seasonal and the quality of pitch may not meet local specifications. The pitch could be gasified, but costs are generally prohibitive. Pitch is therefore not a desired byproduct.

SUMMARY OF THE CLAIMED EMBODIMENTS

[0005] ~~In one aspect, e~~Embodiments disclosed herein relate to a process for upgrading residuum hydrocarbons. The process may include: feeding pitch, hydrogen, and a partially spent catalyst recovered from a hydrocracking reactor to an ebullated bed pitch hydrocracking reactor; contacting the pitch, hydrogen, and the catalyst in the ebullated bed pitch hydrocracking reactor at reaction conditions of temperature and pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons; and separating the distillate hydrocarbons from the catalyst. In one aspect, there is provided a process for upgrading pitch, the process comprising: feeding pitch, hydrogen, and a partially spent catalyst recovered from a hydrocracking reactor to an ebullated bed pitch hydrocracking reactor; contacting the pitch, hydrogen, and the catalyst in the ebullated bed pitch hydrocracking reactor at reaction conditions of temperature and pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons; separating the distillate hydrocarbons from the catalyst. In some embodiments, the process may include selecting the ebullated bed pitch hydrocracking reactor reaction conditions to be at or below the level where sediment formation would otherwise become excessive and prevent continuity of operations.

[0006] ~~In another aspect, e~~Embodiments disclosed herein relate to a process for upgrading residuum hydrocarbons. The process may include: feeding pitch, hydrogen, and a spent or partially spent catalyst recovered from a hydrocracking reactor to a pitch hydrocracking reactor; contacting the pitch, hydrogen, and the catalyst in the pitch hydrocracking reactor at reaction conditions of temperature and pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons; separating the distillate hydrocarbons from the catalyst. In another aspect, there is provided a process for upgrading pitch, the process comprising: feeding pitch, hydrogen, and a spent or partially spent catalyst recovered from a hydrocracking reactor to a pitch hydrocracking reactor; contacting the pitch, hydrogen, and the catalyst in the pitch hydrocracking reactor at reaction conditions of temperature and

pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons; separating the distillate hydrocarbons from the catalyst.

[0007] ~~In another aspect, e~~Embodiments disclosed herein relate to a system for upgrading residuum hydrocarbons. The system may include: a residuum hydrocarbon conversion reactor system for contacting a residuum hydrocarbon, hydrogen, and a hydrocracking catalyst to convert at least a portion of the residuum hydrocarbon to distillate range hydrocarbons; a separation system for fractionating the distillate range hydrocarbons into two or more hydrocarbon fractions including a vacuum tower bottoms fraction; a separation system for recovering at least some of the spent catalyst from the residuum hydrocarbon conversion reactor system; a solvent deasphalting unit for solvent deasphalting the vacuum tower bottoms fraction to produce a deasphalted oil fraction and a pitch fraction; and a pitch hydrocracking reactor system for contacting the pitch, hydrogen, and spent catalyst recovered from the residuum

hydrocarbon reactor system at reaction conditions of temperature and pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons. In an aspect, there is provided a system for upgrading residuum hydrocarbons, the system comprising: a residuum hydrocarbon conversion reactor system for contacting a residuum hydrocarbon, hydrogen, and a hydrocracking catalyst to convert at least a portion of the residuum hydrocarbon to distillate range hydrocarbons; a separation system for fractionating the distillate range hydrocarbons into two or more hydrocarbon fractions including a vacuum tower bottoms fraction; a separation system for recovering at least some of the spent catalyst from the residuum hydrocarbon conversion reactor system; a grinder for grinding the recovered spent catalyst; a solvent deasphalting unit for solvent deasphalting the vacuum tower bottoms fraction to produce a deasphalted oil fraction and a pitch fraction; a pitch hydrocracking reactor system for contacting the pitch, hydrogen, and the ground spent catalyst at reaction conditions of temperature and pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons. In another aspect, there is provided a system for upgrading pitch, the system comprising: a pitch hydrocracking reactor for contacting pitch, hydrogen, and a spent catalyst at reaction conditions of temperature and pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons; a separator for separating the distillate hydrocarbons from the spent catalyst; a vacuum distillation tower to fractionate the distillate hydrocarbons to produce one or more hydrocarbon fractions and a vacuum distillation tower bottoms fraction; and a recycle system for recycling the vacuum distillation tower bottoms fraction to the pitch hydrocracking reactor. In yet another aspect, there is provided a system for upgrading residuum hydrocarbons, the system comprising: a hydrocracking reaction system comprising one or more hydrocracking reaction stages comprising an ebullated bed hydrocracking reactor for contacting a heavy oil feedstock, hydrogen, and a hydrocracking catalyst; a separation system for recovering spent catalyst from the ebullated bed hydrocracking reactor; a grinder for grinding the recovered spent catalyst; a pitch hydrocracking reactor system for contacting pitch, hydrogen, and the ground spent catalyst at reaction conditions of temperature and pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons;

and a separation system for separating the distillate hydrocarbons from the ground spent catalyst.

[0008] Other ~~aspects~~ embodiments and advantages will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0009] Figures 1-3 are simplified process flow diagrams of processes for upgrading hydrocarbon feedstocks according to embodiments disclosed herein.

DETAILED DESCRIPTION

[0010] In one aspect, embodiments herein relate generally to hydroconversion processes, including processes for hydrocracking residuum and other heavy hydrocarbon fractions. More specifically, embodiments disclosed herein relate to processes for upgrading asphaltenic pitch via hydrocracking in an ebullated bed hydrocracking reactor using a spent or partially spent catalyst recovered from a hydrocracking reactor system.

[0011] As used herein, "residuum hydrocarbons," "heavy oils," or other terms referring to residuum hydrocarbons, refers to hydrocarbon fractions having boiling points or a boiling range above about 340°C, but could also include whole heavy crude processing. Residuum hydrocarbon feedstocks that may be used with processes disclosed herein may include various refinery and other hydrocarbon streams such as petroleum atmospheric or vacuum residuum, deasphalted oil, deasphalter pitch, hydrocracked atmospheric tower or vacuum tower bottoms, straight run vacuum gas oil, hydrocracked vacuum gas oil, fluid catalytically cracked (FCC) slurry oils, vacuum gas oil from an ebullated bed process, shale oils, coal-derived oils, tar sands bitumen, tall oils, black oils, as well as other similar hydrocarbon streams, or a combination of these, each of which may be straight run, process derived, hydrocracked, partially desulfurized, and/or low-metal streams. In some embodiments, residuum hydrocarbon fractions may include hydrocarbons having a normal boiling point of at least 480°C, at least 524°C, or at least 565°C.

[0012] The residuum hydrocarbons described above may be hydrocracked in a hydrocracking reaction system having one or more reaction stages including one or more hydrocracking reactors. For example, a hydrocracking reaction system may include a single reaction stage having a single hydrocracking reactor, such as an

a separation system for fractionating the distillate range hydrocarbons into two or more hydrocarbon fractions including a vacuum tower bottoms fraction;

a separation system for recovering at least some of the spent catalyst from the residuum hydrocarbon conversion reactor system;

a grinder for grinding the recovered spent catalyst;

a solvent deasphalting unit for solvent deasphalting the vacuum tower bottoms fraction to produce a deasphalted oil fraction and a pitch fraction;

a pitch hydrocracking reactor system for contacting the pitch, hydrogen, and the ground spent catalyst ~~recovered from the residuum hydrocarbon reactor system~~ at reaction conditions of temperature and pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons.

36. The system of claim 35, further comprising a separation system for separating the distillate hydrocarbons from the ground spent catalyst.

37. The system of claim 35, wherein the residuum hydrocarbon conversion reactor system comprises one or more hydrocracking reaction stages comprising an ebullated bed hydrocracking reactor.

38. The system of claim 37, wherein the grinder is configured to receive spent catalyst from a first hydrocracking reaction stage.

39. The system of claim 37, wherein the grinder is configured to receive spent catalyst from a second hydrocracking reaction stage.

40. The system of claim 37, wherein the grinder is configured to receive spent catalyst from both a first and a second hydrocracking reaction stage.

41. The system of claim 35, further comprising a mixer for forming a slurry of the ground catalyst for feeding the ground catalyst as a slurry to the pitch hydrocracking reactor.

42. The system of claim 41, further comprising a freeze unit for cooling and solidifying the vacuum distillation tower bottoms.

43. The system of claim 42, wherein the grinder is configured to grind the spent catalyst and the solidified vacuum distillation tower bottoms to form a ground mixture, and wherein the mixer is configured to slurry the ground mixture in a liquid hydrocarbon.

44. A system for upgrading pitch, the system comprising:

a pitch hydrocracking reactor for contacting pitch, hydrogen, and a spent catalyst at reaction conditions of temperature and pressure sufficient to convert at least a portion of the pitch to distillate hydrocarbons;

a separator for separating the distillate hydrocarbons from the spent catalyst;

a vacuum distillation tower to fractionate the distillate hydrocarbons to produce one or more hydrocarbon fractions and a vacuum distillation tower bottoms fraction; and

a recycle system for recycling the vacuum distillation tower bottoms fraction to the pitch hydrocracking reactor.

45. The system of claim 44, further comprising an ebullated bed hydrocracking reactor for hydrocracking a heavy oil feedstock with a catalyst.

46. The system of claim 45, further comprising a separator for recovering the spent catalyst from the ebullated bed hydrocracking reactor.

47. The system of claim 46, further comprising a grinder for grinding the spent catalyst recovered from the ebullated bed hydrocracking reactor.

48. A system for upgrading residuum hydrocarbons, the system comprising:

a hydrocracking reaction system comprising one or more hydrocracking reaction stages comprising an ebullated bed hydrocracking reactor for contacting a heavy oil feedstock, hydrogen, and a hydrocracking catalyst;

a separation system for recovering spent catalyst from the ebullated bed hydrocracking reactor;

a grinder for grinding the recovered spent catalyst;

a pitch hydrocracking reactor system for contacting pitch, hydrogen, and the ground spent catalyst at reaction conditions of temperature and pressure

sufficient to convert at least a portion of the pitch to distillate hydrocarbons; and

a separation system for separating the distillate hydrocarbons from the ground spent catalyst.

49. The system of claim 48, wherein the pitch hydrocracking reactor system comprises an ebullated bed pitch hydrocracking reactor.

50. The system of claim 49, wherein the ebullated bed pitch hydrocracking reactor is configured to receive the ground spent catalyst proximate a top of the ebullated bed pitch hydrocracking reactor and to discharge fully spent catalyst proximate a bottom of the ebullated bed pitch hydrocracking reactor.

51. The system of claim 48, further comprising a metals reclamation system for reclaiming metals from the fully spent catalyst.

52. The system of claim 49, wherein the ebullated bed pitch hydrocracking reactor is configured to receive a slurry of the ground spent catalyst proximate a bottom of the ebullated bed pitch hydrocracking reactor.

53. The system of claim 48, wherein the pitch hydrocracking reactor system is a single pass upflow reactor.

54. The system of claim 48, further comprising a quench system for quenching a hydrocarbon effluent from the pitch hydrocracking reactor system.