Claims

What is claimed is:

1. A method of forming a composite tubular 62 comprising:

(a) providing axial filaments 54 and hoop filaments 58 mixed with a matrix material 60;

(b) characterized by forming a first annular ply 52_1 comprising axial filaments 54 arranged at an angle of from about 10° to about 20° offset from an axis of the tubular 62 and hoop filaments 58 arranged at an angle of from about 45° to about 65° offset from the axis of the tubular 62; and

(c) forming a laminate of successive annular plies 52_{i+1-n} by arranging axial filaments 54 over an underlying one of the plies 52_{i+1-n} at an angle of from about 10° to about 20° offset from the axis of the tubular 62 and arranging hoop filaments 58 over an underlying one of the plies 52_{i+1-n} at an offset angle from the axis of the tubular 62 that exceeds the offset angle of hoop filaments 58 within the underlying ply 52_{i-1}.

2. The method of claim 1, characterized in that the offset angle of the hoop filaments 58 in step (c) has a maximum value of about 90°.

3. The method of claims 1 or 2, characterized in that the hoop filaments 58 in the first ply 52_1 are arranged at an offset angle of about 60°.

4. The method of any of claims 1-3, characterized in that when a hoop stress is generated on a side wall of the tubular 62, the hoop stress at an outer surface of the tubular 62 is about 30% of the hoop stress at an inner surface of the tubular 62.

5. The method of any of claims 1-4, characterized in that the offset angle of hoop filaments 58 within the successive annular plies 52_{i-n} increases over that of an underlying ply by an amount of

one or more of a same amount, an increasing amount, a linearly increasing amount, and an exponentially increasing amount.

6. The method of any of claims 1-5, characterized in that the tubular 62 comprises an elongated line used for choke and kill applications in a subsea wellhead assembly.

7. The method of any of claims 1-6, characterized in that the steps of forming plies comprise winding the filaments 54, 56, 58 around a mandrel 14.

8. A composite tubular 62 comprising:

an inner layer 52_1;

intermediate layers $52_{i+1-n-1}$ that concentrically circumscribe the inner layer 52_1;

an outer layer 52_n circumscribing the outermost intermediate layer 52_{n-1};

characterized by axial filaments 54 within each layer 52_i that are arranged in the inner layer 52_1 at an angle of about 10° to about 20° with respect to an axis of the tubular 62;

hoop filaments 58 within each layer 52_i that are arranged at an angle with respect to an axis of the tubular 62 that increases with proximity to the outer layer 52_n; and

a matrix material 60 impregnated within the filaments 54, 58.

9. The composite tubular of claim 8, characterized in that the hoop filaments in the intermediate layers $52_{i+1-n-1}$ are arranged with respect to the axis of the tubular 62 at angles ranging from more than the angle of orientation of the hoop filaments 58 in the inner layer 52_1 and up to about 90°.

10. The composite tubular of claims 8 or 9, characterized in that when pressure is applied to an inner surface of the tubular 62 and directed radially outward from the axis of the tubular 62, the hoop stress in the outer layer 52_n is at least about 20% of the hoop stress in the inner layer 52_1.

11. The composite tubular of any of claims 8-10, characterized in that he hoop filaments 58 in the inner layer 52_1 are at an angle of at least about 50° with respect to the axis of the tubular 62.

12. The composite tubular of any of claims 8-11, characterized in that the hoop filaments 58 in the outer layer 52_n are at an angle of about 90° with respect to the axis of the tubular 62.

13. A method of forming a thick walled tubular 62 comprising:

providing axial filaments 54, 56 and hoop filaments 58 mixed with a matrix material 60 to produce a composite;

fashioning the composite into an annular laminate that comprises an inner layer 52_1, intermediate layers $52_{i+1\,-\,n-1}$ that concentrically circumscribe the inner layer, an outer layer 52_n circumscribing the outermost intermediate layer 52_{n-1};

characterized by angling the axial filaments 54 in each layer at about 10° to about 20° from an axis of the tubular 62;

angling the hoop filaments 58 in the inner layer 52_1 at about 60° from the axis of the tubular 62;

angling the hoop filaments 58 in the outer layer 52_n at about 90° from the axis of the tubular 62; and

angling the hoop filaments 58 in the intermediate layers from greater than about 60° up to about 90° from the axis of the tubular 62.

14. The method of claim 13, characterized in that the angle of the hoop filaments 58 in the intermediate layers $52_{i+1\,-\,n-1}$ increases with distance from the inner layer 52_1.

15. The method of claims 13 or 14, characterized in that the tubular 62 comprises an elongated line used for choke and kill applications in a subsea wellhead assembly.

Claims

What is claimed is:

1. A composite tubular comprising:

an inner layer;

intermediate layers that concentrically circumscribe the inner layer;

an outer layer circumscribing the outermost intermediate layer;

axial filaments within each layer that are arranged in the inner layer at an angle of about 10° to about 20° with respect to an axis of the tubular;

hoop filaments within each layer that are arranged at an angle with respect to an axis of the tubular that increases with proximity to the outer layer; and

a matrix material impregnated within the filaments.

2. The composite tubular of claim 1, wherein the hoop filaments in the intermediate layers are arranged with respect to the axis of the tubular at angles ranging from more than the angle at orientation of the hoop filaments in the inner layer and up to about 90°.

3. The composite tubular of claim 1, wherein when pressure is applied to an inner surface of tubular and directed radially outward from the axis of the tubular, the hoop stress in the outer layer is at least about 20% of the hoop stress in the inner layer.

4. The composite tubular of claim 1, wherein the hoop filaments in the inner layer are at an angle of at least about 50° with respect to the axis of the tubular.

5. The composite tubular of claim 1, wherein the hoop filaments in the outer layer are at an angle of about 90° with respect to the axis of the tubular.