gas stream is admixed. Beside olefins, both refinery gases also contain diolefins such as 1,3-butadiene. It is taught that the olefin content and the content of such streams in organic sulfur compounds requires a pretreatment, in order to avoid the deposition of carbon on the reforming catalyst or the poisoning of the catalyst with sulfur compounds which otherwise might lead to a deactivation of such catalyst.

The U.S. patent specification US 7,037,485 B1 also teaches the formation of a mixed feed for steam reforming, comprising a natural gas stream and a refinery gas stream. The two feed streams initially are combined and mixed and subsequently heated by indirect heat exchange against the hot product stream from the CO conversion plant downstream of the steam reforming plant. Subsequently, the heated mixed stream is treated in a reactor which contains a catalyst active both for the hydrogenation of the olefins and the sulfur compounds and for the partial autothermal reformation (ATR). Steam used as temperature moderator and optionally oxygen is added to the reactor when the reactor is to be operated in the partial ATR mode, wherein pre-reforming of the higher hydrocarbons to methane and synthesis gas constituents already is effected. What is disadvantageous is the logistics needed for supplying steam and oxygen. Too much addition of steam also can lower the temperature in the reactor too much and thus negatively influence pre-reforming. Furthermore, the downstream sulfur separation then is impaired as well.

US 7,037,485 B1 furthermore teaches two embodiments of the process, in which the natural gas stream and the refinery gas stream are pretreated completely separately and are combined only before introduction into the steam reforming unit. It is very disadvantageous that all pretreatment devices accordingly must be present twice.

Summary

In one aspect, there is provided a process for producing a mixed feed stream for a steam reforming plant containing at least one reforming stage, comprising a first feed stream containing methane and a second feed stream comprising higher hydrocarbons, olefins and diolefins, wherein the first and/or the second feed stream also contains sulfur compounds, and wherein the process comprises the following steps:
(a) providing the first feed stream and the second feed stream,

(b) heating the first feed stream in a first heating device,

(c) combining and mixing at least a part of the first feed stream with the second feed stream, introducing this mixture into a first hydrogenation zone, at least partly converting the diolefins in the first hydrogenation zone under diolefin hydrogenation conditions, discharging a diolefin hydrogenation product stream from the first hydrogenation zone,

(d) introducing the diolefin hydrogenation product stream into a second hydrogenation zone, at least partly converting the olefins in the second hydrogenation zone under olefin hydrogenation conditions, discharging an olefin hydrogenation product stream from the second hydrogenation zone,

(e) introducing the olefin hydrogenation product stream into a third hydrogenation zone, at least partly converting the sulfur compounds in the third hydrogenation zone under conditions of the hydrodesulfurization (HDS) to desulfurized hydrocarbons and hydrogen sulfide, discharging an HDS product stream from the third hydrogenation zone,

(f) introducing the HDS product stream into at least one adsorption zone, filled with an adsorbent selective for hydrogen sulfide, at least partly separating the hydrogen sulfide by adsorption on the adsorbent, discharging an adsorber product stream depleted of hydrogen sulfide from the adsorption zone,

(g) introducing the adsorber product stream as mixed feed stream into at least one reforming stage, characterized in that

- after heating in the first heating device, the first feed stream is split up into a first hydrogenation partial stream and a second hydrogenation partial stream,
- the first hydrogenation partial stream is introduced into a cooling device,
- a cooled first hydrogenation partial stream is discharged from the cooling device,
- the cooled first hydrogenation partial stream is combined and mixed with the second feed stream,
- the mixture thus obtained is introduced into the first hydrogenation zone.

In another aspect of the present disclosure, there is provided an apparatus for producing a mixed feed stream for a steam reforming plant containing at least one reforming stage, comprising a first feed stream containing methane and a second feed stream comprising higher hydrocarbons, olefins and diolefins, wherein the first and/or

the second feed stream also contains sulfur compounds, and wherein the apparatus comprises the following components which are in fluid connection with each other:

(a) means for providing the first feed stream and the second feed stream,

(b) a first heating device for heating the first feed stream,

(c) means for combining and mixing at least a part of the first feed stream with the second feed stream, a first hydrogenation zone, means for introducing this mixture into the first hydrogenation zone, means for discharging a diolefin hydrogenation product stream from the first hydrogenation zone,

(d) a second hydrogenation zone, means for introducing the diolefin hydrogenation product stream into the second hydrogenation zone, means for discharging an olefin hydrogenation product stream from the second hydrogenation zone,

(e) a third hydrogenation zone (HDS), means for introducing the olefin hydrogenation product stream into the third hydrogenation zone, means for discharging an HDS product stream from the third hydrogenation zone,

(f) an adsorption zone, filled with an adsorbent selective for hydrogen sulfide, means for introducing the HDS product stream into the at least one adsorption zone, means for discharging an adsorber product stream depleted of hydrogen sulfide from the adsorption zone,

(g) at least one reforming stage, means for introducing the adsorber product stream as mixed feed stream into the at least one reforming stage,

wherein the apparatus further comprises:

- a separating device for splitting up the first feed stream, after heating in the first heating device, into a first hydrogenation partial stream and a second hydrogenation partial stream,
- a cooling device and means for introducing the first hydrogenation partial stream into the cooling device,
- means for discharging a cooled first hydrogenation partial stream from the cooling device,
- means for combining and mixing the cooled first hydrogenation partial stream with the second feed stream,
- means for introducing the mixture thus obtained into the first hydrogenation zone.

Description of the Invention

Claims:

1. A process for producing a mixed feed stream for a steam reforming plant containing at least one reforming stage, comprising a first feed stream containing methane and a second feed stream comprising higher hydrocarbons, olefins and diolefins, wherein the first and/or the second feed stream also contains sulfur compounds, and wherein the process comprises the following steps:

(a) providing the first feed stream and the second feed stream,

(b) heating the first feed stream in a first heating device,

(c) combining and mixing at least a part of the first feed stream with the second feed stream, introducing this mixture into a first hydrogenation zone, at least partly converting the diolefins in the first hydrogenation zone under diolefin hydrogenation conditions, discharging a diolefin hydrogenation product stream from the first hydrogenation zone,

(d) introducing the diolefin hydrogenation product stream into a second hydrogenation zone, at least partly converting the olefins in the second hydrogenation zone under olefin hydrogenation conditions, discharging an olefin hydrogenation product stream from the second hydrogenation zone,

(e) introducing the olefin hydrogenation product stream into a third hydrogenation zone, at least partly converting the sulfur compounds in the third hydrogenation zone under conditions of the hydrodesulfurization (HDS) to desulfurized hydrocarbons and hydrogen sulfide, discharging an HDS product stream from the third hydrogenation zone,

(f) introducing the HDS product stream into at least one adsorption zone, filled with an adsorbent selective for hydrogen sulfide, at least partly separating the hydrogen sulfide by adsorption on the adsorbent, discharging an adsorber product stream depleted of hydrogen sulfide from the adsorption zone,

(g) introducing the adsorber product stream as mixed feed stream into at least one reforming stage, characterized in that

- after heating in the first heating device, the first feed stream is split up into a first hydrogenation partial stream and a second hydrogenation partial stream,
- the first hydrogenation partial stream is introduced into a cooling device,
- a cooled first hydrogenation partial stream is discharged from the cooling device,

- the cooled first hydrogenation partial stream is combined and mixed with the second feed stream,
- the mixture thus obtained is introduced into the first hydrogenation zone.

2. The process according to claim 1, characterized in that combining and mixing of at least a part of the first feed stream with the second feed stream is effected such that on entry into the first hydrogenation zone the mixture has a temperature of less than 300 °C, preferably less than 250 °C, most preferably less than 230 °C.

3. The process according to claim 1 or 2, characterized in that the diolefin hydrogenation product stream is combined and mixed with the second hydrogenation partial stream and the mixture thus obtained is introduced into the second hydrogenation zone.

4. The process according to claim 2 or 3, characterized in that an air cooler or a heat exchanger is used as cooling device, wherein in use of a heat exchanger cooling preferably is effected by indirect heat exchange against at least a part of the first feed stream before the first heating device.

5. The process according to any of the preceding claims, characterized in that the cooling capacity of the cooling device and/or the quantity ratio of the first hydrogenation partial stream to the second hydrogenation partial stream is chosen such that on entry into the first hydrogenation zone the mixture has a temperature of less than 300 °C, preferably less than 250 °C, most preferably less than 230 °C.

6. The process according to any of the preceding claims, characterized in that prior to combining and mixing with at least a part of the first feed stream the second feed stream is introduced into an adsorption zone which is filled with an adsorbent selective for metals.

7 The process according to any of the preceding claims, characterized in that the first heating device is designed as heat exchanger, wherein the first feed stream is heated by indirect heat exchange against a hot raw synthesis gas product stream from the

steam reforming plant, against a hot flue gas stream from the reformer furnace or against a hot product gas stream from the CO conversion plant (CO shift) downstream of the stream reforming plant.

8. The process according to any of the preceding claims, characterized in that the steam reforming plant comprises a pre-reforming stage (prereformer) in which higher hydrocarbons are at least partly converted to methane under pre-reforming conditions.

9. An apparatus for producing a mixed feed stream for a steam reforming plant containing at least one reforming stage, comprising a first feed stream containing methane and a second feed stream comprising higher hydrocarbons, olefins and diolefins, wherein the first and/or the second feed stream also contains sulfur compounds, and wherein the apparatus comprises the following components which are in fluid connection with each other:

(a) means for providing the first feed stream and the second feed stream,

(b) a first heating device for heating the first feed stream,

(c) means for combining and mixing at least a part of the first feed stream with the second feed stream, a first hydrogenation zone, means for introducing this mixture into the first hydrogenation zone, means for discharging a diolefin hydrogenation product stream from the first hydrogenation zone,

(d) a second hydrogenation zone, means for introducing the diolefin hydrogenation product stream into the second hydrogenation zone, means for discharging an olefin hydrogenation product stream from the second hydrogenation zone,

(e) a third hydrogenation zone (HDS), means for introducing the olefin hydrogenation product stream into the third hydrogenation zone, means for discharging an HDS product stream from the third hydrogenation zone,

(f) an adsorption zone, filled with an adsorbent selective for hydrogen sulfide, means for introducing the HDS product stream into the at least one adsorption zone, means for discharging an adsorber product stream depleted of hydrogen sulfide from the adsorption zone,

(g) at least one reforming stage, means for introducing the adsorber product stream as mixed feed stream into the at least one reforming stage,

wherein the apparatus further comprises:

- a separating device for splitting up the first feed stream, after heating in the first heating device, into a first hydrogenation partial stream and a second hydrogenation partial stream,
- a cooling device and means for introducing the first hydrogenation partial stream into the cooling device,
- means for discharging a cooled first hydrogenation partial stream from the cooling device,
- means for combining and mixing the cooled first hydrogenation partial stream with the second feed stream,
- means for introducing the mixture thus obtained into the first hydrogenation zone.

10. The apparatus according to claim 9, characterized in that the apparatus furthermore comprises means which provide for carrying out the combining and mixing of at least a part of the first feed stream with the second feed stream such that on entry into the first hydrogenation zone the mixture has a temperature of less than 300 °C, preferably less than 250 °C, most preferably less than 230 °C.

11. The apparatus according to claim 9 or 10, characterized in that the apparatus furthermore comprises means for combining and mixing the diolefin hydrogenation product stream with the second hydrogenation partial stream and for introducing the obtained mixture into the second hydrogenation zone.

12. The apparatus according to any of claims 9 to 11, characterized in that an air cooler or a heat exchanger is used as cooling device, wherein in use of a heat exchanger cooling preferably is effected by indirect heat exchange against at least a part of the first feed stream before the first heating device.

13. The apparatus according to any of claims 9 to 12, characterized in that the cooling capacity of the cooling device can be set and/or the quantity ratio of the first hydrogenation partial stream to the second hydrogenation partial stream can be chosen by

means of a flow control device such that on entry into the first hydrogenation zone the mixture has a temperature of less than 300 °C, preferably less than 250 °C, most preferably less than 230 °C.

14. The apparatus according to any of claims 9 to 13, characterized in that the apparatus furthermore comprises an adsorption zone which is filled with an adsorbent selective for metals and which is disposed upstream of the one or more means for combining and mixing the second feed stream with at least a part of the first feed stream.

15. The apparatus according to any of claims 9 to 14, characterized in that the first heating device is designed as heat exchanger and suited to carry out an indirect heat exchange between the first feed stream and a hot raw synthesis gas product stream from the steam reforming plant, a hot flue gas stream from the reformer furnace, or a hot product gas stream from the CO conversion plant (CO shift) downstream of the steam reforming plant.

16. The apparatus according to any of claims 9 to 15, characterized in that the steam reforming plant comprises a pre-reforming stage (prereformer) in which higher hydrocarbons are at least partly converted to methane under pre-reforming conditions.