WHAT IS CLAIMED IS:

1. Method of producing a base oil product, the method comprising:

hydroprocessing unconverted oil from a hydrocracker in a separate unconverted oil upgrade reactor to produce upgraded unconverted oil; and

dewaxing the upgraded unconverted oil to produce the base oil product.

2. The method according to claim 1, further comprising, prior to hydroprocessing the unconverted oil from the hydrocracker:

hydrocracking a hydrocarbonaceous feedstock in the hydrocracker to produce a hydrocracked effluent comprising the unconverted oil; and

separating the unconverted oil from the hydrocracked effluent.

3. The method according to claim 2, wherein the hydrocarbonaceous feedstock has a boiling point in the range from about 572 °F to about 1112 °F (about 300 °C to about 600 °C) and/or comprises a gas oil such as vacuum gas oil (VGO) or heavy coker gas oil (HCGO).

4. The method according to any preceding claim, wherein hydroprocessing the unconverted oil from the hydrocracker to produce upgraded unconverted oil comprises increasing the viscosity index (VI) of the unconverted oil.

5. The method according to any preceding claim, wherein hydroprocessing the unconverted oil from the hydrocracker to produce upgraded unconverted oil comprises contacting the unconverted oil with a hydroprocessing catalyst in the presence of hydrogen under hydroprocessing conditions such that VI-increasing molecular transformations predominate in the hydroprocessing; or wherein the hydroprocessing conditions comprise:

(a) a reaction temperature from about 400 °F to about 950 °F (from about 204 °C to about 510 °C), for example from about 650 °F to about 850 °F (from about 343 °C to about 454 °C);

(b) a reaction gauge pressure from about 500 psi to about 5000 psi (from about 3447 kPa to about 34474 kPa), for example, from about 1500 psi to about 2500 psi (from about 10342 kPa to about 17237 kPa), or from about 1200 psi to about 2500 psi from about 8274 kPa to about 17237 kPa);

(c) an LHSV from about 0.1 hr^{-1} to about 15 hr^{-1}, for example from about 0.2 hr^{-1} to about 10 hr-1, or from about 0.2 hr^{-1} to about 2.5 hr^{-1}, or from about 0.1 hr^{-1} to about 10 hr^{-1}; and/or

(d) a hydrogen consumption from about 100 scf to about 2500 scf per barrel of liquid hydrocarbon feed (from about 17.8 to about 445 m^3 H_2/m^3 feed), for example from about 200 scf to about 2500 scf per barrel (from about 35.6 to about 445 m^3 H_2/m^3 feed), or from about 100 scf to about 1500 scf per barrel (from about 17.8 to about 267 m^3 H_2/m^3 feed) .

6. The method according to claim 5, wherein the hydroprocessing catalyst comprises:

(a) one or more metals selected from Groups VI and VIII to X and/or one or more compounds thereof; and

(b) a catalyst support, for example a porous refractory support, for example an alumina, a silica, an amorphous silica-alumina material, or a combination thereof; and, optionally,

(c) one or more molecular sieves, for example zeolites.

7. The method according to any preceding claim, wherein hydroprocessing the unconverted oil from the hydrocracker to produce upgraded unconverted oil comprises hydrotreating, hydroisomerizing and/or hydrocracking the unconverted oil from the hydrocracker.

8. The method according to claim 4, where dependent on claim 2, wherein hydroprocessing the unconverted oil from the hydrocracker comprises hydrocracking the unconverted oil from the hydrocracker and wherein the level of hydrocracking conversion during hydrocracking the unconverted oil from the hydrocracker is about 5 % to 30% and the level of hydrocracking conversion during hydrocracking the hydrocarbonaceous feedstock in the hydrocracker is about 30 % to about 70%.

9. The method according to any preceding claim, wherein, prior to hydroprocessing the unconverted oil from the hydrocracker, the unconverted oil comprises one or more of the following:

(a) no greater than about 100 ppm of sulfur;

(b) no greater than about 20 ppm of nitrogen;

(c) no greater than about 1 ppm of nickel, vanadium and/or copper;

(e) an API gravity of from about 25 to about 45;

(f) a TBP 95% point from about 800 °F to about 1100 °F (from about 427 °C to about 593 °C); and

(g) a viscosity index (VI), measured according to ASTM D-2270, of from about 100 to about 150 at a kinematic viscosity of 4 cSt (4 $mm^2 s^{-1}$) at 100 °C (212 °F).

10. The method according to any preceding claim, wherein the base oil product has a viscosity index (VI), measured according to ASTM D-2270, of no less than 120 at a kinematic viscosity of 4 cSt (4 $mm^2 s^{-1}$) at 100 °C (212 °F) or is a Group III base oil product.

11. Method of modifying an existing base oil product manufacturing process to increase a viscosity index (VI) of the base oil produced, the existing base oil product manufacturing process comprising:

hydrocracking a hydrocarbonaceous feedstock in a hydrocracker to produce a hydrocracked effluent comprising unconverted oil;

separating the unconverted oil from the hydrocracked effluent; and

dewaxing the unconverted oil separated from the hydrocracked effluent to produce the base oil product;

wherein the method of modifying the existing base oil product manufacturing process comprises:

hydroprocessing the unconverted oil separated from the hydrocracked effluent in a separate unconverted oil upgrade reactor prior to dewaxing the unconverted oil to produce the base oil product.

12. The method according to claim 11, wherein the hydrocarbonaceous feedstock has a boiling point in the range from about 572 °F to about 1112 °F (about 300 °C to about 600 °C) and/or comprises a gas oil such as vacuum gas oil (VGO) or heavy coker gas oil (HCGO).

13. The method according to claim 11, wherein hydroprocessing the unconverted oil comprises increasing the viscosity index (VI) of the unconverted oil.

14. The method according to any of claims 11 to 13, wherein hydroprocessing the unconverted oil comprises contacting the unconverted oil with a hydroprocessing catalyst in the presence of hydrogen under hydroprocessing conditions selected such that VI-increasing molecular transformations predominate in the hydroprocessing; or

wherein the hydroprocessing conditions comprise:

(a) a reaction temperature from about 400 °F to about 950 °F (from about 204 °C to about 510 °C), for example from about 650 °F to about 850 °F (from about 343 °C to about 454 °C);

(b) a reaction gauge pressure from about 500 psi to about 5000 psi (from about 3447 kPa to about 34474 kPa), for example, from about 1500 psi to about 2500 psi (from about 10342 kPa to about 17237 kPa), or from about 1200 psi to about 2500 psi from about 8274 kPa to about 17237 kPa);

(c) an LHSV from about 0.1 hr^{-1} to about 15 hr^{-1}, for example from about 0.2 hr^{-1} to about 10 hr-1, or from about 0.2 hr^{-1} to about 2.5 hr^{-1}, or from about 0.1 hr^{-1} to about 10 hr^{-1}; and/or

(d) a hydrogen consumption from about 100 scf to about 2500 scf per barrel of liquid hydrocarbon feed (from about 17.8 to about 445 m^3 H_2/m^3 feed), for example from about 200 scf to about 2500 scf per barrel (from about 35.6 to about 445 m^3 H_2/m^3 feed), or from about 100 scf to about 1500 scf per barrel (from about 17.8 to about 267 m^3 H_2/m^3 feed).

15. The method according to claim 14, wherein the hydroprocessing catalyst comprises:

(a) one or more metals selected from Groups VI and VIII to X and/or one or more compounds thereof; and

(b) a catalyst support, for example a porous refractory support, for example an alumina, a silica, an amorphous silica-alumina material, or a combination thereof; and, optionally,

(c) one or more molecular sieves, for example zeolites.

16. The method according to any of claims 14 to 15, wherein hydroprocessing the unconverted oil comprises hydrotreating, hydroisomerizing and/or hydrocracking the unconverted oil.

17. The method according to claim 16, wherein hydroprocessing the unconverted oil comprises hydrocracking the unconverted oil and wherein the level of hydrocracking conversion during hydrocracking the unconverted oil is about 5% to about 30% and the level of hydrocracking conversion during hydrocracking the hydrocarbonaceous feedstock in the hydrocracker is about 30% to about 70%.

18. The method according to any of claims 14 to 17, wherein, prior to hydroprocessing the unconverted oil, the unconverted oil comprises one or more of the following:

(a) no greater than about 100 ppm of sulfur;

(b) no greater than about 20 ppm of nitrogen;

(c) no greater than about 1 ppm of nickel, vanadium and/or copper;

(d) an API gravity of from about 25 to about 45;

(e) a TBP 95% point from about 800 °F to about 1100 °F (from about 427 °C to about 593 °C); and

(f) a viscosity index (VI), measured according to ASTM D-2270, of from about 100 to about 150 at a kinematic viscosity of 4 cSt (4 $mm^2 s^{-1}$) at 100 °C (212 °F).

19. The method according to any of claims 14 to 18, wherein the base oil product has a viscosity index (VI), measured according to ASTM D-2270, of no less than 120 at a kinematic viscosity of 4 cSt (4 $mm^2 s^{-1}$) at 100 °C (212 °F) or is a Group III base oil product.

20. System for producing a base oil product, the system comprising:

a hydrocracker for hydrocracking a hydrocarbonaceous feedstock to produce a hydrocracked effluent comprising unconverted oil; and

a separate unconverted oil upgrade reactor for hydroprocessing unconverted oil, separated from the hydrocracked effluent, to produce upgraded unconverted oil.

21. The system according to claim 20, further comprising:

a dewaxing unit for dewaxing unconverted oil, produced by the unconverted oil upgrade reactor, to produce the base oil product.

22. The system according to claim 20 or claim 21, wherein the hydrocarbonaceous feedstock has a boiling point in the range from about 572 °F to about 1112 °F (about 300 °C to about 600 °C) and/or comprises a gas oil such as vacuum gas oil (VGO) or heavy coker gas oil (HCGO).

23. The system according to any of claims 20 to 22, wherein the unconverted oil upgrade reactor is configured to increase the viscosity index (VI) of the unconverted oil.

24. The system according to any of claims 20 to 23, wherein the unconverted oil upgrade reactor has a hydroprocessing zone comprising one or more beds containing a hydroprocessing catalyst, the hydroprocessing zone being maintained at hydroprocessing conditions such that VI-increasing molecular transformations predominate in the hydroprocessing; or

wherein the hydroprocessing conditions comprise:

(a) a reaction temperature from about 400 °F to about 950 °F (from about 204 °C to about 510 °C), for example from about 650 °F to about 850 °F (from about 343 °C to about 454 °C);

(b) a reaction gauge pressure from about 500 psi to about 5000 psi (from about 3447 kPa to about 34474 kPa), for example, from about 1500 psi to about 2500 psi (from about 10342 kPa to about 17237 kPa), or from about 1200 psi to about 2500 psi from about 8274 kPa to about 17237 kPa);

(c) an LHSV from about 0.1 hr^{-1} to about 15 hr^{-1}, for example from about 0.2 hr^{-1} to about 10 hr-1, or from about 0.2 hr^{-1} to about 2.5 hr^{-1}, or from about 0.1 hr^{-1} to about 10 hr^{-1}; and/or

(d) a hydrogen consumption from about 100 scf to about 2500 scf per barrel of liquid hydrocarbon feed (from about 17.8 to about 445 m^3 H_2/m^3 feed), for example from about 200 scf to about 2500 scf per barrel (from about 35.6 to about 445 m^3 H_2/m^3 feed), or from about 100 scf to about 1500 scf per barrel (from about 17.8 to about 267 m^3 H_2/m^3 feed).

25. The system according to claim 24, wherein the hydroprocessing catalyst comprises:

(a) one or more metals selected from Groups VI and VIII to X and/or one or more compounds thereof; and

(b) a catalyst support, for example a porous refractory support, for example an alumina, a silica, an amorphous silica-alumina material, or a combination thereof; and, optionally,

(c) one or more molecular sieves, for example zeolites.

26. The system according to any of claims 24 to 25, wherein hydroprocessing the unconverted oil comprises hydrotreating, hydroisomerizing and/or hydrocracking the unconverted oil.

27. The system according to claim 26, wherein hydroprocessing the unconverted oil comprises hydrocracking the unconverted oil and wherein the hydroprocessing zone and the hydrocracker are

configured such that the level of hydrocracking conversion during hydrocracking the unconverted oil in the hydroprocessing zone is about 5% to about 30% and the level of hydrocracking conversion during hydrocracking the hydrocarbonaceous feedstock in the hydrocracker is about 30% to 70%.

28. The system according to any of claims 20 to 27configured to feed to the unconverted oil upgrade reactor unconverted oil from the hydrocracker comprising one or more of the following:

(a) no greater than about 100 ppm of sulfur;

(b) no greater than about 20 ppm of nitrogen;

(c) no greater than about 1 ppm of nickel, vanadium and/or copper;

(d) an API gravity of from about 25 to about 45;

(e) a TBP 95% point from about 800 °F to about 1100 °F (from about 427 °C to about 593 °C); and

(f) a viscosity index (VI), measured according to ASTM D-2270, of from about 100 to about 150 at a kinematic viscosity of 4 cSt (4 $mm^2 s^{-1}$) at 100 °C (212 °F).

29. The system according to any of claims 20 to 28, wherein the unconverted oil upgrade reactor is configured to increase the viscosity index (VI) of the unconverted oil by about 5 to by about 30.

30. The system according to any of claims 20 to 29 configured to produce a base oil product having a viscosity index (VI), measured according to ASTM D-2270, of no less than 120 at a kinematic viscosity of 4 cSt (4 $mm^2 s^{-1}$) at 100 °C (212 °F) or a Group III base oil product.

31. The system according to any of claims 20 to 30, wherein the system is a base oil production plant.

32. Method of modifying an existing system for producing a base oil product to increase a viscosity index (VI) of the base oil product, the existing system for producing the base oil product comprising:

a hydrocracker for hydrocracking a hydrocarbonaceous feedstock to produce a hydrocracked effluent comprising unconverted oil; and

a dewaxing unit for dewaxing unconverted oil, separated from the hydrocracked effluent, to produce the base oil product;

wherein the method of modifying the existing system comprises:

installing in the existing system a separate unconverted oil upgrade reactor for hydroprocessing the unconverted oil, separated from the hydrocracked effluent, prior to dewaxing the unconverted oil to produce the base oil product.

33. The method according to claim 32, wherein the hydrocarbonaceous feedstock has a boiling point in the range from about 572 °F to about 1112 °F (about 300 °C to about 600 °C) and/or comprises a gas oil such as vacuum gas oil (VGO) or heavy coker gas oil (HCGO).

34. The method according to claim 32 or claim 33, wherein the unconverted oil upgrade reactor is configured to increase the viscosity index (VI) of the unconverted oil.

35. The method according to any of claims 32 to 34, wherein the unconverted oil upgrade reactor has a hydroprocessing zone comprising one or more beds containing a hydroprocessing catalyst, the hydroprocessing zone being maintained at hydroprocessing conditions which are selected such that VI-increasing molecular transformations predominate in the hydroprocessing; or wherein the hydroprocessing conditions comprise:

(a) a reaction temperature from about 400 °F to about 950 °F (from about 204 °C to about 510 °C), for example from about 650 °F to about 850 °F (from about 343 °C to about 454 °C);

(b) a reaction gauge pressure from about 500 psi to about 5000 psi (from about 3447 kPa to about 34474 kPa), for example, from about 1500 psi to about 2500 psi (from about 10342 kPa to about 17237 kPa), or from about 1200 psi to about 2500 psi from about 8274 kPa to about 17237 kPa);

(c) an LHSV from about 0.1 hr^{-1} to about 15 hr^{-1}, for example from about 0.2 hr^{-1} to about 10 hr-1, or from about 0.2 hr^{-1} to about 2.5 hr^{-1}, or from about 0.1 hr^{-1} to about 10 hr^{-1}; and/or

(d) a hydrogen consumption from about 100 scf to about 2500 scf per barrel of liquid hydrocarbon feed (from about 17.8 to about 445 m^3 H_2/m^3 feed), for example from about 200 scf to about 2500 scf per barrel (from about 35.6 to about 445 m^3 H_2/m^3 feed), or from about 100 scf to about 1500 scf per barrel (from about 17.8 to about 267 m^3 H_2/m^3 feed).

36. The method according to claim 35, wherein the hydroprocessing catalyst comprises:

(a) one or more metals selected from Groups VI and VIII to X and/or one or more compounds thereof; and

(b) a catalyst support, for example a porous refractory support, for example an alumina, a silica, an amorphous silica-alumina material, or a combination thereof; and, optionally,

(c) one or more molecular sieves, for example zeolites.

37. The method according to any of claims 35 to 36, wherein hydroprocessing the unconverted oil comprises hydrotreating, hydroisomerizing and/or hydrocracking the unconverted oil.

38. The method according to claim 37, wherein hydroprocessing the unconverted oil comprises hydrocracking the unconverted oil and wherein the hydroprocessing zone and the hydrocracker are configured such that the level of hydrocracking conversion during hydrocracking the unconverted oil in the hydroprocessing zone is about 5% to about 30% and the level of hydrocracking conversion during hydrocracking the hydrocarbonaceous feedstock in the hydrocracker is about 30% to about 70%.

39. The method according to any of claims 32 to 38, wherein the method comprises configuring the existing system to feed to the unconverted oil upgrade reactor unconverted oil from the hydrocracker comprising one or more of the following:

(a) no greater than about 100 ppm of sulfur;

(b) no greater than about 20 ppm of nitrogen;

(c) no greater than about 1 ppm of nickel, vanadium and/or copper;

(d) an API gravity of from about 25 to about 45;

(e) a TBP 95% point from about 800 °F to about 1100 °F (from about 427 °C to about 593 °C); and

(f) a viscosity index (VI), measured according to ASTM D-2270, of from about 100 to about 150 at a kinematic viscosity of 4 cSt (4 $mm^2 s^{-1}$) at 100 °C (212 °F).

40. The method according to any of claims 32 to 39, wherein the unconverted oil upgrade reactor is configured to increase the viscosity index (VI) of the unconverted oil by about 5 to by about 30.

41. The method according to any of claims 32 to 40, wherein, after modifying the existing system, the base oil product produced has a viscosity index (VI), measured according to ASTM D-2270, of no less than 120 at a kinematic viscosity of 4 cSt (4 $mm^2 s^{-1}$) at 100 °C (212 °F) or the base oil product produced is a Group III base oil product.

42. The method according to any of claims 32 to 41, wherein the existing system is a base oil production plant.

43. An unconverted oil upgrade reactor for hydroprocessing unconverted oil, separated from the hydrocracked effluent of a hydrocracker, prior to dewaxing the unconverted oil to produce a base oil product, the unconverted oil upgrade reactor:

(a) having a hydroprocessing zone comprising one or more beds containing a hydroprocessing catalyst, the hydroprocessing zone being maintained at hydroprocessing conditions; and

(b) being configured to increase the viscosity index (VI) of the unconverted oil.

44. The unconverted oil upgrade reactor according to claim 43, wherein:

(a) the hydroprocessing catalyst comprises:

(i) one or more metals selected from Groups VI and VIII to X and/or one or more compounds thereof; and

(ii) a catalyst support, for example a porous refractory support, for example an alumina, a silica, an amorphous silica-alumina material, or a combination thereof; and, optionally,

(iii) one or more molecular sieves, for example zeolites; and/or

(b) the hydroprocessing conditions comprise:

(i) a reaction temperature from about 400 °F to about 950 °F (from about 204 °C to about 510 °C), for example from about 650 °F to about 850 °F (from about 343 °C to about 454 °C);

(ii) a reaction gauge pressure from about 500 psi to about 5000 psi (from about 3447 kPa to about 34474 kPa), for example, from about 1500 psi to about 2500 psi (from about 10342 kPa to about 17237 kPa), or from about 1200 psi to about 2500 psi from about 8274 kPa to about 17237 kPa);

(iii) an LHSV from about 0.1 hr^{-1} to about 15 hr^{-1}, for example from about 0.2 hr^{-1} to about 10 hr^{-1}, or from about 0.2 hr^{-1} to about 2.5 hr^{-1}, or from about 0.1 hr^{-1} to about 10 hr^{-1}; and/or

(iv) a hydrogen consumption from about 100 scf to about 2500 scf per barrel of liquid hydrocarbon feed (from about 17.8 to about 445 m^3 H_2/m^3 feed), for example from about 200 scf to about 2500 scf per barrel (from about 35.6 to about 445 m^3 H_2/m^3 feed), or from about 100 scf to about 1500 scf per barrel (from about 17.8 to about 267 m^3 H_2/m^3 feed).

45. Base oil product produced (a) by the method according to any of claims 1 to 10, (b) using the system according to any of claims 20 to 31, or (c) using the system modified by the method according to any of claims 32 to 42.

46. Lubricant comprising the base oil product of claim 45.

47. Use of an upgraded unconverted oil in the manufacture of a base oil product to increase the viscosity index (VI) of the manufactured base oil product.

48. The use according to claim 47, wherein the manufacture of the base oil product comprises dewaxing the upgraded unconverted oil in a dewaxing unit, and wherein the upgraded unconverted oil is obtained by hydroprocessing unconverted oil obtained from hydrocracking a hydrocarbonaceous feedstock having a boiling point in the range from about 572 °F to about 1112 °F (about 300 °C to about 600 °C) and/or comprising a gas oil such as vacuum gas oil (VGO) or heavy coker gas oil (HCGO).

49. Use of a dewaxed, upgraded unconverted oil as a base oil product in a lubricant to increase the viscosity index (VI) of the lubricant, wherein the dewaxed, upgraded unconverted oil is obtained by (a) hydroprocessing unconverted oil obtained from hydrocracking a hydrocarbonaceous feedstock having a boiling point in the range from about 572 °F to about 1112 °F (about 300 °C to about 600 °C) and/or comprising a gas oil such as vacuum gas oil (VGO) or heavy coker gas oil (HCGO) and (b) dewaxing the hydroprocessed unconverted oil.