CLAIMS

1. A method of processing a workpiece to inhibit precipitation of intermetallic compounds, the method comprising:

at least one of thermomechanically working and cooling a workpiece including an austenitic alloy, wherein during the at least one of thermomechanically working and cooling the workpiece, the austenitic alloy is at temperatures in a temperature range spanning a temperature just less than a calculated sigma solvus temperature of the austenitic alloy down to a cooling temperature for a time no greater than a critical cooling time;

wherein the austenitic alloy comprises, in weight percentages based on total alloy weight, up to 0.2 carbon, up to 20 manganese, 0.1 to 1.0 silicon, 14.0 to 28.0 chromium, 15.0 to 25.43 nickel, 2.0 to 9.0 molybdenum, 0.1 to 3.0 copper, 0.08 to 0.9 nitrogen, 0.1 to 5.0 tungsten, 0.5 to 5.0 cobalt, up to 1.0 titanium, up to 0.05 boron, up to 0.05 phosphorus, up to 0.05 sulfur, 0.01 to 1.0 vanadium, 20 to 60 iron, and incidental impurities;

wherein the calculated sigma solvus temperature is a function of the composition of the austenitic alloy in weight percentages and, in Fahrenheit degrees, is equal to 1155.8 - (760.4)•(nickel/iron) + (1409)•(chromium/iron) + (2391.6)•(molybdenum/iron) - (288.9)•(manganese/iron) - (634.8)•(cobalt/iron) + (107.8)•(tungsten/iron);

wherein the cooling temperature is a function of the composition of the austenitic alloy in weight percentages and, in Fahrenheit degrees, is equal to 1290.7 - (604.2)•(nickel/iron) + (829.6)•(chromium/iron) + (1899.6)•(molybdenum/iron) - (635.5)•(cobalt/iron) + (1251.3)•(tungsten/iron); and

wherein the critical cooling time is a function of the composition of the austenitic alloy in weight percentages and, in minutes, is equal to, in $\log_{10}$, 2.948 + (3.631)•(nickel/iron) - (4.846)•(chromium/iron) - (11.157)•(molybdenum/iron) + (3.457)•(cobalt/iron) - (6.74)•(tungsten/iron), and wherein the critical cooling time is in a range of 10 minutes to 30 minutes.

2. The method of claim 1, wherein thermomechanically working the workpiece comprises forging the workpiece.

3. The method of claim 2, wherein forging the workpiece comprises at least one of roll forging, swaging, cogging, open-die forging, impression-die forging, press forging, automatic hot forging, radial forging, and upset forging.

4. The method of claim 1, wherein thermomechanically working the workpiece comprises radial forging the workpiece.

5. The method of claim 1, further comprising, after at least one of thermomechanically working and cooling the workpiece:

heating the workpiece to an annealing temperature that is at least as great as the calculated sigma solvus temperature, and holding the workpiece at the annealing temperature for a period of time sufficient to anneal the workpiece;

wherein as the workpiece cools from the annealing temperature, the austenitic alloy is at temperatures in a temperature range spanning a temperature just less than the calculated sigma solvus temperature down to the cooling temperature for a time no greater than the critical cooling time.

6. The method of claim 1, wherein the austenitic alloy comprises a combined weight percentage of niobium and tantalum no greater than 0.3.

7. The method of claim 1, wherein the austenitic alloy comprises up to 0.2 weight percent vanadium.

8. The method of claim 1, wherein the austenitic alloy comprises up to 0.1 weight percent aluminum.

9. The method of claim 1, wherein the austenitic alloy comprises a combined weight percentage of cerium and lanthanum no greater than 0.1.

10. The method of claim 1, wherein the austenitic alloy comprises up to 0.5 weight percent ruthenium.

11. The method of claim 1, wherein the austenitic alloy comprises up to 0.6 weight percent zirconium.

12. The method of claim 1, wherein the austenitic alloy comprises a cobalt/tungsten weight percentage ratio from 2:1 to 4:1.

13. The method of claim 1, wherein the austenitic alloy has a $PREN_{16}$ value of greater than 40, wherein the $PREN_{16}$ value is determined by the equation:

$$PREN_{16} = \%Cr + 3.3(\%Mo) + 16(\%N) + 1.65(\%W),$$

wherein the percentages are weight percentages.

14. The method of claim 1, wherein the austenitic alloy has a $PREN_{16}$ value in the range of 40 to 60, wherein the $PREN_{16}$ value is determined by the equation:

$$PREN_{16} = \%Cr + 3.3(\%Mo) + 16(\%N) + 1.65(\%W),$$

wherein the percentages are weight percentages.

15. The method of claim 1, wherein the austenitic alloy is non-magnetic.

16. The method of claim 1, wherein the austenitic alloy has a magnetic permeability value less than 1.01.

17. The method of claim 1, wherein the austenitic alloy has an ultimate tensile strength of at least 110 ksi, a yield strength of at least 50 ksi, and a percent elongation of at least 15%.

18. The method of claim 1, wherein the austenitic alloy has an ultimate tensile strength in the range of 90 ksi to 150 ksi, a yield strength in the range of 50 ksi to 120 ksi, and a percent elongation in the range of 20% to 65%.

19. The method of claim 1, wherein the austenitic alloy has an ultimate tensile strength in the range of 100 ksi to 240 ksi, a yield strength in the range of 110 ksi to 220 ksi, and a percent elongation in the range of 15% to 30%.

20. The method of claim 1, wherein the austenitic alloy has a critical pitting temperature of at least 45℃.

21. The method of claim 1, wherein the austenitic alloy comprises, in weight percentages based on total alloy weight: up to 0.05 carbon; 1.0 to 9.0 manganese; 0.1 to 1.0 silicon; 18.0 to 26.0 chromium; 19.0 to 25.43 nickel; 3.0 to 7.0 molybdenum; 0.4 to 2.5 copper; 0.1 to 0.55 nitrogen; 0.2 to 3.0 tungsten; 0.8 to 3.5 cobalt; up to 0.6 titanium; a combined weight percentage of niobium and tantalum no greater than 0.3; up to 0.2 vanadium; up to 0.1 aluminum; up to 0.05 boron; up to 0.05 phosphorus; up to 0.05 sulfur; 20 to 50 iron; and incidental impurities.

22. The method of claim 21, wherein the austenitic alloy comprises 2.0 to 8.0 weight percent manganese.

23. The method of claim 21, wherein the austenitic alloy comprises 19.0 to 25.0 weight percent chromium.

24. The method of claim 21, wherein the austenitic alloy comprises 20.0 to 25.43 weight percent nickel.

25. The method of claim 21, wherein the austenitic alloy comprises 3.0 to 6.5 weight percent molybdenum.

26. The method of claim 21, wherein the austenitic alloy comprises 0.5 to 2.0 weight percent copper.

27. The method of claim 21, wherein the austenitic alloy comprises 0.3 to 2.5 weight percent tungsten.

28. The method of claim 21, wherein the austenitic alloy comprises 1.0 to 3.5 weight percent cobalt.

29. The method of claim 21, wherein the austenitic alloy comprises 0.2 to 0.5 weight percent nitrogen.

30. The method of claim 1, wherein the austenitic alloy comprises, in weight percentages based on total alloy weight: up to 0.05 carbon; 2.0 to 8.0 manganese; 0.1 to 0.5 silicon; 19.0 to 25.0 chromium; 20.0 to 25.4 nickel; 3.0 to 6.5 molybdenum; 0.5 to 2.0 copper; 0.2 to 0.5 nitrogen; 0.3 to 2.5 tungsten; 1.0 to 3.5 cobalt; up to 0.6 titanium; a combined weight percentage of niobium and tantalum no greater than 0.3; up to 0.2 vanadium; up to 0.1 aluminum; up to 0.05 boron; up to 0.05 phosphorus; up to 0.05 sulfur; 20 to 50 iron; trace elements; and incidental impurities.

31. The method of claim 30, wherein the austenitic alloy comprises 2.0 to 6.0 weight percent manganese.

32. The method of claim 30, wherein the austenitic alloy comprises 20.0 to 22.0 weight percent chromium.

33. The method of claim 30, wherein the austenitic alloy comprises 6.0 to 6.5 weight percent molybdenum.

34. The method of claim 30, wherein the austenitic alloy comprises 40 to 45 weight percent iron.

35. A method of processing an austenitic alloy workpiece to inhibit precipitation of intermetallic compounds, the method comprising:

forging the workpiece;

cooling the forged workpiece; and

optionally, annealing the cooled workpiece;

wherein the austenitic alloy comprises, in weight percentages based on total alloy weight, up to 0.2 carbon, up to 20 manganese, 0.1 to 1.0 silicon, 14.0 to 28.0 chromium, 15.0 to 25.43 nickel, 2.0 to 9.0 molybdenum, 0.1 to 3.0 copper, 0.08 to 0.9 nitrogen, 0.1 to 5.0 tungsten, 0.5 to 5.0 cobalt, up to 1.0 titanium, up to 0.05 boron, up to 0.05 phosphorus, up to 0.05 sulfur, 0.01 to 1.0 vanadium, 20 to 60 iron, and incidental impurities;

wherein during forging the workpiece and cooling the forged workpiece the austenitic alloy cools through a temperature range spanning a temperature just less than a calculated sigma solvus temperature of the austenitic alloy down to a cooling temperature for a time no greater than a critical cooling time;

wherein the calculated sigma solvus temperature is a function of the composition of the austenitic alloy in weight percentages and, in Fahrenheit degrees, is equal to 1155.8 - (760.4)•(nickel/iron) + (1409)•(chromium/iron) + (2391.6)•(molybdenum/iron) - (288.9)•(manganese/iron) - (634.8)•(cobalt/iron) + (107.8)•(tungsten/iron);

wherein the cooling temperature is a function of the composition of the austenitic alloy in weight percentages and, in Fahrenheit degrees, is equal to 1290.7 - (604.2)•(nickel/iron) + (829.6)•(chromium/iron) + (1899.6)•(molybdenum/iron) - (635.5)•(cobalt/iron) + (1251.3)•(tungsten/iron); [[and]]

wherein the critical cooling time is a function of the composition of the austenitic alloy in weight percentages and, in minutes, is equal to, in $\log_{10}$, 2.948 +

(3.631)•(nickel/iron) - (4.846)•(chromium/iron)
- (11.157)•(molybdenum/iron) + (3.457)•(cobalt/iron) - (6.74)•(tungsten/iron), and wherein the critical cooling time is in a range of 10 minutes to 30 minutes.

36. The method of claim 35, wherein forging the workpiece occurs entirely at temperatures greater than the calculated sigma solvus temperature.

37. The method of claim 35, wherein forging the workpiece occurs through the calculated sigma solvus temperature.

38. The method of claim 35, wherein forging the workpiece comprises at least one of roll forging, swaging, cogging, open-die forging, impression-die forging, press forging, automatic hot forging, radial forging, and upset forging.