CLAIMS

1. A hollow composite vessel, wherein a wall of the hollow composite vessel comprises a multilayer structure, said multilayer structure comprising:

an inner layer comprising one or more thermoplastic polymers;

an outer layer comprising a plurality of filaments selected from one or more of carbon, glass, aramid and basalt filaments, and one or more thermosetting polymers; and

a middle layer disposed between the inner layer and the outer layer, said middle layer comprising one or more fibrous materials;

wherein the one or more fibrous materials is at least partly infiltrated with both the one or more thermoplastic polymers and the one or more thermosetting polymers.

2. The hollow composite vessel according to claim 1, wherein the one or more thermoplastic polymers of the inner layer comprise one or more of ethylene homopolymers, ethylene co-polymers, propylene homopolymers, propylene co-polymers, fluoropolymers, polyvinylchloride, polyvinylidene chloride, polyaryl ether ketone, and polyamide.

3. The hollow composite vessel according to claim 1 or claim 2, wherein the one or more thermoplastic polymers comprise polyethylene, or ethylene tetrafluoroethylene, or ethylene chlorotrifluoroethylene.

4. The hollow composite vessel according to any one of claims 1 to 3, wherein the one or more thermosetting polymers of the outer layer comprise one or more of polyester, polyacrylate, epoxy, vinyl ester, bismaleimide, and polyurethane.

5. The hollow composite vessel according to any one of claims 1 to 4, wherein the one or more fibrous materials of the middle layer comprises one or more fabricated textile materials.

6. The hollow composite vessel according to claim 5, wherein the one or more fabricated textile materials comprise one or more of woven, knitted, and braided materials.

7. The hollow composite vessel according to claim 5 or claim 6, wherein the one or more fabricated textile materials comprise yarns of plied strands.

8. The hollow composite vessel according to claim 7, wherein the spacing between at least some yarns of the fibrous material of the middle layer is from about 0.01 micron to about 5000 micron, or from about 0.1 micron to about 5000 micron, or between about 1 micron and 5000 micron, or between about 10 micron and about 5000 micron.

9. The hollow composite vessel according to any one of claims 1 to 8, wherein the one or more fibrous materials of the middle layer comprise one or more of ceramic fibres and polymeric fibres.

10. The hollow composite vessel according to claim 9, wherein the one or more ceramic fibres comprise one or more of glass, carbon and basalt fibres, or precursors thereof.

11. The hollow composite vessel according to claim 9, wherein the one or more polymeric fibres comprise one or more of polyamide and polyolefin.

12. The hollow composite vessel according to any one of claims 1 to 11, wherein the plurality of filaments of the outer layer have a filament diameter from about 0.1 micron to about 500 micron, or from about 0.1 micron to about 100 micron, or from about 0.1 micron to about 50 micron, or from about 1 micron to about 20 micron.

13. The hollow composite vessel according to any one of claims 1 to 12, wherein the plurality of filaments of the outer layer are in the form of one or more of wound filaments, fabric sections comprising multiple yarns, braided yarns and chopped fibres.

14. The hollow composite vessel according to any one of claims 1 to 13, wherein the thickness of the inner layer of the multilayer structure is from about 0.1 mm to about 50 mm or from 0.2 mm to 30 mm, the thickness of the middle layer is from about 0.1 mm to about 5 mm or from 0.2 mm to 3 mm, and the thickness of the outer layer is from about 0.1 mm to about 1000 mm or from 2 mm to 30 mm.

15. The hollow composite vessel according to any one of claims 1 to 14, wherein thermoplastic polymer is embedded in gaps between yarns of the fibrous material.

16. The hollow composite vessel according to any one of claims 1 to 15, wherein thermoplastic polymer is embedded within the structure of individual yarns of the fibrous material.

17. The hollow composite vessel according to any one of claims 1 to 16, wherein tendrils of the fibrous material of the middle layer extend from a surface of yarns into the inner layer.

18. The hollow composite vessel according to any one of claims 1 to 17, wherein the strength of the union between the thermoplastic polymer and the fibrous layer is greater than the cohesive strength of the thermoplastic polymer.

19. The hollow composite vessel according to any one of claims 1 to 18, wherein the thermoplastic polymer is embedded in the fibrous layer to an extent such that shear

failure of the multilayer structure occurs through cohesive failure of the thermoplastic polymer.

20. The hollow composite vessel according to any one of claims 1 to 19, wherein the multilayer structure has a maximum lap shear strength which is proportional to the tensile strength of the thermoplastic polymer.

21. The hollow composite vessel according to any one of claims 1 to 20, wherein the multilayer structure has a maximum lap shear strength substantially equal to the tensile strength of the thermoplastic polymer multiplied by 0.58.

22. The hollow composite vessel according to any one of claims 1 to 21, wherein the lap shear strength of the multilayer structure is greater than 5 MPa, or greater than about 6 MPa, or greater than about 7 MPa, or greater than about 8 MPa, or greater than about 9 MPa, or greater than about 10 MPa.

23. The hollow composite vessel according to any one of claims 1 to 22, wherein the fibrous layer has a single pressure average permeability of less than about 10^{-11} m^2, or

less than about $9*10^{-12}$ m^2, or less than about $8*10^{-12}$ m^2, or less than about $7*10^{-12}$ m^2, or less than about $6*10^{-12}$ m^2, or less than about $5*10^{-12}$ m^2, or less than about $4*10^{-12}$ m^2.

24. A method of manufacturing a hollow composite vessel according to any one of claims 1 to 23 comprising the following steps:

a) applying one or more fibrous materials to the internal surface of a hollow mold;

b) heating and rotating the hollow mold in the presence of one more thermoplastic polymers located within the hollow mold so that the thermoplastic polymer melts and at least partially infiltrates the fibrous material;

c) cooling the mold so that the thermoplastic polymer solidifies;

d) releasing a hollow thermoplastic polymer/fibrous material composite vessel from the mold; and one or more of steps e) to g);

e) applying a plurality of filaments selected from one or more of carbon, glass, aramid and basalt filaments to the outside of the hollow thermoplastic polymer/fibrous material composite vessel, wherein prior to application the plurality of filaments are at least partly wetted with one or more thermoset polymers;

f) applying a plurality of filaments selected from one or more of carbon, glass, aramid and basalt filaments to the outside of the hollow thermoplastic polymer/fibrous material composite vessel followed by application of one or more thermoset polymers;

g) applying one or more thermoset polymers to the outside of the hollow thermoplastic polymer/fibrous material composite vessel followed by application of a plurality of filaments selected from one or more of carbon, glass, aramid and basalt filaments.

25. The method according to claim 24, further comprising curing the one or more thermoset polymers.

26. The method according to claim 24 or claim 25, wherein the mold is simultaneously rotated about two directions.

27. The method according to any one of claims 24 to 26, wherein the fibrous material is fixed to the internal surface of the mold through mechanical or adhesive means, or through the application of pressure.

28. A hollow composite vessel according to claim 1, wherein a wall of the hollow composite vessel comprises a multilayer structure, said multilayer structure comprising:

an inner layer comprising one or more thermoplastic polymers selected from one or more of ethylene homopolymers, ethylene co-polymers, propylene homopolymers, propylene co-polymers, fluoropolymers, polyvinylchloride, polyvinylidene chloride, polyaryl ether ketone, and polyamide;

an outer layer comprising a plurality of filaments selected from one or more of carbon, glass, aramid and basalt filaments, and one or more thermosetting polymers selected from one or more of polyester, polyacrylate, epoxy, vinyl ester, bismaleimide, and polyurethane; and

a middle layer disposed between the inner layer and the outer layer, said middle layer comprising one or more fibrous materials in the form of fabricated textile materials;

wherein the one or more fabricated textile materials is at least partly infiltrated with both the one or more thermoplastic polymers and the one or more thermosetting polymers;

wherein the thickness of the inner layer of the multilayer structure is from about 0.1 mm to about 50 mm, the thickness of the middle layer is from about 0.1 mm to about 5 mm, and the thickness of the outer layer is from about 2 mm to about 500 mm; and

wherein the lap shear strength of the multilayer structure is greater than about 5 MPa.

29. A hollow composite vessel according to claim 1, wherein a wall of the hollow composite vessel comprises a multilayer structure, said multilayer structure comprising:

an inner layer comprising one or more thermoplastic polymers selected from one or more of ethylene homopolymers, ethylene co-polymers, propylene homopolymers, propylene co-polymers, fluoropolymers, polyvinylchloride, polyvinylidene chloride, polyaryl ether ketone, and polyamide;

an outer layer comprising a plurality of filaments selected from one or more of carbon, glass, aramid and basalt filaments, and one or more thermosetting polymers selected from one or more of polyester, polyacrylate, epoxy, vinyl ester, bismaleimide, and polyurethane; and

a middle layer disposed between the inner layer and the outer layer, said middle layer comprising one or more fibrous materials in the form of fabricated textile materials;

wherein the one or more fabricated textile materials is at least partly infiltrated with both the one or more thermoplastic polymers and the one or more thermosetting polymers;

wherein the thickness of the inner layer of the multilayer structure is from about 0.1 mm to about 50 mm, the thickness of the middle layer is from about 0.1 mm to about 5 mm, and the thickness of the outer layer is from about 2 mm to about 500 mm; and

wherein the fibrous layer has a single pressure average permeability of less than about 10^{-11} m^2.

30. A hollow composite vessel according to claim 1, wherein a wall of the hollow composite vessel comprises a multilayer structure, said multilayer structure comprising:

an inner layer comprising one or more thermoplastic polymers selected from one or more of ethylene homopolymers, ethylene co-polymers, propylene homopolymers, propylene co-polymers, fluoropolymers, polyvinylchloride, polyvinylidene chloride, polyaryl ether ketone, and polyamide;

an outer layer comprising a plurality of filaments selected from one or more of carbon, glass, aramid and basalt filaments, and one or more thermosetting polymers selected from one or more of polyester, polyacrylate, epoxy, vinyl ester, bismaleimide, and polyurethane; and

a middle layer disposed between the inner layer and the outer layer, said middle layer comprising one or more fibrous materials in the form of fabricated textile materials;

wherein the one or more fabricated textile materials is at least partly infiltrated with both the one or more thermoplastic polymers and the one or more thermosetting polymers;

wherein the thickness of the inner layer of the multilayer structure is from about 0.1 mm to about 50 mm, the thickness of the middle layer is from about 0.1 mm to about 5 mm, and the thickness of the outer layer is from about 2 mm to about 500 mm; and

wherein the multilayer structure has a maximum lap shear strength which is proportional to the tensile strength of the thermoplastic polymer.