CLAIMS

1. A method for forming light olefins, the method comprising:

introducing a hydrocarbon feed stream into a reactor;

reacting the hydrocarbon feed stream with a dehydrogenation catalyst in the reactor to form a high temperature dehydrogenated product, the dehydrogenated product comprising at least a portion of the hydrocarbon feed stream that was not catalytically reacted;

separating at least a portion of the dehydrogenation catalyst from the high temperature dehydrogenated product in a primary separation device, wherein the temperature of the dehydrogenated product and dehydrogenation catalyst in the primary separation device is at least 550°C;

following the exit of high temperature dehydrogenation product from the primary separation device, combining the high temperature dehydrogenation product with a quench stream to cool the high temperature dehydrogenation product and form an intermediate temperature dehydrogenation product, wherein the quench stream is a gas stream, and wherein temperature of the intermediate temperature dehydrogenation product is at least 10°C less than the temperature of the high temperature dehydrogenation product,

cooling the intermediate temperature dehydrogenation product to form a cooled dehydrogenation product, wherein a portion of the cooled dehydrogenation product is utilized as at least a portion of the quench stream.

2. The method of any of the preceding claims, wherein the hydrocarbon feed comprises propane, n-butane, iso-butane, ethane, ethylbenzene, or combinations thereof.

3. The method of any of the preceding claims, wherein the quench stream is at least 300°C less than the temperature of the high temperature dehydrogenated product.

4. The method of any of the preceding claims, wherein the rate of thermal cracking in the intermediate temperature dehydrogenation product of the portion of the hydrocarbon feed stream that was not catalytically reacted is less than 90% of that in the high temperature dehydrogenated product.

5. The method of any of the preceding claims, further comprising passing the intermediate temperature product to a secondary separation device where the remainder of the dehydrogenation catalyst is removed from the intermediate temperature product.

6. The method of any of the preceding claims, wherein the cooled dehydrogenation product has a temperature of less than or equal to 150°C.

7. The method of any of the preceding claims, wherein a heat exchanger and/or liquid quenching system cools the intermediate temperature dehydrogenation product to the cooled dehydrogenation product.

8. The method of any of the preceding claims, wherein the quench stream comprises less than 3 wt.% steam.

9. The method of any of the preceding claims, wherein the dehydrogenation catalyst is a solid and the high temperature dehydrogenated product is a gas.

10. The method of any of the preceding claims, wherein the quench stream comprises one or more of ethylene, propylene, or a butene isomer.

11. The method of any of the preceding claims, wherein the dehydrogenation catalyst is a gallium and/or platinum catalyst.

12. A method for forming light olefins, the method comprising:

introducing a hydrocarbon feed stream into a reactor;

reacting the hydrocarbon feed stream with a dehydrogenation catalyst in the reactor to form a high temperature dehydrogenated product, the dehydrogenated product comprising at least a portion of the hydrocarbon feed stream that was not catalytically reacted;

separating at least a portion of the dehydrogenation catalyst from the high temperature dehydrogenated product in a primary separation device, wherein the temperature of the dehydrogenated product and dehydrogenation catalyst in the primary separation device is at least 550°C;

following the exit of high temperature dehydrogenation product from the primary separation device, combining the high temperature dehydrogenation product with a quench stream to cool the high temperature dehydrogenation product and form an intermediate temperature dehydrogenation product, wherein the quench stream is a gas stream, and wherein temperature of the intermediate temperature dehydrogenation product is at least 10°C less than the temperature of the high temperature dehydrogenation product;

passing the intermediate temperature product to a secondary separation device where the remainder of the dehydrogenation catalyst is removed from the intermediate temperature product;

cooling the intermediate temperature dehydrogenation product to form a cooled dehydrogenation product, wherein a portion of the cooled dehydrogenation product is utilized as at least a portion of the quench stream.

13. The method of claim 12, wherein the hydrocarbon feed comprises propane, n-butane, iso-butane, ethane, ethylbenzene, or combinations thereof.

14. The method of claim 12 or 13, wherein the rate of thermal cracking in the intermediate temperature dehydrogenation product of the portion of the hydrocarbon feed stream that was not catalytically reacted is less than 70% of that in the high temperature dehydrogenated product.

15. The method of claim 12, 13, or 14, wherein the cooled dehydrogenation product has a temperature of less than or equal to 150°C.

16. The method of any one of claims 1 to 11, wherein the reactor comprises an upstream reactor section operating as a fast fluidized, turbulent, or bubbling bed upflow reactor and a downstream reactor section operating as a dilute phase riser reactor.

17. The method of any one of claims 12 to 14, wherein the reactor comprises an upstream reactor section operating as a fast fluidized, turbulent, or bubbling bed upflow reactor and a downstream reactor section operating as a dilute phase riser reactor.