CLAIMS:

What is claimed is:

1. A method for forming an olefin, the method comprising:

introducing a hydrocarbon feed stream into a reactor including a dehydrogenation catalyst;

reacting the hydrocarbon feed stream with the dehydrogenation catalyst in the reactor to form a high temperature dehydrogenated product, the high temperature dehydrogenated product including at least a portion of the dehydrogenation catalyst;

separating at least a portion of the dehydrogenation catalyst from the high temperature dehydrogenated product in a primary separation device and a secondary separation device downstream of and in fluid communication with the primary separation device;

following the exit of high temperature dehydrogenation product from the secondary 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 includes a hydrocarbon and wherein the combining of the high temperature dehydrogenation product with the quench stream occurs within a plenum section of the reactor; and

cooling the intermediate temperature dehydrogenation product to form a cooled dehydrogenation product.

2. The method of claim 1, wherein said quench stream includes a liquid hydrocarbon and said intermediate temperature product is completely in a vapor phase.

3. The method of claim 1, wherein the combining includes combining the high temperature dehydrogenation product from a plurality of secondary separation devices with the quench stream, at a location within the plenum that minimizes secondary catalytic cracking within the high temperature dehydrogenation product.

4. The method of any of the preceding claims, wherein the quench stream comprises aromatics which are not formed in the high temperature dehydrogenated product.

5. The method of any of the preceding claims, further comprising further cooling of the intermediate temperature dehydrogenation product downstream of the reactor, to obtain the cooled dehydrogenation product with a heat exchanger or a secondary quench stream,

wherein the quench stream includes at least a portion of the cooled dehydrogenation product after having been further cooled by the heat exchanger or the secondary quench stream.

6. The method of any of the preceding claims, wherein the quench stream is not provided to an output region of the primary separation device.

7. The method of any of the preceding claims, wherein the primary separation device and the secondary separation device are each a cyclone separator, and together they remove at least 98% of the dehydrogenation catalyst present in the high temperature dehydrogenated product.

8. The method of any of the preceding claims, wherein the hydrocarbon feed is propane, the olefin is propylene, and the dehydrogenation catalyst includes a PtSn/MgO catalyst, with Pt content ranging from 0.001 wt% to 6 wt%, Sn content 0 wt% to 10 wt%, and the catalyst meets requirements of a Geldart A or Geldart B classification, and a reaction temperature within the reactor is 600°C to 700ºC.

9. The method of any of the preceding claims, wherein the high temperature dehydrogenation product is at least 620ºC.

10. The method of any of the preceding claims, wherein the intermediate temperature dehydrogenation product is no greater than 620ºC.

11. The method of any of the preceding claims, wherein a residence time of the high temperature dehydrogenation product in each of the primary separation device and the secondary separation device is less than one second.

12. The method of any of the preceding claims, wherein:

the dehydrogenation catalyst comprises Pt, an inorganic support, and a contaminant, wherein the Pt has a concentration in the range of from 0.001 wt% to 6 wt%, based on the weight of the inorganic support,

the inorganic support comprises at least 0.5 wt% of a Group 2 element, based on the weight of the inorganic support,

the Group 2 element comprises Mg,

at least a portion of the Group 2 element is in a form of MgO or a mixed metal oxide comprising Mg, and

the catalyst further comprises up to 10 wt% of a promoter, based on weight of the inorganic support, and wherein the promoter comprises one or more of the following elements: Sn, Ag, Cu, a combination thereof, or a mixture thereof.

13. A system for forming an olefin from a hydrocarbon feed stream, the system comprising:

a reactor configured to receive the hydrocarbon feed stream under reaction conditions with a dehydrogenation catalyst, wherein the reaction conditions generate a high temperature dehydrogenated product, the high temperature dehydrogenated product including at least a portion of the dehydrogenation catalyst;

a plurality of separation devices configured to separate at least a portion of the dehydrogenation catalyst from the high temperature dehydrogenated product, the plurality of separation devices including a primary separation device and a secondary separation device downstream of and in fluid communication with the primary separation device;

a quench system configured to combine 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 includes a hydrocarbon, and wherein the quench system is configured to combine the high temperature dehydrogenation product with the quench stream within a plenum section of the reactor; and

a heat transfer system configured to cool the intermediate temperature dehydrogenation product to form a cooled dehydrogenation product.

14. The system of claim 13, wherein said quench stream includes a liquid hydrocarbon and said intermediate temperature product is completely in a vapor phase

15. The system of claim 13 or claim 14, wherein quench system is configured to inject the quench stream at a location within the plenum section that minimizes secondary catalytic cracking within the high temperature dehydrogenation product.

16. The system of any of claims 13 to 15, wherein the heat transfer system includes a heat exchanger or a nozzle configured to supply a secondary quench stream.

17. The system of any of claims 13 to 16, wherein the quench system is configured to not provide the quench stream to an output region of the primary separation device.

18. The system of any of claims 13 to 17, wherein the primary separation device and the secondary separation device are each a cyclone separator, and together they are configured to remove at least 98% of the dehydrogenation catalyst present in the high temperature dehydrogenated product.