen via line 179. In some embodiments, at least a portion of the separated methane in line 178 can be used as a fuel gas and/or recycled to the steam cracker 116 for the production of synthesis gas and molecular hydrogen. In some embodiments, at least a portion of the molecular hydrogen in line 179 can be recycled to a hydroprocessing stage, e.g., for use in upgrading the gasoline hydrogenation unit 148.

water wash tower 210, and the separation stage 230 that includes an absorption based demethanizer.

[0047] FIG. 3 depicts a schematic of another illustrative pre-treatment stage 104 for pre-treating the refinery gas in line 103 to remove at least a portion of any nitrogen oxide and/or at least a portion of any molecular oxygen, according to one or more embodiments. The refinery gas via line 103 can be introduced into a compressor 305 to produce a compressed refinery gas via line 307. The compressed refinery gas via line 307 and a lean amine solution via line 310 can be introduced into an amine tower 315 and contacted therein. A rich-amine solution via line 317 and an overhead lean in acidic gases via line 319 can be conducted away from the amine tower 315. The overhead via line 319 can be introduced into a DeOx reactor 325 to remove at least a portion of any oxygen, at least a portion of any nitrogen oxides, at least a portion of any acetylene, at least a portion of any mercury, at least a portion of any carbonyl sulfide, and/or at least a portion of any arsine that can be present in the refinery gas in line 103. The DeOx reactor 325 can include one or more catalysts that can contact the refinery gas in the presence of molecular hydrogen under conditions sufficient to convert at least a portion of any nitrogen oxides to ammonia and/or to convert at least a portion of any molecular oxygen to water. In some embodiments, the catalyst can be or can include, but is not limited to, nickel-based sulfided catalysts, copper-based catalysts, and the like. The pretreated refinery gas via line 105 can be recovered from the DeOx reactor 325 and combined with the process gas produced in the steam cracker 115 as described above.

[0048] In an alternative embodiment, the pre-treatment stage 104 can include the compressor 305 and the DeOx reactor 325, or the amine tower 315 and the DeOx reactor 325, or only the DeOx reactor 325. The use of the compressor 305 and the amine tower 315, in some cases, can be optional and can depend, at least in part, on the pressure of the refinery gas in line 103 and the amount of ammonia present in the refinery gas in line 103.

[0049] FIG. 4 depicts another illustrative pre-treatment stage 104 for pre-treating the refinery gas in line 103 by removing at least a portion of any carbonyl sulfide therefrom, according to one or more embodiments. The refinery gas via line 103 can be introduced into carbonyl sulfide removal stage 410 and contacted with a sorbent 412 to cause at least a portion of any carbonyl sulfide to sorb onto the sorbent to produce a pre-treated refinery gas lean in carbonyl sulfide and a sorbent rich in carbonyl sulfide. Suitable sorbents 412 can be or can include, but are not limited to, commercially available sorbents such as SELEXSORB® available from BASF and AXSORB® 980/984 available from Axens. The pre-treated refinery gas via line

CLAIMS:

What is claimed is:

1. A process for removing contaminants from a refinery gas, comprising:

recovering a process gas comprising ethylene and propylene from a steam cracker effluent recovered from a stream cracker in a steam cracker facility;

recovering a refinery gas from a refinery facility;

compressing the process gas in a plurality of compressor stages;

determining a pressure of the refinery gas;

selecting a compressor stage in the plurality of compressor stages for introducing the refinery gas using the determined pressure of the refinery gas, wherein the selected compressor stage is located after a first compressor stage and before a last compressor stage of the plurality of compressor stages;

introducing the refinery gas into the selected compressor stage to produce a combined gas comprising the process gas and the refinery gas; and

removing at least a portion of one or more impurities from the combined gas in the steam cracker facility to produce an upgraded combined gas lean in the one or more impurities.

2. The process of claim 1, wherein the one or more impurities comprise at least one of: ammonia, methanol, methyl mercaptan, ethyl mercaptan, hydrogen sulfide, carbon dioxide, and acetaldehyde, and wherein removing the at least a portion of the one or more impurities from the combined gas comprises contacting the combined gas with an aqueous amine, an aqueous inorganic base, or a combination thereof to produce a spent aqueous amine, a spent caustic, or a combination thereof and a combined gas lean in the one or more impurities.

3. The process of claim 1, wherein the one or more impurities comprise carbonyl sulfide, and wherein removing the at least a portion of the one or more impurities from the combined gas comprises contacting the combined gas with a sorbent under conditions sufficient to cause at least a portion of the carbonyl sulfide to sorb onto the sorbent to produce a treated combined gas lean in carbonyl sulfide and a sorbent rich in carbonyl sulfide.

4. The process of claim 3, further comprising:

contacting the sorbent rich in carbonyl sulfide with a regenerating gas comprising molecular hydrogen, one or more C_1-C_4 hydrocarbons, or a mixture thereof to produce a regenerated sorbent and a desorb effluent comprising a sulfur-based contaminant; and

introducing at least a portion of the desorb effluent into a pyrolysis zone in the steam cracker.

5. The process of claim 4, wherein the regenerating gas comprises one or more C_1-C_4 alkanes, wherein the regenerating gas comprises < 5 mol% of any alkenes, and wherein the regenerating gas is recovered from the upgraded combined gas.

6. The process of any of the preceding claims, wherein the combined gas comprises water vapor, and wherein removing the at least a portion of the one or more impurities from the combined gas comprises removing at least a portion of the water vapor to produce a dried combined gas.

7. The process of any of the preceding claims, wherein the refinery gas is recovered from an upgrading process comprising at least one of: fluid catalytic cracking, coking, hydrocracking, hydrotreating, isomerization, reforming, decoking, hydrocarbon combustion, and hydrocarbon distillation.

8. The process of any of the preceding claims, further comprising:

recovering an alkane feed comprising at least one of ethane and propane from the upgraded combined gas; and

introducing at least a portion of the alkane feed to a pyrolysis zone in the steam cracker.

9. The process of any of the preceding claims, further comprising pre-treating the refinery gas to remove at least a portion of one or more impurities comprising at least one of: molecular nitrogen, a nitrogen oxide, and molecular oxygen to produce a pre-treated refinery gas, wherein the pre-treated refinery gas is introduced into the selected compressor stage to produce the combined gas.

10. A process for removing contaminants from a refinery gas, comprising:

recovering a refinery gas from a refinery facility;

pre-treating the refinery gas to remove at least a portion of one or more first impurities comprising at least one of: molecular nitrogen, a nitrogen oxide, and molecular oxygen to produce a pre-treated refinery gas;

recovering a process gas comprising ethylene and propylene from a steam cracker effluent in a steam cracker facility;

compressing the process gas in a plurality of compressor stages to produce a compressed process gas;

determining a pressure, a composition, or a pressure and a composition of the pre-treated refinery gas;

selecting a location in the steam cracker facility for combining at least a portion of the pre-treated refinery gas with the compressed process gas using the pressure, the composition, or the pressure and the composition of the pre-treated refinery gas, wherein the selected location is a compressor stage in the plurality of compressor stages located after a first compressor stage and before a last compressor stage of the plurality of compressor stages;

adding at least a portion of the pre-treated refinery gas to the process gas at the selected location to produce a combined gas comprising the process gas and the refinery gas; and

removing at least a portion of one or more second impurities from the combined gas in the steam cracker facility to produce an upgraded combined gas lean in the one or more second impurities.

11. The process of claim 10, further comprising recovering a tail gas and a C_{2+} gas from the pre-treated refinery gas, wherein the tail gas comprises at least one of molecular hydrogen and methane, and wherein the C_{2+} gas is added to the process gas at the selected location.

12. The process of claim 11, further comprising:

introducing at least a portion of the tail gas and an oxidant into a combustor in a steam cracker located in the steam cracker facility;

combusting the tail gas to produce heat and a combustion effluent; and

transferring at least a portion of the heat to a radiant section of the steam cracker.

13. The process of any of claims 10 to 12, wherein the one or more first impurities further comprises at least one of: ammonia, water, and mercury, and wherein pre-treating the refinery gas further comprises removing at least a portion any ammonia, at least a portion of any water, and at least a portion of any mercury therefrom to produce the pre-treated refinery gas.

14. The process of any of claims 10 to 13, wherein the refinery gas comprises at least one of the nitrogen oxide and the molecular oxygen, and wherein pre-treating the refinery gas comprises contacting the refinery gas with a catalyst in the presence of molecular hydrogen under conditions sufficient to convert at least a portion of any nitrogen oxide to ammonia and to convert at least a portion of any molecular oxygen to water.

15. The process of any of claims 10 to 14, wherein the refinery gas is recovered from an upgrading process comprising at least one of: fluid catalytic cracking, coking, hydrocracking, hydrotreating, isomerization, reforming, decoking, hydrocarbon combustion, and hydrocarbon distillation.

16. A process for removing contaminants from a refinery gas, comprising:

recovering a refinery gas comprising one or more C_1-C_5 hydrocarbons and carbonyl sulfide from a refinery facility;

contacting the refinery gas with a sorbent under conditions sufficient to cause at least a portion of the carbonyl sulfide to sorb onto the sorbent to produce a pre-treated refinery gas lean in carbonyl sulfide and a sorbent rich in carbonyl sulfide;

contacting the sorbent rich in carbonyl sulfide with a regenerating gas to produce a regenerated sorbent and a desorb effluent comprising a sulfur-based contaminant;

introducing at least a portion of the desorb effluent into a pyrolysis zone of a steam cracker in a steam cracker facility to produce a steam cracker effluent;

recovering a process gas comprising one or more C_1-C_4 hydrocarbons from the steam cracker effluent;

compressing the process gas in a plurality of compressor stages to produce a compressed process gas;

combining the pre-treated refinery gas and the compressed process gas to produce a combined gas comprising the pre-treated refinery gas and the process gas; and

removing one or more impurities from the combined gas in the steam cracker facility to produce an upgraded combined gas lean in the one or more impurities.

17. The process of claim 16, wherein the regenerating gas comprises at least one of: hydrogen, methane, ethane, propane, and butane separated from the combined gas.

18. The process of claim 16 or claim 17, wherein, during the introduction of the desorb effluent into the pyrolysis zone, the steam cracker effluent comprises sulfur obtained from the desorb effluent at least partly as hydrogen sulfide.

19. The process of any of claims 16 to 18, wherein removing the one or more impurities from the combined gas comprises contacting the combined gas with an aqueous amine, an aqueous inorganic base, or a combination thereof to produce a spent aqueous amine, a spent caustic, or a combination thereof and the upgraded combined gas.

20. The process of any of claims 16 to 19, wherein the refinery gas is recovered from an upgrading process comprising at least one of: fluid catalytic cracking, coking, hydrocracking, hydrotreating, isomerization, reforming, decoking, hydrocarbon combustion, and hydrocarbon distillation.

21. The process of any of claims 16 to 20, further comprising removing one or more acid gas from the refinery gas or the pre-treated refinery gas to produce a refinery gas or a pre-treated refinery gas lean in one or more acid gases.

22. The process of claim 21, wherein the refinery gas further comprises a mercaptan, and wherein the sorbent is a first sorbent, the process further comprising:

contacting the refinery gas with a second sorbent under conditions sufficient to cause at least a portion of the mercaptan to sorb onto the second sorbent to produce the pre-treated refinery gas and a second sorbent rich in the mercaptan; and

contacting the second sorbent rich in the mercaptan with the regenerating gas to produce a regenerated second sorbent and the desorb effluent, wherein the refinery gas is contacted with the first sorbent first and the second sorbent second, the second sorbent first and the first sorbent second, or substantially simultaneously with the first and second sorbents.

23. The process of claim 1, wherein the refinery gas comprises one or more C_1-C_5 alkanes, and wherein the refinery gas comprising the one or more C_1-C_5 alkanes is introduced into the selected compressor stage to produce the combined gas.

24. The process of claim 10, wherein the refinery gas comprises one or more C_1-C_5 alkanes, and wherein the refinery gas comprising the one or more C_1-C_5 alkanes is introduced into the selected compressor stage to produce the combined gas.

25. The process of claim 16, further comprising:

determining a pressure of the refinery gas;

selecting a compressor stage in the plurality of compressor stages for introducing the refinery gas using the determined pressure of the refinery gas, wherein the selected compressor stage is located after a first compressor stage and before a last compressor stage of the plurality of compressor stages; and

introducing the refinery gas into the selected compressor stage to produce the combined gas comprising the pre-treated refinery gas and the process gas.