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HIGH ALLOY STEEL

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ABSTRACT OF THE DISCLOSURE

Described herein is a composition consisting essentially of, in weight percent, 16–25% chromium, 10–22% nickel, 4–10% molybdenum, up to 0.08% carbon, up to 2.0% manganese, up to 1.5% silicon and the balance essentially iron and steel making residuals.

Stainless steel has been frequently used in applications requiring resistance to corrosion in environments involving exposure to chloride and chlorine ions. Commonly used materials for these applications have been high alloy stainless steels such as type 316 and type 316L. Such high alloyed compositions, however, suffer from the disadvantage that they are difficult to hot work and as a result pose serious fabrication problems.

In some cases it has been suggested to utilize powder metallurgical techniques to produce articles of high alloy stainless steel to avoid the aforementioned fabrication difficulties which may be associated with such materials. However, because of their porous nature, pressed and sintered stainless steel powder articles are particularly subject to corrosive attack as a result of susceptibility to crevice corrosion. Even such high alloyed materials as type 316 and type 316L prove inadequate in pressed and sintered articles when exposed to corrosion testing. This is evidenced by the failure of sintered parts of type 316L to withstand 100 hours exposure in 5% neutral sodium chloride spray without rusting. This rusting has been found to occur at all levels of density up to, but not including, 100% and is attributed to the presence of pores in the surface. It is evident that there is a need for stainless steel compositions which, when manufactured into articles

from powder metal, will provide more resistance to corrosive environments such as the chlorine ion than that of type 316L steels and possess improved resistance to crevice corrosion as a pressed and sintered article.

The present invention provides a novel composition which avoids the aforementioned difficulties associated with powder metal parts manufactured of presently available high alloy steel powders. In accordance with the invention there is provided a composition consisting essentially of, in weight percent, up to 0.08% carbon, preferably up to 0.03%; up to 2.0% manganese, preferably up to 0.3%; up to 1.5% silicon, preferably 0.6 to 1.25%; 16 to 25% chromium, preferably 17 to 25%; 10 to 22% nickel, preferably 14 to 22%; 4 to 10% molybdenum, preferably 4–7%; and the balance essentially iron and the usual steel making residuals. Alloys, in accordance with the invention, may be melted and atomized into pre-alloyed powder and then pressed and sintered into powder metal components of greater corrosion resistance than possessed by the most highly alloyed commercially available stainless steel powder, e.g., type 316L. The minimum values of the alloying elements chromium, nickel and molybdenum, in the foregoing broad range have been found to be the minimum amounts necessary to obtain satisfactory corrosion resistance for these alloys in powder articles. However, no significant improvement is observed beyond the maximum values. For commercial powder metallurgical operations, it is desirable to utilize irregularly shaped particles. The preferred limits of 0.3% maximum manganese and at least 0.6% silicon are established to maximize the desirable particle configuration.

The following examples illustrate the practice of the invention and the superior properties obtainable thereby.

Atomized powders of the compositions described in Table I were prepared and screened to a size suitable for powder metal processing (about 0.149 mm. and finer), having the characteristics described in Table II. Thereafter they were pressed into compacts and sintered in dry hydrogen at temperatures of 2000 to 2200° F. The sintered compacts were about 75 to 90% of their full density. A commercial type 316L powder was pressed and sintered in a similar fashion.

TABLE I

Run No.	C	Mn	P	S	Si	Cr	Ni	Mo	Fe
416	0.014	0.098	0.008	0.005	1.05	17.97	10.22	4.92	Balance.
Commercial T316	0.045	0.16	1.014	0.008	0.80	16.85	12.78	2.34	Do.
418	0.014	0.038	0.010	0.004	0.95	18.05	12.20	4.80	Do.
420	0.020	0.043	0.003	0.003	0.81	17.65	15.05	3.07	Do.
437	0.026	0.049	0.008	0.006	0.79	17.69	14.95	4.02	Do.
419	0.030	0.040	0.012	0.004	0.86	17.74	15.00	5.05	Do.
417	0.021	0.094	0.008	0.003	0.99	17.92	14.90	7.05	Do.
398	0.020	0.13	0.013	0.003	0.84	17.75	19.86	6.96	Do.
449	0.027	0.13	0.010	0.011	0.74	21.16	12.08	4.00	Do.
438	0.020	0.054	0.015	0.008	0.76	21.40	12.30	5.00	Do.
411	0.0057	0.033	0.015	0.007	0.70	20.88	21.60	7.30	Do.
367	0.020	0.080	0.018	0.013	0.71	24.08	20.88	4.00	Do.

TABLE II

Properties of Atomized Pre-Alloyed Powders

Run No.	Mesh size distribution, wt. percent			Flow,[1] seconds/50g.	Apparent density, g./cu. cm.
	−100/+200	−200/+325	−325		
416	43.9	21.0	35.0	23.0	3.17
Commercial T316					
418	26.9	20.8	52.3	27.6	2.73
420	41.1	21.3	37.6	24.6	3.06
437	39.3	28.3	32.4	22.7	3.18
419	30.5	20.7	48.8	24.8	2.98
417	41.5	19.5	39.0	23.1	3.29
398	30.6	21.8	47.6	27.4	2.91
449	36.6	27.3	36.1	23.7	3.23
438	35.4	27.2	37.4	23.1	3.16
411	40.6	21.1	38.3	24.8	3.06
439	35.4	27.0	37.5	20.3	3.26
367	36.8	25.7	37.4	26.5	2.92

[1] ASTM Method B213–48.
[2] ASTM Method B212–48.

The pressed and sintered compacts of the compositions disclosed in Table I were exposed to the following corrosive environments:

(1) 5% neutral NaCl spray
(2) Immersion in aqueous solutions of 5, 10, and 20 weight percent NaCl.
(3) Immersion in aqueous solutions of 5, 10 and 20 weight percent NH_4Cl.

In all cases, alloys in accordance with the invention demonstrated superior corrosion resistance than the commercially available powder.

It is apparent from the foregoing that various changes and modifications may be made without departing from the invention. Thus, for example, it is possible to include various additives, such as lubricants, to the metal powders when manufacturing powder metal articles. Similarly, various pressing and sintering practices may be employed depending upon the particular desired result and a variety

of atmospheres may be used. In addition the density of the compacts produced may vary depending upon the nature of the article manufactured.

I claim:

1. An atomized, prealloyed powder consisting essentially of, in weight percent, up to 0.08% carbon, up to 0.3% manganese, 0.6 to 1.25% silicon, 16 to 25% chromium, 10 to 22% nickel, 4 to 10% molybdenum and the balance essentially iron and steel making residuals.

2. An atomized, prealloyed powder according to claim 1 having 4 to 7% molybdenum.

3. An atomized, prealloyed powder according to claim 1 having 17 to 25% chromium.

4. An atomized, prealloyed powder according to claim 1 having 14 to 22% nickel.

5. An atomized, prealloyed powder according to claim 1 having up to 0.03% carbon, 17 to 25% chromium, 14 to 22% nickel and 4 to 7% molybdenum.

TABLE III

Corrosion Test Results of Pressed and Sintered Atomized Pre-Alloyed Powders

Run No.	Cast density, g./cu. cm.	Sintered density, g./cu. cm.	Percent of cast density	100 hour exposure to 5% neutral salt spray [1]	Hours to rust when immersed in aqueous solutions of—					
					5% NaCl	10% NaCl	20% NaCl	5% NH_4Cl	10% NH_4Cl	20% NH_4Cl
416	7.88	5.95	75.5	N.R.	504 N.R.	504 N.R.	168	504 N.R.	504 N.R.	48.
Commercial T316	[2] 7.90	6.28	79.5	Rust	528 N.R.	24	3	504 N.R.	24	3.
418	7.97	5.66	71.0	N.R.	504 N.R.	168	24	504 N.R.	504 N.R.	24.
420	7.97	5.83	73.2	N.R.	528 N.R.	528 N.R.	96	504 N.R.	504 N.R.	96.
437	7.98	5.85	73.3	N.R.	528 N.R.	528 N.R.	600 N.R.	504 N.R.	----------	528 N.R.
419	7.99	6.02	75.3	N.R.	504 N.R.	504 N.R.	168	504 N.R.	504 N.R.	24.
417	8.01	5.61	70.0	N.R.	528 N.R.	528 N.R.	600 N.R.	504 N.R.	528 N.R.	528 N.R.
398	8.02	5.67	70.7	N.R.	528 N.R.	528 N.R.	600 N.R.	504 N.R.	504 N.R.	504 N.R.
449	7.91	5.68	71.8	N.R.	504 N.R.	504 N.R.	24	504 N.R.	504 N.R.	24.
438	7.86	5.54	70.5	N.R.	504 N.R.	504 N.R.	168	504 N.R.	504 N.R.	24.
411	8.04	5.60	69.7	N.R.	528 N.R.	528 N.R.	600 N.R.	504 N.R.	504 N.R.	504 N.R.
439	7.81	5.50	70.4	N.R.	528 N.R.	528 N.R.	600 N.R.	504 N.R.	504 N.R.	504 N.R.
367	7.93	5.44	68.6	N.R.	504 N.R.	504 N.R.	600 N.R.	504 N.R.	504 N.R.	504 N.R.

[1] ASTM Method B117.
[2] Published value.

NOTE.—N.R.=No rust.

References Cited

UNITED STATES PATENTS

2,819,161	1/1958	Cupler	75—126
3,547,625	12/1970	Bieber, et al.	75—128
2,872,311	2/1959	Marshall	75—200
3,334,999	8/1967	Naeser	75—200 X
3,425,813	2/1969	Orlemann	75—0.5 BA X
3,520,680	7/1970	Orlemann	75—200 X

OTHER REFERENCES

Metals Handbook, 8th Edition, Vol. 1, Properties and Selection of Metals, American Society for Metals, Metals Park, Ohio, pp. 408 and 409.

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75—0.5 BA, 0.5 C