methanol, etc for the production of light olefins, where the two-reactor scheme does not have limitations on selectivity and operability, meets heat balance requirements, and also maintains a low piece count. Select embodiments disclosed herein use a conventional riser reactor in combination with a countercurrent bubbling / turbulent fluidized bed reactor designed for maximizing light olefins production. The effluents from the riser reactor and countercurrent flow reactor are processed in a common catalyst disengagement vessel, and the catalysts used in each of the riser reactor and the countercurrent flow reactor are regenerated in a common catalyst regeneration vessel. This flow scheme is effective for maintaining a high cracking activity, overcomes the heat balance problems, and also improves yield and selectivity of light olefins from various hydrocarbon streams, yet simplifies the product quenching and unit hardware, as will be described in more detail below.

[0013] In one aspect, embodiments disclosed herein relate to a process for the catalytic cracking of hydrocarbons, including: regenerating a spent catalyst having a first cracking catalyst with a first average particle size and density and a second cracking catalyst with a second average particle size and density in a catalyst regeneration vessel to form a regenerated catalyst comprising the first cracking catalyst and the second cracking catalyst. The average particle size of the first cracking catalyst is less than the average particle size of the second cracking catalyst. A first hydrocarbon feed is contacted in co-current flow with a first portion of the regenerated catalyst in a riser reactor to produce a first effluent including a first cracked hydrocarbon product and a spent mixed catalyst fraction. A second portion of the regenerated catalyst is fed to a countercurrent flow reactor, where concurrently: (i) the first cracking catalyst is separated from the second cracking catalyst based on at least one of density and particle size; (ii) a second hydrocarbon feed is contacted in countercurrent flow with the second cracking catalyst to produce a second cracked hydrocarbon product; (iii) a second effluent is recovered from the countercurrent flow reactor including the second cracked hydrocarbon product and the first cracking catalyst; and (iv) a third effluent is recovered including spent second catalyst. The first effluent and the second effluent are fed to a disengagement vessel to separate the spent mixed catalyst fraction and the separated first cracking catalyst from the first and second cracked hydrocarbon products. The separated catalysts are fed from the disengagement vessel to the catalyst regeneration vessel as the spent catalyst.

[0014] In another aspect, embodiments disclosed herein relate to an apparatus for the catalytic cracking of hydrocarbons. The system ~~may~~ includes a catalyst regeneration vessel for regenerating a spent catalyst including a first cracking catalyst having a first average particle size and density and a second cracking catalyst having a second average particle size and density to form a regenerated catalyst comprising the first cracking catalyst and the second cracking catalyst. The average particle size of the first cracking catalyst is less than the average particle size of the second cracking catalyst. The system also includes a riser reactor for contacting in co-current flow a first hydrocarbon feed with a first portion of the regenerated catalyst to produce a first effluent including a first cracked hydrocarbon product and a spent mixed catalyst fraction. A flow conduit is provided for feeding a second portion of the regenerated catalyst to a countercurrent flow reactor. The countercurrent flow reactor is configured to concurrently: (i) separate the first cracking catalyst from the second cracking catalyst based on at least one of density and particle size; (ii) contact in countercurrent flow a second hydrocarbon feed with predominantly second cracking catalyst to produce a second cracked hydrocarbon product; (iii) recover a second effluent from the countercurrent flow reactor comprising the second cracked hydrocarbon product and the first cracking catalyst; and (iv) recover a third effluent comprising spent second catalyst. A disengagement vessel is then used for separating the first effluent and the second effluent and to recover (a) a spent catalyst fraction including the spent mixed catalyst fraction and the separated first cracking catalyst and (b) an effluent including the first and second cracked hydrocarbon products. A flow conduit is also provided for feeding the spent catalyst fraction from the disengagement vessel to the catalyst regeneration vessel.

[0015] Other ~~aspects~~ embodiments and advantages will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0016] Figure 1 is a simplified process flow diagram of a process for cracking hydrocarbons and producing light olefins according to one or more embodiments disclosed herein.

DETAILED DESCRIPTION