

5

Nickel (Ni) should be present in an amount of at least about 8% by weight. Generally, the Ni content should not exceed about 22% by weight, however this is not an absolute upper limit. Although higher amounts of Ni can be used in the stainless steel alloy of the present invention, it is preferable that the Ni content should be between about 10% and 16% by weight and most preferably between 12% and 16% by weight. Although Ni is high in cost and detrimental to nitrogen solubility, Ni helps to insure gamma (γ) phase stability.

Nitrogen (N) should be present in an amount between about 0.8% and about 0.97% by weight, and preferably between 0.8% and 0.95% by weight. This content of N ensures high strength and gamma (γ) stability. The amount of N should not exceed the upper limit of about 0.97% by weight since amounts of N exceeding this upper limit tend to form stable nitrides, such as Cr₂N.

The alloy of the present invention can also contain up to about 3% by weight Tungsten (W). As is known in the art, W tends to reduce the formation of intermetallic phases.

The balance of the high nitrogen stainless steel alloy is iron (Fe). Typically, the amount of Fe present in the alloy will not exceed about 60% by weight. Preferably, the content of Fe is between about 39% and about 50% by weight, and most preferably between 39% and 47% by weight.

Finally, the alloy of the present invention may also contain a minor amount of impurities. Typical impurities include, but are not limited to, silicon, oxygen, carbon and sulfur. Generally, the amount of the impurities should not exceed about 1% by weight of the alloy, and more preferably not exceed about 0.6% by weight of the alloy.

The gas atomization process used in the present invention is known to those skilled in the art. U.S. Pat. No. 5,114,470, which is incorporated herein by reference, describes the gas atomization process. Other references such as Janowski et al, "Beneficial Effects of Nitrogen Atomization on an Austenitic Stainless Steel", *Metall. Trans. A*, Vol. 23A, 1992, pp. 3263-3272, hereby incorporated by reference, also describe the gas atomization process. Briefly, a controlled atmosphere or vacuum induction melting can be used to produce the stainless steel alloy powder of the present invention. The starting mixture of metals is melted by a known method and then the melt is subjected to gas atomization using nitrogen gas. The product of these process steps is an alloy powder.

6

Preferably, the mixture of metals is melted in the presence of a nitrogen atmosphere or under a vacuum.

After the alloy powders are formed, the powders can be consolidated using methods known to those skilled in the art. Consolidation methods include, but are not limited to, hot isostatic pressing (HIP), hot pressing, metal injection molding or hot metal extrusion. It is preferred that a hot isostatic press is used to consolidate the metal powder.

Like the gas atomization process, hot isostatic pressing is well known to those skilled in the art and are described in, e.g., Eckenrod et al, "P/M High Performance Stainless Steels for Near Net Shapes," Processing, Properties and Application Advances in Powder Metallurgy and Particulate Material, 1993, Vol. 4, pp.131-140.

EXAMPLES

Table 1 shows the nominal starting compositions for each of the alloys formed in accordance with this invention. A NIST supersonic inert gas metal atomizer (SIGMA) is used to produce the alloys of the examples. The mixture of metals for each was melted using vacuum induction melting at a temperature at or above the melting temperature and under a nitrogen atmosphere. The melting chamber is then back-filled with nitrogen. The liquid metal is then subjected to nitrogen gas atomization in a NIST supersonic inert gas metal atomizer (SIGMA), which is an example of a discrete jet, close-coupled gas atomizer. This process results in an alloy powder.

Each alloy powder was subjected to a consolidation using a hot isostatic press at a temperature of 1180° C. and a pressure of 29 ksi for a period of two hours.

Table 2 shows several compositions of high nitrogen stainless steel alloys prepared within the parameters of the present invention. The only exception is NSS.057 which was prepared for comparative purposes.

Table 3 shows the physical properties for the alloys formed.

TABLE 1

Approximate Nominal Starting Compositions (mass fraction %)									
Alloy	Fe	Cr	Ni	Mn	Mo	Si	O	C	S
NSS.082	41	30	14	12	2	0.5	0.059	0.017	0.002
NSS.083	43	30	14	10	2	0.5	0.055	0.021	0.003
NSS.084	39	27	15	15	2	0.5	0.045	0.019	0.003
NSS.085	44	30	15	8	2	0.5	0.046	0.014	0.003
NSS.086	46	29	15	6	2	0.5	0.044	0.016	0.003
NSS.087	45	29	13	9	2	0.5	0.042	0.020	0.004

TABLE 2

Alloy Compositions (mass fraction %)										
Alloy	Fe	Cr	Ni	Mn	Mo	N	SI	O	C	S
NSS.057	62.59	24.97	4.84	4.06	3.00	0.50	0.00	0.019	0.016	<.003
NSS.082	40.79	29.82	13.93	11.99	1.94	0.97	0.48	0.059	0.017	0.002
NSS.083	42.56	29.90	13.91	10.29	1.95	0.94	0.37	0.055	0.021	0.003
NSS.084	39.27	27.42	14.94	15.07	1.93	0.84	0.46	0.045	0.019	0.003
NSS.085	43.81	29.65	15.13	8.03	1.96	0.86	0.50	0.046	0.014	0.003
NSS.086	46.33	29.35	15.02	5.96	1.94	0.83	0.51	0.044	0.016	0.003
NSS.087	45.29	29.49	12.85	9.00	1.92	0.88	0.50	0.042	0.020	0.004