

CLAIMS

What is claimed:

1. A process for converting high sulfur fuel oils to petrochemicals, the process comprising:
hydrocracking a high sulfur fuel oil in an ebullated bed or slurry bed fuel oil hydrocracker
to form a cracked fuel oil effluent;
separating the cracked fuel oil effluent into a light fraction and a heavy fraction;
hydrocracking the light fraction in a distillate hydrocracker to form a cracked effluent;
separating the cracked effluent into a hydrogen fraction, a light hydrocarbon fraction, a
light naphtha fraction, and a heavy naphtha fraction;
reforming the heavy naphtha fraction to produce a reformer effluent comprising hydrogen
and at least one of benzene, toluene, and xylenes;
steam cracking the light hydrocarbon fraction and/or the light naphtha fraction to produce
a steam cracker effluent comprising at least one of ethylene, propylene, benzene,
toluene, and xylenes.
2. The process of claim 1, further comprising:
gasifying the heavy fraction to produce a syngas comprising carbon monoxide and
hydrogen; and
feeding the syngas or hydrogen recovered from the syngas to the fuel oil hydrocracker.
3. The process of claim 1, further comprising separating the steam cracker effluent into a
hydrogen fraction, one or more light olefin fractions, one or more aromatic fractions, and
a pyrolysis gas oil fraction.
4. The process of claim 3, further comprising feeding the steam cracker effluent hydrogen
fraction to the distillate hydrocracker.
5. The process of claim 3, further comprising feeding the pyrolysis gas oil fraction to the
fuel oil hydrocracker.
6. The process of claim 1, further comprising separating the reformer effluent to form a
hydrogen fraction and one or more aromatics fractions.
7. The process of claim 6, further comprising feeding the reformer effluent hydrogen
fraction to the distillate hydrocracker.

8. A system for converting high sulfur fuel oils to petrochemicals, the system comprising:
 - an ebullated bed or slurry bed fuel oil hydrocracker for hydrocracking a high sulfur fuel oil to form a cracked fuel oil effluent;
 - a first separation system for separating the cracked fuel oil effluent into a light fraction and a heavy fraction;
 - a distillate hydrocracker for hydrocracking the light fraction to form a cracked effluent;
 - a second separation system for separating the cracked effluent into a hydrogen fraction, a light hydrocarbon fraction, a light naphtha fraction, and a heavy naphtha fraction;
 - a catalytic reformer for reforming the heavy naphtha fraction to produce a reformer effluent comprising hydrogen and at least one of benzene, toluene, and xylenes;
 - a steam cracker for steam cracking the light hydrocarbon fraction and/or the light naphtha fraction to produce a steam cracker effluent comprising at least one of ethylene, propylene, benzene, toluene, and xylenes.
9. The system of claim 8, further comprising:
 - a gasifier for gasifying the heavy fraction to produce a syngas comprising carbon monoxide and hydrogen; and
 - a flow line for feeding the syngas or hydrogen recovered from the syngas to the fuel oil hydrocracker.
10. The system of claim 8, further comprising a third separation system for separating the steam cracker effluent into a hydrogen fraction, one or more light olefin fractions, one or more aromatic fractions, and a pyrolysis gas oil fraction.
11. The system of claim 10, further comprising a flow line for feeding the steam cracker effluent hydrogen fraction to the distillate hydrocracker.
12. The system of claim 10, further comprising a flow line for feeding the pyrolysis gas oil fraction to the fuel oil hydrocracker or the distillate hydrocracker or both.
13. The system of claim 8, further comprising a fourth separation system for separating the reformer effluent to form a hydrogen fraction and one or more aromatics fractions.
14. The system of claim 13, further comprising a flow line for feeding the reformer effluent hydrogen fraction to the distillate hydrocracker.
15. The system of claim 8, further comprising a separator for separating the pyrolysis gas oil fraction into a light pyrolysis gas oil fraction and a heavy pyrolysis gas oil fraction.

16. The system of claim 15, further comprising a flow line for feeding the heavy pyrolysis gas oil fraction to the fuel oil hydrocracker and a flow line for feeding the light pyrolysis gas oil fraction to the distillate hydrocracker.
17. A process for converting high sulfur fuel oils to petrochemicals, the process comprising:
 - hydrocracking a high sulfur fuel oil in an ebullated bed or slurry bed fuel oil hydrocracker to form a cracked fuel oil effluent;
 - separating the cracked fuel oil effluent into a light fraction and a heavy fraction;
 - hydrocracking the light fraction in a distillate hydrocracker to form a cracked effluent;
 - separating the cracked effluent to recover one or more gas fractions comprising hydrogen, hydrogen sulfide, and/or ammonia, and to recover two or more hydrocarbon fractions, including a light hydrocarbon fraction and a heavy hydrocarbon fraction;
 - hydrocracking the heavy hydrocarbon fraction to produce a hydrocracked effluent comprising naphtha range and lighter hydrocarbons;
 - feeding the light hydrocarbon fraction and the hydrocracked effluent to an ethylene complex to produce petrochemicals including ethylene, propylene, butadiene, benzene, toluene, xylenes, and/or methyl tertiary-butyl ether.
18. The process of claim 17, further comprising:
 - gasifying the heavy fraction to produce a syngas comprising carbon monoxide and hydrogen; and
 - feeding the syngas or hydrogen recovered from the syngas to the fuel oil hydrocracker;
19. The process of claim 17, further comprising feeding the heavy fraction to a delayed coking unit or a cement plant.
20. The process of claim 17, wherein the heavy fraction is an IMO compliant ultralow sulfur fuel oil comprising less than 0.5 wt% sulfur.
21. The process of claim 17, wherein the producing petrochemicals in the ethylene complex comprises one or more of steam cracking, catalytic cracking, metathesis, etherification, butadiene extraction, aromatics extraction, and/or disproportionation.
22. The process of claim 17, wherein the hydrocracking the light fraction in a distillate hydrocracker to form a cracked effluent comprises:
 - reacting the light fraction in a first reaction zone containing hydrotreating catalyst;
 - reacting the first reaction zone effluent in a second reaction zone containing an unsupported tri-metallic catalyst; and

reacting the second reaction zone effluent in a third reaction zone containing a nitrogen-tolerant hydrocracking catalyst.

23. The process of claim 22, wherein each of the first, second, and third reaction zones are operated at a temperature in the range from about 340°C to about 430°C, a pressure in the range from about 150 bara to about 180 bara, and a liquid hourly space velocity in the range from about 0.5 h⁻¹ to about 2.5 h⁻¹.
24. The process of claim 17, wherein the hydrocracking the heavy hydrocarbon fraction to produce a hydrocracked effluent comprising naphtha range and lighter hydrocarbons comprises:
 - reacting the heavy hydrocarbon fraction in a reaction zone containing an unsupported tri-metallic catalyst; and
 - reacting the reaction zone effluent in a downstream reaction zone containing a noble metal zeolitic catalyst.
25. The process of claim 24, wherein each of the reaction zone and the downstream reaction zone are operated at a temperature in the range from about 300°C to about 400°C, a pressure in the range from about 150 bara to about 180 bara, and a liquid hourly space velocity in the range from about 0.5 h⁻¹ to about 3.0 h⁻¹.
26. The process of claim 17, wherein the hydrocracking a high sulfur fuel oil in a fuel oil hydrocracker comprises reacting the high sulfur fuel oil in a reaction zone operated at a temperature in the range from about 390°C to about 440°C, a pressure in the range from about 170 bara to about 195 bara, and a liquid hourly space velocity in the range from about 0.1 h⁻¹ to about 0.5 h⁻¹.
27. A system for converting high sulfur fuel oils to petrochemicals, the system comprising:
 - an ebullated bed or slurry bed fuel oil hydrocracker for hydrocracking a high sulfur fuel oil in to form a cracked fuel oil effluent;
 - a separator for separating the cracked fuel oil effluent into a light fraction and a heavy fraction;
 - a distillate hydrocracker for hydrocracking the light fraction in to form a cracked effluent;
 - a separation system for separating the cracked effluent to recover one or more gas fractions comprising hydrogen, hydrogen sulfide, and/or ammonia, and to recover two or more hydrocarbon fractions, including a light hydrocarbon fraction and a heavy hydrocarbon fraction;

- a hydrocracker for hydrocracking the heavy hydrocarbon fraction to produce a hydrocracked effluent comprising naphtha range and lighter hydrocarbons;
 - an ethylene complex for converting the light hydrocarbon fraction and the hydrocracked effluent to produce petrochemicals including ethylene, propylene, butadiene, benzene, toluene, xylenes, and/or methyl tertiary-butyl ether.
28. The system of claim 27, further comprising:
- a gasifier for gasifying the heavy fraction to produce a syngas comprising carbon monoxide and hydrogen; and
 - a flow line for feeding the syngas, or hydrogen recovered from the syngas, to the fuel oil hydrocracker;
29. The system of claim 27, wherein the ethylene complex comprises one or more of a steam cracker, a catalytic cracker, a metathesis unit, an etherification unit, a butadiene extraction unit, an aromatics extraction unit, and/or a disproportionation unit.
30. The system of claim 27, wherein the distillate hydrocracker comprises:
- a first reaction zone containing hydrotreating catalyst;
 - a second reaction zone containing an unsupported tri-metallic catalyst; and
 - a third reaction zone containing a nitrogen-tolerant hydrocracking catalyst.
31. The system of claim 27, wherein the hydrocracker for hydrocracking the heavy hydrocarbon fraction to produce a hydrocracked effluent comprises:
- a reaction zone containing an unsupported tri-metallic catalyst; and
 - a downstream reaction zone containing a noble metal zeolitic catalyst.