

COMPOSITE DRIVE SHAFT

BACKGROUND OF THE INVENTION

The function of a drive shaft is to convey torque from a power source to a means for converting this energy into useful work. Often such requires the use of connection joints. In the case of marine application, the function of a drive shaft is to convey torque from an engine via a gearbox to a propeller or water-jet unit. The connection between a gear box and composite drive shaft, or between a composite shaft and a propeller, as well as the bearing and couplings are critical and have been the focus of important research and development.

Traditionally shafts have been made of a solid or hollow metal material however composite drive shafts provide the benefits of being of a lighter weight and of a construction which is easy to manufacture. The disadvantage of utilising an entirely composite shaft for the transmission of torque between a prime mover and a propulsion device is that the shaft does need to be coupled to other components. Traditional metal shafts have used couplings including flanges which can bolt to like flanges and wherein bolts normally extend in a direction parallel with the shaft direction. Whilst composite materials can provide good torque transmission, bending and tensile strength, they can be of a very brittle nature, especially when subjected to the complex loading at bolted flange joints. Whilst methods are available to ameliorate the stress that arises in a full composite flange and planar assemblies, these significantly add to the cost complexity of manufacture and maintenance. Accordingly it is desirable to incorporate a metal flange into a composite shaft assembly.

Several types of joints are known for applications combining metal components with composite components. They include, mechanical joints, adhesive bonded or both mechanically joined and adhesive bonded. Mechanical joints are created with direct touch of a composite shaft by fastening the substrates with bolts or rivets (see for example Figure 3 to 5). Bonded joints use an adhesive interlayer between the composite shafts and joints (see for example Figures 6 to 10).

Mechanical joints show the advantages of being easily disassembled for inspection and repair, less affected by service environments and less contact area required although it has higher stress concentration. The adhesive bonded joints can distribute the load over larger areas than mechanical joints, require no holes, add very little weight to the structure and have superior fatigue resistance, however they require careful surface preparation of adherends and their performance declines in detrimental environmental conditions.

Prior art patents disclose mechanical connection methods for joining a composite material shaft to metal end member. R. N. Salzman (US patent number 4722717 and 4834932) invented a method for making an end connection of composite shafts in automotive and aerospace vehicles which accommodates differences in stiffness, thermal expansion and chemical resistance between the shaft and the member connected thereto and operates under oscillating torque, thrust, and bending loads. It also provides for manufacturing flexibility in enabling the shaft and the connection to be produced as separate parts which are formed when final assembly is to occur. The connection has a male insert, which is inserted into the end of the composite shaft. Axial and circumferential grooves are cut in the surfaces of the male insert and the shaft. These grooves are aligned to form circumferential and axial keyways which intersect each other. Stanwood (US patent number 4289557, 4279275) describes a method for joining composite shaft, wherein the joint is capable of withstanding a large range of temperatures and humidity and can handle high torque and has high resistance to fatigue. The design of parallel grooves on the end of a metallic sleeve concentrically aligned within the shaft is amenable to mass production.

Derek N. Yates etc. (US patent no. 4187135) believed the direct bonding or welding of a resin shaft to metal did not create a sufficiently strong and durable connection on a consistent and reliable basis and that the use of metallic connector sleeves mounted at the ends of the shaft would provide a means for accomplishing a secure welded connection similar to that utilised with conventional metallic shafts. He therefore patented a tubular fibre reinforced composite shaft, which integrally

incorporated a metal sleeve or connection at the end thereof. Initially a metal sleeve having circumferentially spaced recesses on the outer periphery is positioned upon a segment of a mandrel. Fibrous materials bearing non-solidified resinous materials are applied around the mandrel and around the recesses in the sleeve. Portions of the previously applied fibrous materials bearing the non-solidified resinous materials are pressed into the recesses. Additional fibrous materials bearing the non-solidified resinous materials are applied to the previously applied fibrous materials. The resinous materials are then solidified to form a tubular composite shaft whereby a secure torsion-transmitting connection is made with the sleeve, and the mandrel is subsequently removed.

Tapered joint and helical end connection are also used as joining means between composite shaft and steel components shaft and steel components. Richard Lee T. (US Patent No. 4097626) described a golf shaft of the type which is referred to as a constant-taper-constant shaft. In such a shaft, the grip portion of the shaft has a constant section which mates with a tapering section and terminates in a constant but smaller diameter section mating with the golf club head. Gordon Peter (U.S. Patent No. 4089190) invented a lightweight tubular drive shafts having noise and vibration dampening characteristics, and capable of operating at high speeds without significant misalignment between their geometric axes and their axes of rotation. The shaft ends are a composite of a plurality of layers of carbon fibres in a solid resin matrix wherein the fibres are disposed circumferentially and helically about the longitudinal axis of the shaft.

Most of the prior publications as herein described have the disadvantage of being complex to manufacture or assemble.

Accordingly it is an object of the present invention to provide a composite drive shaft including a metallic coupling element which overcomes the above disadvantages or which will at least provide the public with a useful choice.

It is a further object of the present invention to provide an assembly of a composite drive shaft and a metallic coupling component which overcomes the above disadvantages or which will at least provide the public with a useful choice.

BRIEF DESCRIPTION OF THE INVENTION

Accordingly in a first aspect the present invention consists in a composite drive shaft assembly comprising

a. an elongate shaft of a fiber reinforced plastics material and including at at least a first distal end thereof a connection region of a hollow section wherein a surface selected from one or both of the exterior surface and interior surface of said connection region is tapered with a direction of taper to present the normal to said surface(s) of said taper in a direction towards said first distal end

b. a coupling member of a metallic material engaged with said elongate shaft at said connection region, said coupling member including

- i. a longitudinally extending shank coaxial with said elongate shaft, said shank including an annular slot provided therein, said annular slot extending in the longitudinal direction presenting radially inward and radially outward facing mating surfaces with which said corresponding exterior and interior surfaces of said connection region of said elongate shaft are adhered in a mating relationship,
- ii. means to couple for engagement of said drive shaft with a means to derive or input rotation via said drive shaft.

Preferably said hollow section is a pipe section.

Preferably said elongate shaft is a pipe section and said connection region defined at at least one end of said elongate shaft.

Preferably said elongate shank is of a pipe section.

Preferably said connection region of said elongate shaft is provided with a said taper to both its exterior and interior surface.

Preferably said taper is of a kind to reduce the thickness of the elongate shaft at its first distal end from its thickness away from its first distal end.

Preferably said elongate shaft is substantially of a tubular cross section save for the at least one connection region.

Preferably said annular slot is disposed into said elongate shank from said first end thereof and wherein said means to couple is disposed from said elongate shank away from said first end of said elongate shank.

Preferably said means to couple is a means to transfer torque to of from said elongate shaft via said shank.

Preferably said means to couple is disposed from said elongate flange at its distal end away from said first end of said elongate shank.

Preferably said means to couple is a coupling flange coaxial with said elongate shaft.

Preferably said means to couple is a transmission gear coaxial with said elongate shaft.

Preferably said means to couple is a region for engagement by a rotational transmission member.

Preferably said annular slot is defined between a radially outward facing surface of an interior sleeve of said coupling member and radially inward facing surface of an exterior sleeve of said coupling member.

Preferably said interior and exterior sleeves are affixed to each other at a region of said elongate shank away from said first end thereof and beyond said annular slot.

Preferably said interior and exterior sleeves are engaged with each other at least at concentric engaging surfaces.

Preferably said interior and exterior sleeves are indexed together.

Preferably the interior and exterior sleeves are indexed together with at least one longitudinally extending indexing pin extending in its longitudinal cross section across the interface between said engaging surfaces of said interior and exterior sleeves.

Preferably the interior and exterior sleeves are indexed together with at least one longitudinal index pin extending radially to elongate shank and across the interface between said engaging surfaces of said interior and exterior sleeves.

Preferably the interior and exterior sleeves are indexed together with at least one longitudinal index pin extending radially to elongate shank and across the interface between said engaging surfaces of said exterior sleeve with the exterior surface of said engaging region of said elongate shaft and across the interface between the engaging surfaces of said interior sleeve with the interior surface of said engaging region of said elongate shaft.

Preferably a cured adhesive resin adhesively engages said mating surfaces of said connection region of said elongate shaft and said elongate shank.

In a second aspect the present invention consists in a method of manufacturing a composite shaft assembly which incorporates

a. an elongate shaft of a fiber reinforced plastics material and including at at least a first distal end thereof a connection region of a hollow section wherein a surface selected from one or both of the exterior surface and interior surface of said connection region is tapered with a direction of taper to present the normal to said surface(s) of said taper in a direction towards said first distal end

b. a coupling member of a metallic material, said coupling member including

- i. a longitudinally extending shank coaxial with said elongate shaft, said shank including an annular slot provided therein, said annular slot extending in the longitudinal direction and presenting radially inward and radially outward facing mating surfaces,
- ii. means to couple,

said method including

- (a) surface roughening and cleaning of the interior and exterior mating surfaces of the connection region of said elongate shaft to produce engageable surfaces,
- (b) application of adhesive to said mating surfaces of said connection region of said elongate shaft and/or said radially inward and radially outward facing mating surfaces of said annular slot,

- (c) assembly by longitudinally sliding the said mating surfaces of said elongate shaft into said annular slot of said coupling member by pushing home of said respective mating surfaces of said elongate shaft and said slot surfaces,
- (d) allowing the curing of said adhesive.

Preferably said roughening includes at least sanding of said tapered surfaces.

Preferably said roughening includes at least the blasting with grit or granulated soft media of said tapered surfaces.

Preferably said cleaning includes degreasing.

Preferably said elongate shaft interior and exterior surfaces are pre-formed such that said mating surfaces conform with each other.

Preferably said elongate shaft interior and exterior surfaces are machined such that said mating surfaces conform with each other.

Preferably said coupling member comprises at least an internal and external sleeve concentrically and co-axially engaged at an annular interface at regions away from said annular slot, said annular slot defined between non engaging facing surfaces of said external and internal sleeve, wherein after curing of said adhesive resin, indexing pins are inserted extending between said at least two sleeves.

Preferably said indexing pins are engaged substantially perpendicularly to the axis or rotation of said resulting shaft between said sleeves.

Preferably said indexing pins pass or penetrate through said connection region of said elongate shaft.

In a further aspect the present invention consists in a vessel of a kind which utilises an internal combustion engine for the powering of a propulsion means, a composite shaft assembly extending between a prime mover of said vessel and said propulsion means said composite shaft assembly comprising

- a. an elongate shaft of a fiber reinforced plastics material and including at at least a first distal end thereof a connection region of a hollow section wherein a surface selected from one or both of the exterior surface and interior surface of said

connection region is tapered with a direction of taper to present the normal to said surface(s) of said taper in a direction towards said first distal end

b. a coupling member of a metallic material engaged with said elongate shaft at the first distal end of said shaft, said coupling member including

- i. a longitudinally extending shank coaxial with said elongate shaft, said shank including an annular slot provided therein, said annular slot extending in the longitudinal direction presenting radially inward and radially outward facing mating surfaces with which said corresponding exterior and interior surfaces of said connection region of said elongate shaft are adhered in a mating relationship,
- ii. a means to couple in coupling engagement to either of said prime mover or said propulsion device.

In a further aspect the present invention relates to a coupling member for an elongate shaft of a fiber reinforced plastics material and including at at least a first distal end thereof a connection region of a hollow section wherein a surface selected from one or both of the exterior surface and interior surface of said connection region is tapered with a direction of taper to present the normal to said surface(s) of said taper in a direction towards said first distal end, said coupling member comprising

- i. a longitudinally extending shank including an annular slot provided therein, said annular slot extending in the longitudinal direction presenting radially inward and radially outward facing mating surfaces with which said corresponding exterior and interior surfaces of said connection region of said elongate shaft are to become adhered in a mating relationship,
- ii. means to couple for engagement of said drive shaft with a means to derive or input rotation via said drive shaft

wherein said coupling member is of a metallic material.

This invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more of said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this invention relates, such known equivalents are deemed to be incorporated herein as if individually set forth. For the purposes of illustrating the invention, there is shown in the drawings a form which is presently preferred. It is being understood however that this invention is not limited to the precise arrangements shown.

A preferred form of the present invention will now be described with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a sectional view through an assembly of a composite drive shaft and a metallic coupling,

Figure 2 is a perspective view of a metallic coupling and composite drive shaft,

Figures 3 to 5 describe mechanical type prior art joints of composite materials and metallic materials,

Figures 6 to 9 describe adhesive type prior art joints of composite materials and metallic materials,

Figure 10 is a perspective view of a coupling component without the composite shaft engaged therewith and wherein the coupling component is of a kind which provides a spline-like coupling configuration for engagement to other transmission components,

Figure 11 is a cross section of a composite shaft showing the hollow nature and the taper, both internal and external of the shaft end to be coupled with the metallic coupling to form the complete drive shaft, and

Figure 12 to 13 show further cross-sections of the assembled composite shaft and metallic coupling with a variant register or index pin location,

perpendicular to the axis of rotation through only the metallic coupling components (a) and through the metallic components and the composite shaft (b) for increased torsion transfer.

DETAILED DESCRIPTION OF THE INVENTION

A composite drive shaft assembly may for example consist of a shaft section 1 which is made from a composite material such as an epoxy carbon fibre composite or epoxy fibre-glass or Kevlar composite or combination thereof. The present invention may utilise such materials or materials which are known to provide the desirable characteristics for the provision of a shaft. The shaft of the present invention is preferably utilised in the transmission of a torque and any axial compression and tension load between a prime mover and a propulsion device such as for example a propeller of a ship.

With reference to Figure 1 the present invention provides a composite shaft section 1 engaged with a metallic coupling component 2. The metallic coupling may include a flange 3. The flange 3 includes a plurality of preferably equally spaced apertures 4 of a desirable configuration to allow for bolts or pins or the like to extend therethrough or into, to allow for the flange 3 to couple with a complimentary flange (not shown) of for example a means to or from which torque will be transmitted via the composite shaft assembly. As can be seen with reference to Figure 1, the aperture 4 extends substantially parallel to the centre line or axis of rotation 5 of the assembly. However depending upon the topology of the joint the bolt holes may be aligned or disaligned with the centre line or shaft axis 5. For example they may be bolted through at an angle to the shaft axis to counteract the shear loading of torque transfer. Blind holes may also be used.

Whilst the most common form of joining flanges together is by bolts alternative means of ensuring a fastening or torque and/or load transmission may be utilised. As an example the flange 3 or other coupling region of the coupling component 2 joined to the composite shaft section 1 may have a machined or

manufactured mating profile to that of the component it is to drive, such as, for example a spline drive (see Figure 10).

The coupling component 2 and at least that portion thereof which provides the flange 3 is made from a metallic material such as a mild steel, tempered steel, aluminium, stainless steel or similar. The coupling component 2 defines an annular shank section 6 which extends substantially parallel to the shaft axis 5. The free end 7 of this coupling component 2 has a taper or chamfer as shown in Figure 12 which relieves the stress placed upon the composite shaft and/or coupling component when assembled and in use.

The shaft axis 5 is the rotational axis of the composite shaft and is the axis about which the composite shaft assembly is in rotational balance thereabout. The annular shank section 6 includes a free end 7 and is engaged whether directly unitarily or by intermediate, with the flange 3 which is the preferred configuration for coupling to other transmission components. The flange 3 presents a coupling surface 8 which is capable of engaging against a surface of a complimentary coupling member with which the composite shaft assembly is to engage. In the most preferred form the flange 3 and the annular shank section 6 are formed unitarily as for example shown in Figure 1.

The annular shank section 6 has extending from its free end 7 in an axial direction, an annular slot 9. The annular slot is preferably a slot continuous about the shaft axis 5.

Alternatively the annular slot may be of slot segments which extend annularly about the shaft axis 5. However in the most preferred form the slot is continuous. The slot is of a configuration where its depth (in the longitudinal direction parallel with the shaft axis 5) is greater than its width (in the radial direction to the shaft axis 5). Furthermore the slot 9 has at least a single and preferably a double tapered annular surface boundary. As can be seen in Figure 1, the exterior annular surface 20 has a slight taper to the longitudinal direction parallel with the shaft axis 5. In addition, the interior annular surface 21 also has a taper relative to the longitudinal direction parallel to the shaft axis 5. Each surface

20 and 21 is preferably at an angle to the longitudinal direction of between 0.5 and 2 degrees. In the most preferred form the angle is substantially 1 degrees to the longitudinal direction so as to create an overall angle 22 between the two surfaces 21 and 20 of substantially 2 degrees. The angle of each of the outer and inner surfaces 20 and 21 of the slot 9 are in opposite directions to the longitudinal direction. The end of the shaft section 1 providing its connection region for engagement with the shank section 6 is also tapered in a complementary manner. The taper is such that the normal N (see Figure 13) has a component of direction towards the end 60 of the shaft section 1. Accordingly a composite shaft section 1 can be inserted into the slot by a relative sliding movement between the coupling component 2 and the composite shaft section 1 in the longitudinal direction. The end of the composite shaft section 1 can be inserted into the slot as a result of the taper of each of the surfaces 20 and 21 being of a kind so as to provide no undercutting of the slot in the longitudinal direction. With reference to Figure 10 there is shown a coupling component 2 which along its annular section 6 provides the slot 9 therein. The shaft section 1 includes at its connection region which is to engage with the coupling component 2, a complimentary shaped tapered wall section such that its exterior surface of such wall section engages with the exterior surface 20 of the slot 9 and the interior surface of the end wall section of the shaft 1 engages with the inner surface 21 of the slot 9. During the assembly of the shaft section 1 with the coupling component 2, adhesive bonding between the interior and exterior wall surfaces of the shaft section 1 with the corresponding surfaces of the slot 9 occurs. The composite shaft itself may be made from an epoxy or polyester or similar resin based fibre reinforced structure such as for example utilising carbon, Kevlar or fibre-glass, K-glass or S-glass or similar, or any combination of these as the design requires. The adhesive bonding between the shaft section 1 and the coupling component 2 may include the use of a similar resin material that is used in forming the shaft section 1, to provide adhesive affixing. Dependent on the nature of the torque to be transmitted via the composite shaft assembly of the present invention will determine the minimum depth of the slot 9. With the increase in

surface area bonding between the shaft section 1 and the coupling component 2, will thereby increase the torque transmission capacity of the composite shaft assembly. Furthermore the diameter of the shaft and hence the corresponding diameter of the slot will also have an influence on the maximum torque transmission capacity of the composite shaft assembly. The taper of the shaft section 1 and the coupling component 2 may be linear or curved.

The assembly of the composite shaft assembly will include the steps of taking a pre-cured composite shaft section 1 which may have been manufactured by such techniques such as pultrusion, filament winding or other or combination of techniques and may have been pre-formed during manufacture with the desirable tapered end configuration as mentioned above. Where such end configuration is not pre-formed during its manufacturing step the shaft will need to be machined to provide the tapered end configuration. The application of adhesive to the end and/or to the interior of the slot is to occur prior to the end of the composite shaft sliding into the slot 9 until it is brought home to its permanent relative axial displacement with the coupling component 2 and as a result of the mating of the tapered surfaces of the slot with the tapered surfaces of the shaft section 1. The slot 9 is of a depth which is sufficient to allow for the composite shaft section 1 to be slidably engaged therein to a condition where the tapered surfaces mate with each other. As can be seen in Figure 1, the shaft is of a lesser depth than required and the cavity 24 is created due to the tapered connection region of the composite shaft section 1 being of lesser length than the tapered section of the annular slot 9.

Adhesive that is forced down into the cavity 24 is then, via the pumping action of the insertion of the shaft, driven back up the shaft to ensure thorough coating of the shaft and metallic coupling join.

With reference to Figure 1, it can be seen that the coupling component 2 may be made from two concentric components. Such components provide a split plane through the slot 9. The external component 26 and the internal component 27 are separately fabricated components and are split along a split plane 28 which is

preferably of a circular configuration and extends cylindrically in the longitudinal direction parallel to the shaft axis 5.

The coupling component 2 is made up of the two sleeves 26 and 27 for ease and accuracy of manufacture. This allows for the deep slot 9 to be manufactured therein with the sufficient tolerance required.

In order to ensure that the internal and external sleeves remain in rotational register with each other, register or indexing pins 29 are provided. The pins 29 extend between the interface of the interior and exterior sleeves 27 and 26. The register pins 29 couple the exterior and interior sleeves 26 and 27 together and through shear strength of the register pins 29 prevent the exterior sleeve 26 from rotating relative to the interior sleeve 27 about the rotational axis 5. The register pins are engaged into apertures formed by the engagement of the exterior sleeve 26 with the interior sleeve 27 in the fully assembled condition and such apertures are of a size to snugly and preferably tightly receive the register pins 29. The register pins 29 may be of a size which requires them to be forcefully inserted into the apertures formed, or may involve a taper. The pins may be affixed by such forceful engagement and/or by subsequent affixing using adhesives or welding or the like.

The register pins 29 are preferably provided in a region where they do not make contact with the composite shaft section 1. Indeed the pins preferably do not extend radially through the flange portion 6 of the coupling 2 which would result in them extending through the composite shaft section 1. Accordingly the integrity of the composite shaft section 1 is not affected by the configuration of the register pins 29 being utilised in the format as shown in the accompanying drawings. The pins 29 provide register between the interior sleeve 27 and exterior sleeve 26 at a region of the coupling 2 away from where the composite shaft section 1 is engaged with the coupling 2.

A variant location of the register pins is shown in Figure 12 and 13, where the register pins 37 are substantially perpendicular to the rotational axis of the shaft. They may be clear of the composite shaft in Figure 12 or may engage the composite shaft section in Figure 13. Such locations will aid the transfer of torque between the

metallic coupling components and the shaft (see Figure 13) but may affect the integrity or strength of the adhesive bond. However, should the adhesive taper interface of the shaft and metallic coupling fail for any reason then the embodiment of Figure 13 the transfer of torque may still be maintained. Such pin location as shown in Figure 13 may serve as a tell-tale of such a failure or other characteristics of the shaft/coupling interface.

The assembly of the composite drive shaft involves the steps or surface preparation, adhesive application, assembly and curing. More specifically the inner 36 and outer 35 mating surfaces of the machined or preshaped composite shaft section 1 to be engaged in the metallic coupling 2 are sanded and then blasted by either soft media or grit material to produce an engageable surface. The metallic flange is assembled of two or more parts to provide the required cavity 9. All mating surfaces of the shaft and metallic coupling are then degreased. The adhesive is then applied to the mating surfaces of the shaft and/or the metallic coupling component 2 and the shaft section 1 is then located into the metallic coupling cavity 9. The composite shaft section 1 is then pushed home in the cavity and excess adhesive is removed, to produce the required design adhesive thickness for the correct bond strength. Optionally register or indexing pins may be inserted at this stage. The resulting assembly is then cured, either by heat application, air drying or other specified means.

CLAIMS

1. A composite drive shaft assembly comprising
 - a. an elongate shaft of a fiber reinforced plastics material and including at at least a first distal end thereof a connection region of a hollow section wherein a surface selected from one or both of the exterior surface and interior surface of said connection region is tapered with a direction of taper to present the normal to said surface(s) of said taper in a direction towards said first distal end
 - b. a coupling member of a metallic material engaged with said elongate shaft at said connection region, said coupling member including
 - i. a longitudinally extending shank coaxial with said elongate shaft, said shank including an annular slot provided therein, said annular slot extending in the longitudinal direction presenting radially inward and radially outward facing mating surfaces with which said corresponding exterior and interior surfaces of said connection region of said elongate shaft are adhered in a mating relationship, said radially outward facing mating surfaces defined by an interior sleeve of said coupling member and said radially inward facing mating surface defined by an exterior sleeve of said coupling member fitted to and about said interior sleeve,
 - ii. means to couple for engagement of said drive shaft with a means to derive or input rotation via said drive shaft,

wherein said annular slot extends into said shank from a first end thereof and wherein said means to couple is disposed from said elongate shank away from said first end of said elongate shank, said interior and exterior sleeves being affixed to each other at a region of said elongate shank away from said first end thereof and beyond said annular slot, by at least one indexing pin extending parallel to the longitudinal direction and in a longitudinal cross section thereof, extending across the interface between said engaging surfaces of said interior and exterior sleeves, to allow a transfer of torque between said sleeves by said at least one pin, and

wherein a cured adhesive resin adhesively engages said mating surfaces of said connection region of said elongate shaft and said elongate shank.

2. A composite drive shaft assembly as claimed in claim 1 wherein said hollow section is a pipe section.

3. A composite drive shaft assembly as claimed in claims 1 or 2 wherein said elongate shaft is a pipe section and said connection region defined at at least one end of said elongate shaft.

4. A composite drive shaft assembly as claimed in any one of claims 1 to 3 wherein said connection region of said elongate shaft is provided with a said taper to both its exterior and interior surface.

5. A composite drive shaft assembly as claimed in any one of claims 1 to 4 wherein said taper is of a kind to reduce the thickness of the elongate shaft at its first distal end from its thickness away from its first distal end.

6. A composite drive shaft assembly as claimed in any one of claims 1 to 5 wherein said elongate shaft is substantially of a tubular cross section save for the at least one connection region.

7. A composite drive shaft assembly as claimed in any one of claims 1 to 6 wherein said annular slot extends into said shank from a first end thereof and wherein said means to couple is disposed from said elongate shank away from said first end of said elongate shank.

8. A composite drive shaft assembly as claimed in any one of claims 1 to 7 wherein means to couple is a means to transfer torque to of from said elongate shaft via said shank.

9. A composite drive shaft assembly as claimed in any one of claims 1 to 8 wherein said means to couple is disposed from said elongate flange at its distal end away from said first end of said elongate shank.

10. A composite drive shaft assembly as claimed in any one of claims 1 to 9 wherein said means to couple is a coupling flange coaxial with said elongate shaft.

11. A composite drive shaft assembly as claimed in any one of claims 1 to 9 wherein said means to couple is a transmission gear coaxial with said elongate shaft.
12. A composite drive shaft assembly as claimed in any one of claims 1 to 11 wherein said means to couple is a region for engagement by a rotational transmission member.
13. A composite drive shaft assembly as claimed in any one of claims 1 to 12 wherein the interior and exterior sleeves are also indexed together with at least one longitudinal index pin extending radially to elongate shank and across the interface between said engaging surfaces of said interior and exterior sleeves.
14. A composite drive shaft assembly as claimed in any one of claims 1 to 12 wherein the interior and exterior sleeves are also indexed together with at least one longitudinal index pin extending radially to elongate shank and across the interface between said engaging surfaces of said exterior sleeve with the exterior surface of said engaging region of said elongate shaft and across the interface between the engaging surfaces of said interior sleeve with the interior surface of said engaging region of said elongate shaft.
15. A method of manufacturing a composite shaft assembly which incorporates
 - a. an elongate shaft of a fiber reinforced plastics material and including at at least a first distal end thereof a connection region of a hollow section wherein a surface selected from one or both of the exterior surface and interior surface of said connection region is tapered with a direction of taper to present the normal to said surface(s) of said taper in a direction towards said first distal end
 - b. a coupling member of a metallic material, said coupling member including
 - i. a longitudinally extending shank coaxial with said elongate shaft, said shank including an annular slot provided therein, said annular slot extending in the longitudinal direction and presenting radially inward and radially outward facing mating surfaces, said radially outward facing mating surfaces defined

by an interior sleeve of said coupling member and said radially inward facing mating surface defined by an exterior sleeve of said coupling member fitted to and about said interior sleeve,

ii. means to couple,

wherein said annular slot extends into said shank from a first end thereof and wherein said means to couple is disposed from said elongate shank away from said first end of said elongate shank, said interior and exterior sleeves being affixed to each other at a region of said elongate shank away from said first end thereof and beyond said annular slot, by at least one indexing pin extending parallel to the longitudinal direction and in a longitudinal cross section thereof, extending across the interface between said engaging surfaces of said interior and exterior sleeves, to allow a transfer of torque between said sleeves by said at least one pin, and wherein a cured adhesive resin adhesively engages said mating surfaces of said connection region of said elongate shaft and said elongate shank, said method including

- (a) surface roughening and cleaning of the interior and exterior mating surfaces of the connection region of said elongate shaft to produce engageable surfaces,
- (b) application of adhesive to said mating surfaces of said connection region of said elongate shaft and/or said radially inward and radially outward facing mating surfaces of said annular slot,
- (c) assembly by longitudinally sliding the said mating surfaces of said elongate shaft into said annular slot of said coupling member by pushing home of said respective mating surfaces of said elongate shaft and said slot surfaces,
- (d) allowing the curing of said adhesive.

16. A method as claimed in claim 15 wherein said roughening includes at least sanding of said tapered surfaces.

17. A method as claimed in claim 15 wherein said roughening includes at least the blasting with grit or granulated soft media of said tapered surfaces.

18. A method as claimed in claim 15 wherein said cleaning includes degreasing.
19. A method as claimed in any one of claims 15 to 18 wherein said elongate shaft interior and exterior surfaces are pre-formed such that said mating surfaces conform with each other.
20. A method as claimed in any one of claims 15 to 18 wherein said elongate shaft interior and exterior surfaces are machined such that said mating surfaces conform with each other.
21. A method as claimed in any one of claims 15 to 20 wherein after curing of said adhesive resin, indexing pins are inserted extending between said at least two sleeves.
22. A method as claimed in claim 21 wherein said indexing pins are engaged substantially perpendicularly to the axis or rotation of said resulting shaft between said sleeves.
23. A method as claimed in claim 21 or 22 wherein said indexing pins pass or penetrate through said connection region of said elongate shaft.
24. In a vessel of a kind which utilises an internal combustion engine for the powering of a propulsion means, a composite shaft assembly extending between a prime mover of said vessel and said propulsion means said composite shaft assembly comprising
 - a. an elongate shaft of a fiber reinforced plastics material and including at at least a first distal end thereof a connection region of a hollow section wherein a surface selected from one or both of the exterior surface and interior surface of said connection region is tapered with a direction of taper to present the normal to said surface(s) of said taper in a direction towards said first distal end
 - b. a coupling member of a metallic material engaged with said elongate shaft at the first distal end of said shaft, said coupling member including
 - i. a longitudinally extending shank coaxial with said elongate shaft, said shank including an annular slot provided therein, said annular slot extending in the longitudinal direction presenting radially inward and radially outward facing mating

surfaces with which said corresponding exterior and interior surfaces of said connection region of said elongate shaft are adhered in a mating relationship, said radially outward facing mating surfaces defined by an interior sleeve of said coupling member and said radially inward facing mating surface defined by an exterior sleeve of said coupling member fitted to and about said interior sleeve,

- ii. a means to couple in coupling engagement to either of said prime mover or said propulsion device,

wherein said annular slot extends into said shank from a first end thereof and wherein said means to couple is disposed from said elongate shank away from said first end of said elongate shank, said interior and exterior sleeves being affixed to each other at a region of said elongate shank away from said first end thereof and beyond said annular slot, by at least one indexing pin extending parallel to the longitudinal direction and in a longitudinal cross section thereof, extending across the interface between said engaging surfaces of said interior and exterior sleeves, to allow a transfer of torque between said sleeves by said at least one pin, and

wherein a cured adhesive resin adhesively engages said mating surfaces of said connection region of said elongate shaft and said elongate shank.

25. A coupling member for an elongate shaft of a fiber reinforced plastics material and including at at least a first distal end thereof a connection region of a hollow section wherein a surface selected from one or both of the exterior surface and interior surface of said connection region is tapered with a direction of taper to present the normal to said surface(s) of said taper in a direction towards said first distal end, said coupling member comprising

- i. a longitudinally extending shank including an annular slot provided therein, said annular slot extending in the longitudinal direction presenting radially inward and radially outward facing mating surfaces with which said corresponding exterior and interior surfaces of said connection region of said elongate

shaft are to become adhered in a mating relationship, said radially outward facing mating surfaces defined by an interior sleeve of said coupling member and said radially inward facing mating surface defined by an exterior sleeve of said coupling member fitted to and about said interior sleeve,

- ii. means to couple for engagement of said drive shaft with a means to derive or input rotation via said drive shaft

wherein said coupling member is of a metallic material,

wherein said annular slot extends into said shank from a first end thereof and wherein said means to couple is disposed from said elongate shank away from said first end of said elongate shank, said interior and exterior sleeves being affixed to each other at a region of said elongate shank away from said first end thereof and beyond said annular slot, by at least one indexing pin extending parallel to the longitudinal direction and in a longitudinal cross section thereof, extending across the interface between said engaging surfaces of said interior and exterior sleeves, to allow a transfer of torque between said sleeves by said at least one pin, and

wherein a cured adhesive resin adhesively engages said mating surfaces of said connection region of said elongate shaft and said elongate shank.