[0015] In one exemplified end use herein, the impellers are suitable for use in compressing light gases such as helium and hydrogen and achieving higher tip speeds of 500 m/s or greater and as much as over about 600 m/s, or over about 700 m/s.

[0016] Such designs may also be used for more efficient and faster rotating speeds in standard compressor applications. Due to the strength of the composites and the speeds that may be achieved employing the present process and materials, impellers may be provided that improve the compression ratio in a single stage in comparison with the compression of prior art impellers. This allows for compressors to be able to achieve the same level of performance with fewer stages of impellers, in both open and closed impeller designs, providing an economic advantage in manufacture and use of impellers. By increasing speed of standard impellers, more compression occurs in a single stage allowing for reduction in the number of impellers and increased operational efficiency, at speeds of over 300 m/s, 400 m/s, 500 m/s or higher.

[0017] In the applicant's method of forming polymeric composite articles, such as an impeller, individual composite part(s) are prepared such as by composite molding, then assembled into an assembly such as a multi-component assembly and placed within a mold. In embodiments in which the assembly has openings or voids therein, the assembly is positioned within the mold using a removable core within the openings or voids. The assembly within the mold is remolded and the removable core(s) is/are removed. Such removable cores may be withdrawn, removed, machined out of the openings or may be dissolved, *e.g.*, using salt cores or can be removed using any other techniques known to those skilled in the relevant art or to be developed.

[0018] According to an aspect of the present invention, there is provided an impeller for use with centrifugal compressors or pumps, comprising a composite comprising a matrix material selected from at least one thermoplastic polymer or at least one thermosetting polymer; and at least one continuous reinforcing fiber.

[0019] The matrix material may be one or more thermoplastic polymers, for example, the matrix material may be a high-performance thermoplastic polymer selected from the group consisting of polycarbonates, linear aromatic polyesters, linear aromatic polyimides, polyurethanes, polyphenylene oxides, polyphenylene ethers, polyphenylene esters, polyphenylene ether esters, polyphenylene sulfides, polysulfones, polyether sulfones, polyphenylsulfones, polymethylpentenes, polyketones, aramids, polyaryl ethers, polyaryl ether ketones, and combinations and co-polymers thereof. The matrix material may also comprise in a further embodiment at least one polyaryl ether ketone selected from polyetherketone, polyetherketoneketone, polyetheretherketone,

CLAIMS

We claim:

1. An impeller for use with centrifugal compressors or pumps, comprising

a composite comprising a matrix material selected from at least one thermoplastic polymer or at least one thermosetting polymer; and

at least one continuous reinforcing fiber.

2. The impeller according to claim 1, wherein the matrix material is one or more thermoplastic polymers.

3. The impeller according to claim 1, wherein the matrix material is a high-performance polymer selected from the group consisting of polycarbonates, linear aromatic polyesters, linear aromatic polyimides, polyurethanes, polyphenylene oxides, polyphenylene ethers, polyphenylene esters, polyphenylene ether esters, polyphenylene sulfides, polysulfones, polyether sulfones, polyphenylsulfones, polymethylpentenes, polyketones, aramids, polyaryl ethers, polyaryl ether ketones, and combinations and co-polymers thereof.

4. The impeller according to claim 3, wherein the matrix material comprises at least one polyaryl ether ketone selected from polyetherketone, polyetherketoneketone, polyetheretherketone, polyetheretherketoneketone, polyetherketoneetherketoneketone and combinations and copolymers thereof.

5. The impeller according to claim 1, wherein the matrix material is an engineering polymer selected from the group consisting of polybutadiene, polyacrylonitrile, poly(butadiene-styrene), poly(styrene-acrylonitrile), melt-processible fluoropolymers, liquid crystalline polymer, polyacetals, polyacrylates, polyamides, polyolefins, polyalkylene terephthalates, polyphthalimides, polyimides, polyetheramides, and combinations and copolymers thereof.

6. The impeller according to claim 1, wherein the matrix material is one or more thermosetting polymers.

7. The impeller according to claim 1, wherein the matrix material is a thermosetting polymer selected from the group consisting of ethylene propylene diene rubber, ethylenepropylene rubber, thermosetting polyurethane elastomers, epoxy resins, thermosetting biscitraconicimides, bismaleimides (BMI), bismaleimide/triazine/epoxy resins, cyanate esters, cyanate resins, furanic resins, phenolic resins, urea-formaldehyde resins, melamine-formaldehyde resins, phthalocyanine resins, polybenzoxazole resins, acetylene-terminated polyimide resins, silicones, polytriazines, thermosetting polyvinyl

esters, thermosetting polyurethanes, polytetrafluoroethylene, melamines, polyalkyds, xylene resins, and combinations and copolymers thereof.

8. The impeller according to claim 1, wherein the at least one continuous reinforcing fiber comprises at least a portion of fibers that are substantially aligned within the matrix polymer.

9. The impeller according to claim 8, wherein the at least one continuous reinforcing fiber is selected from the group consisting of carbon, glass, aramid, metal, metal alloy, and natural fiber.

10. The impeller according to claim 8, wherein the impeller is formed of separate elements that are comprised of the composite, and wherein within the separate elements, at least a portion of the fibers of the at least one continuous fiber are substantially aligned.

11. The impeller according to claim 1, wherein impeller comprises

at least one first flange comprising the composite and having an exterior surface and an interior surface, the first flange defining a first opening extending longitudinally therethrough; and

at least one rib positioned on the at least one first flange such that the at least one rib engages the interior surface of at least one first flange.

12. The impeller according to claim 11, wherein the at least one rib comprises the composite.

13. The impeller according to claim 11, further comprising at least one ring member in contact with at least one of the at least one flange.

14. The impeller according to claim 11, wherein the impeller is a re-molded assembly of the first flange, the at least one rib and the at least one ring member.

15. The impeller according to claim 11, wherein the impeller further comprises

a second flange comprising the composite, the second flange having an exterior surface and an interior surface, and wherein the second flange comprises at least one surface feature on the interior surface thereof, and the second flange defines a second opening extending longitudinally therethrough;

and wherein each of the at least one rib has a first end and a second end, wherein the second end of the at least one rib engages the at least one surface feature on the interior surface of the second flange and wherein the first and the second openings are positioned to be at least substantially aligned.

16. The impeller according to claim 15, wherein there are a plurality of surface features on the interior surface of the second flange and a plurality of ribs.

17. The impeller according to claim 15, wherein the interior surface of the first flange also comprises at least one surface feature, and the first end of the at least one rib engages the at least one surface feature on the interior surface of the first flange.

18. The impeller according to claim 17, wherein the at least one surface feature on each of the interior surfaces of the first and the second flanges are at least substantially aligned for engaging the first and second ends of the at least one rib.

19. The impeller according to claim 18, wherein there are a plurality of surface features on the interior surface of the first flange and the interior surface of the second flange and a plurality of ribs.

20. The impeller according to claim 15, wherein the exterior surface of the second flange comprises Hirth toothing formed in an inner annular portion of the second flange.

21. The impeller according to claim 15, further comprising at least one ring member in contact with at least one of the at least one flange.

22. The impeller according to claim 21, wherein the at least one ring member comprises a second ring member, the second ring member having an opening extending longitudinally therethrough, wherein the second ring member is configured for engaging the exterior surface of the second flange such that the second opening in the second flange and the opening in the second ring member are at least substantially aligned.

23. The impeller according to claim 22, wherein the second ring member and the second flange each define one or more openings for receiving fasteners to secure the second ring to the second flange.

24. The impeller according to claim 22, wherein the second ring member comprises a metal or metal alloy.

25. The impeller according to claim 21, wherein the at least one ring member further comprises a first ring member defining an opening extending longitudinally therethrough for engaging the exterior surface of the first flange such that the first opening in the first flange and the opening in the first ring member are substantially aligned.

26. The impeller according to claim 25, wherein the first ring member comprises a second composite material.

27. The impeller according to claim 26, wherein the second composite material is the same as the composite material and comprises unidirectionally oriented fibers extending in a circumferential direction.

28. The impeller according to claim 21, wherein each of the first flange and the second flange has a circumferential outer surface extending longitudinally between the interior surface and the exterior surface thereof, and the impeller comprises an outer banding ring,

wherein the at outer banding ring is configured to be positioned circumferentially around and in engagement with the outer surface of the first flange.

29. The impeller according to claim 28, wherein the outer banding ring comprises a third composite material.

30. The impeller according to claim 29, wherein the third composite material is the same as the composite material and has unidirectionally oriented fibers extending in a circumferential direction.

31. The impeller according to claim 29, further comprising a second outer banding ring configured to be positioned circumferentially around and to engage the outer surface of the second flange, wherein the second outer banding ring comprises the third composite material.

32. The impeller according to claim 21, wherein the impeller is a re-molded assembly of the first and second flange, the at least one rib and the at least one ring member.

33. The impeller according to claim 32, wherein the assembly further comprises at least one outer banding ring.

34. The impeller according to claim 11, wherein the composite comprises an engineering polymer or a high-performance polymer and the openings in the impeller are formed by removable core molding.

35. The impeller according to claim 11, wherein the impeller in operation is capable of achieving a tip speed of at least 400 m/s or higher.

36. The impeller according to claim 35, wherein the impeller in operation is capable of achieving a tip speed of at least about 600 m/s.

37. The method according to claim 36, wherein the impeller in operation is capable of achieving a tip speed of at least about 700 m/s.