and depressurising the fluid product stream in a flash vessel, injecting steam, superheated steam or supercritical water into the flash vessel and contacting the fluid product stream with the steam, superheated steam or supercritical water to facilitate fractionation of the fluid product stream, wherein: the fluid product stream is at a temperature of at least 350°C and a pressure of at least 180 bar immediately prior to the depressurising, the depressurising comprises reducing the pressure of the fluid product stream to less than 25 bar in the flash vessel thereby vaporizing at least a portion of the fluid product stream and generating a vapour comprising constituent parts of hydrocarbon products, steam, and gas, the flash vessel is coupled directly with an accumulation apparatus, is an integral part of an accumulation apparatus, or is coupled directly to one or more staged product condensers, and the vaporizing provides energy to facilitate fractionation of the vapour into the constituent parts; and collecting the fractionated vapour.

In another aspect, there is provided a continuous flow reactor apparatus for treating polymeric material, comprising: an extruder for producing an extrudate comprising a molten stream of the polymeric material; a boiler apparatus for preparing and adding supercritical water to the extrudate; a mechanical mixing device configured for mixing of the extrudate with the supercritical water to thereby form a reaction mixture; a reaction zone in communication with the mechanical mixing device and with indirect heaters, wherein the reaction zone is for treating the reaction mixture at a defined temperature and pressure for a defined residence time to thereby produce a fluid product stream; a pressure let down device for depressurisation of the fluid product stream, wherein the pressure let down device is in communication with the reaction zone and a flash vessel; a fired superheater or steam generator for producing steam, superheated steam or supercritical water to be injected into the flash vessel for contacting the fluid product stream to facilitate fractionation of the fluid product stream; and a fractionation apparatus for separation of vapour generated in the flash vessel; wherein the flash vessel: is coupled directly with the fractionation apparatus; or is an integral part of the flash column; or and the fractionation apparatus are separate product condensers.

The present disclosure relates at least in part to the following embodiments:

Embodiment 1. A method for treating polymeric material to produce hydrocarbon products, the method comprising:

- generating a reaction mixture comprising the polymeric material and an aqueous solvent,

CLAIMS

1. A method for treating polymeric material to produce hydrocarbon products, the method comprising:

- generating a reaction mixture comprising the polymeric material and an aqueous solvent,
- treating the reaction mixture in a reactor apparatus at a reaction temperature and a reaction pressure over a period of time suitable for conversion of all or a portion of the polymeric material present in the reaction mixture into a fluid product stream, and
- depressurising the fluid product stream in a flash vessel,
- injecting steam, superheated steam or supercritical water into the flash vessel and contacting the fluid product stream with the steam, superheated steam or supercritical water to facilitate fractionation of the fluid product stream,wherein:

  the fluid product stream is at a temperature of at least 350°C and a pressure of at least 180 bar immediately prior to the depressurising,

  the depressurising comprises reducing the pressure of the fluid product stream to less than 25 bar in the flash vessel thereby vaporizing at least a portion of the fluid product stream and generating a vapour comprising constituent parts of hydrocarbon products, steam, and gas, the flash vessel is coupled directly with an accumulation apparatus, is an integral part of an accumulation apparatus, or is coupled directly to one or more staged product condensers, and

  the vaporizing provides energy to facilitate fractionation of the vapour into the constituent parts; and
- collecting the fractionated vapour.

2. The method of claim 1, wherein the fluid product stream is at:

(i) a temperature of at least: 380°C, 400°C, 420°C, 450°C, or 470°C, and/or

(ii) a pressure of at least: 200 bar, 220 bar, 240 bar, 260 bar, 280 bar or 300 bar; immediately prior to the depressurising.

3. The method of claim 1 or 2, comprising fractionating and condensing the vapour into fractions having a maximum atmospheric equivalent boiling point of less than: 400°C, 450°C, 500°C, 550°C or 600°C and collecting a residual fraction with a minimum atmospheric equivalent boiling point of more than 400°C, 450°C, 500°C, 550°C or 600°C

4. The method of any one of claims 1 to 3, wherein solid fillers and/orinorganic matter and/or metal salts from the depressurized product stream are retained within residue matrix produced by said vaporizing and fractionation.

5. The method of any one of claims 1 to 4, wherein the depressurising and fractionation enables separation of the aqueous solvent from the hydrocarbon products including separation of the aqueous solvent from:
(i) low boiling hydrocarbons at a temperature below: 10°C, 20°C, 30°C, 40°C, 50°C, or 60°C; or
(ii) low boiling hydrocarbons at a temperature below: 10°C, 20°C, 30°C, 40°C, 50°C, or 60°C, conducted under an effective gravity of 9.8_+/- 0.1 m/s^2.

6. The method of any one of claims 1 to 5, wherein said generating of the reaction mixture comprises:

- providing a molten stream of the polymeric material;
- injecting the aqueous solvent into the molten stream of polymeric material, wherein the aqueous solvent is supercritical prior to said injecting; and
- mechanical mixing of the aqueous solvent and the molten stream of polymeric material, wherein the mechanical mixing comprises use of solvent distribution grids in an assembly comprising one or more static mechanical mixing devices.

7. The method of claim 6, wherein the aqueous solvent is water or substantially water.

8. The method of claim 7, wherein the supercritical aqueous solvent is generated in a boiler apparatus comprising a burner fuelled by gas released from the fluid product stream, wherein the supercritical aqueous solvent exits the boiler apparatus at:

(i) a temperature of at least: 450°C, 500°C, or 550°C, and/or

(ii) a pressure of at least 180 bar or at least 200 bar or at least 220 bar or at least 240 bar or at least 250 bar, at least 270 bar, or 290 bar, or 310 bar or 330 bar during generation of the supercritical aqueous solvent.

9. The method of any one of claims 1 to 8, wherein said treating comprises contacting the reaction mixture with supplementary metal catalysts in addition to those present in any solid state transition metal surface in contact with the reaction mixture during said generating or treating, wherein the supplementary metal catalysts are:

- components of a solid material that is mixed into the reaction mixture to facilitate contact between the fluids and the supplementary metal catalyst, and/or
- a component of any said mixing device.

10. The method of any one of claims 1 to 9, further comprising removal of solid materials from the reaction mixture during said treating, wherein the solid materials:

- are inorganic materials present within the polymeric material, wherein the inorganic materials:

  are fillers or contaminants present within the polymeric material prior to conducting the method; and/or

  have reacted with the aqueous solvent and/or with carbon rich materials formed in small volumes by side reactions during said treating;
- have a greater density than fluids within the reaction mixture and separate from the reaction mixture by gravity during said treating; and
- are removed a reactor apparatus in which said treating is conducted by blowing down into a receiver vessel during said treating by means of remotely operated valves.

11. The method of any one of claims 1 to 10, wherein the method is conducted in a reactor apparatus comprising any one or more of:

- systems for testing pressure levels in valving and a pressure letdown vessel within said reactor apparatus,
- a system allowing cooling of material blown down into a receiver vessel of the reactor apparatus,
- a final collection pot with removable lid for blown down material that is interlocked with its lid and with interconnected pipes and valves to prevent accidental removal of the pot and contents,
- venting for release of gases formed during or after said treating,
- providing inert atmospheres comprising nitrogen, argon, carbon dioxide and/or other inert gases preventing ignition and combustion of materials contained within the letdown pot and collection pot,
- sequencing systems to minimise mechanical shock in the reactor apparatus.

12. The method of any one of claims 1 to 11, wherein the reaction temperature is at least: 380°C, 400°C, 450°C, or 500°C.

13. The method of any one of claims 1 to 12, wherein the hydrocarbon product comprises any one or more of:

(i) a naphtha component boiling between 10°C and 210°C AEBP, and wherein the naphtha component comprises:

- more than 10%, 20% 30%, 40% by mass olefins; and/or
- more than 10%, 20%, 30% 40% by mass n-paraffins; and/or
- more than 10%, 20%, 30% 40% by mass cycloalkanes or cycloalkenes; and/or
- more than 10%, 20%, 30% 40% by mass aromatics;

(ii) a gas oil component boiling between 210°C and 360°C AEBP, and wherein the gas oil component comprises:

- more than 10%, 20% 30%, 40% by mass olefins; and/or
- more than 10%, 20%, 30% 40% by mass n-paraffins; and/or
- more than 10%, 20%, 30% 40% by mass cycloalkanes or cycloalkenes; and/or
- more than 10%, 20%, 30% 40% by mass aromatics;

(iii) a heavy gas oil component boiling between 360°C and 550°C AEBP, and the heavy gas oil component comprises:

- more than 10%, 20% 30%, 40% by mass olefins; and/or
- more than 10%, 20%, 30% 40% by mass n-paraffins; and/or

- more than 10%, 20%, 30% 40% by mass cycloalkanes or cycloalkenes; and/or
- more than 10%, 20%, 30% 40% by mass aromatics.

14. The method of any one of claims 1 to 13, wherein:
- the polymeric material used to generate said reaction mixture is a molten polymeric material extrudate;
- the polymeric material extrudate is diverted to a collection vessel prior to generating said reaction mixture;
- the collection vessel is provided with an inert atmosphere avoiding combustion of the molten polymeric material extrudate; and
- the collection vessel is connected to a reactor apparatus by one or more lines providing double valve isolation on each line to prevent reverse flow of the molten polymeric material extrudate from the reactor.

15. The method of any one of claims 1 to 14, wherein:

(i) the treating is performed under conditions of continuous flow; and/or

(ii) the polymeric material does not comprise any one or more of: lignocellulosic matter; naturally-occurring carbohydrate polymers; lignin; cellulose; hemicellulose; combinations of any two of lignin, cellulose, hemicellulose; lignite (brown coal); subbituminous coal; any combination thereof.

16. A continuous flow reactor apparatus for treating polymeric material, comprising:
- an extruder for producing an extrudate comprising a molten stream of the polymeric material;
- a boiler apparatus for preparing and adding supercritical water to the extrudate;
- a mechanical mixing device configured for mixing of the extrudate with the supercritical water to thereby form a reaction mixture;
- a reaction zone in communication with the mechanical mixing device and with indirect heaters, wherein the reaction zone is for treating the reaction mixture at a defined temperature and pressure for a defined residence time to thereby produce a fluid product stream;

- a pressure let down device for depressurisation of the fluid product stream, wherein the pressure let down device is in communication with the reaction zone and a flash vessel;
- a fired superheater or steam generator for producing steam, superheated steam or supercritical water to be injected into the flash vessel for contacting the fluid product stream to facilitate fractionation of the fluid product stream; and
- a fractionation apparatus for separation of vapour generated in the flash vessel;

wherein the flash vessel:

- is coupled directly with the fractionation apparatus; or
- is an integral part of the flash column; or
- and the fractionation apparatus are separate product condensers.

17. The continuous flow reactor apparatus of claim 16, wherein one or more components of the reaction zone comprises a source of solid state transition metal catalysts for the reaction mixture.

18. The continuous flow reactor apparatus of claim 16 or claim 17, comprising a blow down component for removal of solid materials from the reaction mixture, and a receiver vessel for the solid materials.