CLAIMS

What is claimed is:

1. A layered catalyst reactor system comprising a vertical bed or stack of catalyst layers arranged from top to bottom in the following order:
(i) a layer comprising one or more demetallization catalysts;
(ii) a layer of one or more supported hydrotreating catalysts;
(iii) a layer of one or more supported hydrocracking catalysts;
(iv) a layer of one or more self-supported hydrotreating catalysts;
(v) a layer of one or more supported hydrocracking catalysts;
(vi) a layer of one or more self-supported hydrotreating catalysts;
(vii) a layer of one or more supported hydrotreating catalysts;
wherein the total volume of the two layers comprising one or more self-supported hydrotreating catalysts is about 10 to about 50% of the total volume of catalysts in the vertical bed; and
wherein the total volume of the two layers comprising one or more supported hydrocracking catalysts is about 10 to about 30% of the total volume of catalysts in the vertical bed.

2. The layered catalyst reactor system of claim 1, wherein the one or more self-supported hydrotreating catalysts comprises about 5 to about 9 wt% molybdenum, about 21 to 31 wt% nickel, and about 33 to about 42 wt% tungsten.

3. The layered catalyst reactor system of claim 1, wherein the one or more demetallization catalysts are selected from the group consisting of: synthetic aluminum oxide or natural aluminum silicate enriched with the oxides of molybdenum, cobalt and nickel.

4. The layered catalyst reactor system of claim 1, wherein the one or more supported hydrotreating catalysts are selected from the group consisting of: catalysts comprising at least one Group VIII metal and at least one Group VIB metal on a support material selected from the group consisting of alumina, zeolites, amorphous silica-alumina, and titania-alumina.

5. The layered catalyst reactor system of claim 1, wherein the one or more supported hydrotreating catalysts are selected from the group consisting of: catalysts comprising Pd or Pt.

6. The layered catalyst reactor system of claim 1, wherein the one or more hydrocracking catalysts are selected from the group consisting of: catalysts comprising nickel, nickel-cobalt-molybdenum, cobalt-molybdenum and nickel-tungsten and/or nickel-molybdenum.

7. The layered catalyst reactor system of claim 1, wherein the one or more hydrocracking catalysts comprise porous support materials comprising a refractory oxide material.

8. The layered catalyst reactor system of claim 1, wherein the one or more hydrocracking catalysts comprise nickel, cobalt, molybdenum and/or tungsten.

9. A layered catalyst reactor system comprising a vertical bed or stack of catalyst layers arranged from top to bottom in the following order:
(i) a layer comprising one or more demetallization catalysts;
(ii) a layer of one or more supported hydrotreating catalysts;
(iii) a layer of one or more supported hydrocracking catalysts;
(iv) a layer of one or more self-supported hydrotreating catalysts;
(v) a layer of one or more supported hydrocracking catalysts;
(vi) a layer of one or more self-supported hydrotreating catalysts;
(vii) a layer of one or more supported hydrocracking catalysts;
(viii) a layer of one or more self-supported hydrotreating catalysts;
(ix) a layer of one or more supported hydrotreating catalysts;
wherein the total volume of the three layers comprising one or more self-supported hydrotreating catalysts is about 9 to about 45% of the total volume of catalysts in the vertical bed; and
wherein the total volume of the three layers comprising one or more supported hydrocracking catalysts is about 15 to about 30% of the total volume of catalysts in the vertical bed.

10. The layered catalyst reactor system of claim 9, wherein the one or more self-supported hydrotreating catalysts comprises about 5 to about 9 wt% molybdenum, about 21 to 31 wt% nickel, and about 33 to about 42 wt% tungsten.

11. The layered catalyst reactor system of claim 9, wherein the one or more demetallization catalysts are selected from the group consisting of: synthetic aluminum oxide or natural aluminum silicate enriched with the oxides of molybdenum, cobalt and nickel.

12. The layered catalyst reactor system of claim 9, wherein the one or more supported hydrotreating catalysts are selected from the group consisting of: catalysts comprising at least one Group VIII metal and at least one Group VIB metal on a support material selected from the group consisting of alumina, zeolites, amorphous silica-alumina, and titania-alumina.

13. The layered catalyst reactor system of claim 9, wherein the one or more supported hydrotreating catalysts are selected from the group consisting of: catalysts comprising Pd or Pt.

14. The layered catalyst reactor system of claim 9, wherein the one or more hydrocracking catalysts are selected from the group consisting of: catalysts comprising nickel, nickel-cobalt-molybdenum, cobalt-molybdenum and nickel-tungsten and/or nickel-molybdenum.

15. The layered catalyst reactor system of claim 9, wherein the one or more hydrocracking catalysts comprise porous support materials comprising a refractory oxide material.

16. The layered catalyst reactor system of claim 9, wherein the one or more hydrocracking catalysts comprise nickel, cobalt, molybdenum and/or tungsten.

17. A process for hydrotreatment of hydrocarbon feedstocks comprising: (i) contacting a hydrocarbon feedstock which contains contaminants comprised of metals, sulfur, nitrogen and olefins with a layered catalyst reactor system in the presence of hydrogen to produce hydrocarbon product having a lower content of metals sulfur, nitrogen and olefins than the hydrocarbon feedstock; (ii) passing the hydrocarbon feedstock sequentially through the layers of the layered catalyst reactor system vertically from top to bottom; and (iii) recovering the hydrocarbon product from the bottom of the layered catalyst reactor system;

wherein the layered catalyst system comprises a vertical bed or stack of catalyst layers arranged from top to bottom in the following order:
(i) a layer comprising one or more demetallization catalysts;

(ii) a layer of one or more supported hydrotreating catalysts;
(iii) a layer of one or more supported hydrocracking catalysts;
(iv) a layer of one or more self-supported hydrotreating catalysts;
(v) a layer of one or more supported hydrocracking catalysts;
(vi) a layer of one or more self-supported hydrotreating catalysts;
(vii) a layer of one or more supported hydrotreating catalysts;
wherein the total volume of the two layers comprising one or more self-supported hydrotreating catalysts is about 10 to about 50% of the total volume of catalysts in the vertical bed; and
wherein the total volume of the two layers comprising one or more supported hydrocracking catalysts is about 10 to about 30% of the total volume of catalysts in the vertical bed;

or
wherein the layered catalyst reactor system comprises a vertical bed or stack of catalyst layers arranged from top to bottom in the following order:
(i) a layer comprising one or more demetallization catalysts;
(ii) a layer of one or more supported hydrotreating catalysts;
(iii) a layer of one or more supported hydrocracking catalysts;
(iv) a layer of one or more self-supported hydrotreating catalysts;
(v) a layer of one or more supported hydrocracking catalysts;
(vi) a layer of one or more self-supported hydrotreating catalysts;
(vii) a layer of one or more supported hydrocracking catalysts;
(viii) a layer of one or more self-supported hydrotreating catalysts;
(ix) a layer of one or more supported hydrotreating catalysts;
wherein the total volume of the three layers comprising one or more self-supported hydrotreating catalysts is about 9 to about 45% of the total volume of catalysts in the vertical bed; and
wherein the total volume of the three layers comprising one or more supported hydrocracking catalysts is about 15 to about 30% of the total volume of catalysts in the vertical bed.

18. The process of claim 17, wherein the operating temperature of layered catalyst reactor system is in the range of about 700 to about 775°F.

19. The process of claim 17, wherein the weight hourly space velocity (WHSV) of the process is in the range of about 0.4 to about 1.1 hr-1.

20. The process of claim 17, wherein the liquid hourly space velocity (LHSV) of the process is in the range of about 0.3 to about 0.9 hr-1.

21. The process of claim 17, wherein the normalized temperature of the layered catalyst reactor system remains less than about 770°F during the process.