

WHAT IS CLAIMED IS:

1. A wellhead assembly with an axis, comprising:
 - an outer wellhead member having a bore;
 - an inner wellhead member located in the bore;
 - opposing seal surfaces in the bore and on an exterior portion of the inner wellhead member;
 - a seal ring between the inner and outer wellhead members having an inner annular member and an outer annular member circumscribing a portion of the inner annular member, the inner annular member having an inward facing profile and the outer annular member having an outward facing profile;
 - a heat treated seal surface formed on at least one of the inward and outward facing profiles, wherein the heat treated seal surface has a lower yield strength than a remainder of the seal ring; and
 - an annular energizing ring having a lower end insertable between the inner and outer annular members of the seal ring, so that when the lower end of the energizing ring is inserted between the inner and outer annular members of the seal ring, the inner and outer annular members of the seal ring are urged radially apart from each other to place at least one heat treated seal surface into sealing engagement with the seal surface of one of the inner and outer wellhead members.
2. The assembly according to claim 1, further comprising an annular extension extending downwards from and located below the seal ring, the extension having a lower surface that lands on a shoulder portion of the inner wellhead member; the annular extension has a higher yield strength than the heat treated seal surface.

3. The assembly according to claim 1, wherein spheroidal carbides are within the heat treated seal surface.

4. The assembly according to claim 1, wherein a material of the seal ring is steel having a yield strength in a range from approximately 40 to 50K; and

the yield strength of the heat treated seal surface is in a range from approximately 25 to 35K.

5. The assembly according to claim 1, wherein a sealing area is defined by a width of heat treated seal surface and the depth of the heat treated seal surface is 0.200 to 0.500 inches deep into either of the profiles on the inner or outer annular members.

6. The assembly according to claim 1, wherein the heat treated seal surface is defined as a percentage of a thickness of either of the inner and outer annular members of the seal ring in the range from 40 to 100% of thickness.

7. The assembly according to claim 1, wherein the inner and outer annular members of the seal ring form a U-shaped pocket in which the energizing ring inserts; and

a lower end of the heat treated surface is adjacent a lower end of the pocket.

8. The assembly according to claim 1, wherein at least one of the inner or outer wellhead members comprises a set of wickers formed on the seal surfaces, wherein the heat treated seal surface deforms on the wickers upon setting of the seal assembly.

9. The assembly according to claim 1, wherein a U-shaped pocket base of seal ring joins the inner and outer annular members below pocket, an extension extends downward from base nose ring attached to extension and base, extension and nose ring having greater yield strength than heat treated seal surface.

10. The assembly according to claim 1, wherein a hardness for the heat treated seal surface is in the approximate range of HBW 90 to HBW 110; and

a hardness for the remaining portion of the seal ring is in the approximate range of HBW 130 to about HBW 150.

11. The assembly according to claim 1, wherein the heat treated surface comprises heat treated seal surfaces on each of the inward and outward facing profiles.

12. A seal assembly for a subsea wellhead assembly, comprising:

a metal seal ring for sealing between inner and outer wellhead members, in a subsea wellhead assembly, the seal ring having an inner annular member and an outer annular member circumscribing a portion of the inner annular member, the inner and outer annular members being joined at a base, the inner annular member having an inward facing profile and the outer annular member having an outward facing profile;

an annular energizing ring having a lower end insertable between the inner and outer annular members of the seal ring, so that when the lower end of the energizing ring is inserted between the inner and outer annular members of the seal ring, outer walls of the inner and outer annular members of the seal ring are urged radially apart

from each other to place the heat treated seal surface into sealing engagement with one of the inner outer wellhead members;

an annular extension extending downwards from and located below the seal ring, the extension having a lower surface for landing on a portion of the inner wellhead member and having an upward facing shoulder in contact with the inner annular member of the seal ring; and

a heat treated seal surface formed on at least one of the inward and the outward facing profiles, wherein the heat treated seal surface has a lower yield strength than the base, the annular extension, and the energizing ring.

13. The assembly according to claim 12, wherein spheroidal carbides are within the heat treated seal surface.

14. The assembly according to claim 12, wherein a material of the seal ring is steel having a yield strength in a range from approximately 40 to 50K; and

the yield strength of the heat treated seal surface is in a range from approximately 25 to 35K.

15. The assembly according to claim 12, wherein a sealing area is defined by a width of heat treated seal surface and the depth of the heat treated seal surface is 0.200 to 0.500 inches deep into either of the profiles on the inner or outer annular members.

16. The assembly according to claim 12, wherein the heat treated seal surface is defined as a percentage of a thickness of either of the inner and outer annular members of the seal ring in the range from 40 to 100% of thickness.

17. The assembly according to claim 12, wherein at least one of the inner or outer wellhead members comprises a set of wickers formed on the seal surfaces, wherein the heat treated seal surface deforms on the wickers upon setting of the seal assembly.

18. A method for fabricating a seal assembly, comprising:

providing a steel alloy seal ring for installation between inner and outer wellhead members having, an inner annular member and an outer annular member circumscribing a portion of the inner annular member, the inner annular member having an inward facing profile and the outer annular member having an outward facing profile; and

heating at least one of the inward or outward facing profiles to a transformation temperature while keeping a remaining portion of the sealing ring below the transformation temperature, thereby lowering the yield strength of at least one profile below a yield strength of the remaining portion.

19. The method according to claim 18, further comprising the step of cycling heat input between upper and lower critical transformation temperatures for the steel alloy to selectively form spheroidal carbides in the seal ring.

CLAIMS

1. A wellhead assembly with an axis, comprising:
 - an outer wellhead member having a bore;
 - an inner wellhead member located in the bore;
 - opposing seal surfaces in the bore and on an exterior portion of the inner wellhead member;
 - a seal ring between the inner and outer wellhead members having an inner annular member and an outer annular member circumscribing a portion of the inner annular member, the inner annular member having an inward facing profile and the outer annular member having an outward facing profile;
 - a heat treated seal surface formed on at least one of the inward and outward facing profiles, wherein the heat treated seal surface has a lower yield strength than a remainder of the seal ring; and
 - an annular energizing ring having a lower end insertable between the inner and outer annular members of the seal ring, so that when the lower end of the energizing ring is inserted between the inner and outer annular members of the seal ring, the inner and outer annular members of the seal ring are urged radially apart from each other to place at least one heat treated seal surface into sealing engagement with the seal surface of one of the inner and outer wellhead members.
2. The assembly according to claim 1, further comprising an annular extension extending downwards from and located below the seal ring, the extension having a lower surface that lands on a shoulder portion of the inner wellhead member; the annular extension has a higher yield strength than the heat treated seal surface.
3. The assembly according to claim 1 or claim 2, wherein spheroidal carbides are within the heat treated seal surface.
4. The assembly according to any preceding claim, wherein a material of the seal ring is steel having a yield strength in a range from approximately 40 to 50K; and
 - the yield strength of the heat treated seal surface is in a range from approximately 25 to 35K.

5. The assembly according to any preceding claim, wherein a sealing area is defined by a width of heat treated seal surface and the depth of the heat treated seal surface is 0.200 to 0.500 inches deep into either of the profiles on the inner or outer annular members.

6. The assembly according to any preceding claim, wherein the heat treated seal surface is defined as a percentage of a thickness of either of the inner and outer annular members of the seal ring in the range from 40 to 100% of thickness.

7. The assembly according to any preceding claim, wherein the inner and outer annular members of the seal ring form a U-shaped pocket in which the energizing ring inserts; and

a lower end of the heat treated surface is adjacent a lower end of the pocket.

8. The assembly according to any preceding claim, wherein at least one of the inner or outer wellhead members comprises a set of wickers formed on the seal surfaces, wherein the heat treated seal surface deforms on the wickers upon setting of the seal assembly.

9. The assembly according to any preceding claim, wherein a U-shaped pocket base of seal ring joins the inner and outer annular members below pocket, an extension extends downward from base nose ring attached to extension and base, extension and nose ring having greater yield strength than heat treated seal surface.

10. The assembly according to any preceding claim, wherein a hardness for the heat treated seal surface is in the approximate range of HBW 90 to HBW 110; and

a hardness for the remaining portion of the seal ring is in the approximate range of HBW 130 to about HBW 150.

11. The assembly according to any preceding claim, wherein the heat treated surface comprises heat treated seal surfaces on each of the inward and outward facing profiles.

12. A seal assembly for a subsea wellhead assembly, comprising:

a metal seal ring for sealing between inner and outer wellhead members, in a subsea wellhead assembly, the seal ring having an inner annular member and an outer annular member circumscribing a portion of the inner annular member, the inner and outer annular members being joined at a base, the inner annular member having an inward facing profile and the outer annular member having an outward facing profile;

an annular energizing ring having a lower end insertable between the inner and outer annular members of the seal ring, so that when the lower end of the energizing ring is inserted between the inner and outer annular members of the seal ring, outer walls of the inner and outer annular members of the seal ring are urged radially apart from each other to place the heat treated seal surface into sealing engagement with one of the inner outer wellhead members;

an annular extension extending downwards from and located below the seal ring, the extension having a lower surface for landing on a portion of the inner wellhead member and having an upward facing shoulder in contact with the inner annular member of the seal ring; and

a heat treated seal surface formed on at least one of the inward and the outward facing profiles, wherein the heat treated seal surface has a lower yield strength than the base, the annular extension, and the energizing ring.

13. The assembly according to claim 12, wherein spheroidal carbides are within the heat treated seal surface.

14. The assembly according to claim 12 or claim 13, wherein a material of the seal ring is steel having a yield strength in a range from approximately 40 to 50K; and

the yield strength of the heat treated seal surface is in a range from approximately 25 to 35K.

15. The assembly according to any of claims 12 to 14, wherein a sealing area is defined by a width of heat treated seal surface and the depth of the heat treated seal surface is 0.200 to 0.500 inches deep into either of the profiles on the inner or outer annular members.

16. The assembly according to any of claims 12 to 15, wherein the heat treated seal surface is defined as a percentage of a thickness of either of the inner and outer annular members of the seal ring in the range from 40 to 100% of thickness.

17. The assembly according to any of claims 12 to 16, wherein at least one of the inner or outer wellhead members comprises a set of wickers formed on the seal surfaces, wherein the heat treated seal surface deforms on the wickers upon setting of the seal assembly.

18. A method for fabricating a seal assembly, comprising:

providing a steel alloy seal ring for installation between inner and outer wellhead members having, an inner annular member and an outer annular member circumscribing a portion of the inner annular member, the inner annular member having an inward facing profile and the outer annular member having an outward facing profile; and

heating at least one of the inward or outward facing profiles to a transformation temperature while keeping a remaining portion of the sealing ring below the transformation temperature, thereby lowering the yield strength of at least one profile below a yield strength of the remaining portion.

19. The method according to claim 18, further comprising the step of cycling heat input between upper and lower critical transformation temperatures for the steel alloy to selectively form spheroidal carbides in the seal ring.

20. A wellhead assembly substantially as hereinbefore described with reference to the accompanying drawings.

21. A seal assembly substantially as hereinbefore described with reference to the accompanying drawings.

22. A method for fabricating a seal assembly substantially as hereinbefore described with reference to the accompanying drawings.