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FERROUS ALLOY

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This invention relates to ferrous alloys, and more particularly to an improved alloy having heat and corrosion resisting properties.

There are many uses to which alloy compositions are put that call for a high capacity to resist heat and corrosion, and although numerous compositions of this general type are available at present, they fail in several respects to embody the important characteristics of the present composition. Thus, a typical alloy which is in use at the present time is of the following approximate chemical composition:

	Per cent
Carbon	.12
Silicon	.30
Manganese	.60
Chromium	12.00

with the balance iron, except for impurities.

This material, although widely used today, falls substantially short of embodying the same degree of heat resistance at high temperature that does the alloy of the present invention. By quenching the above alloy in oil from 1725 degrees F., results in a hardness of 375 Brinell, and on tempering to 1050, will have a hardness of 330 Brinell. If tested in this condition, the Brinell hardness of various elevated temperatures are as follows:

Temperature	Brinell
Room temperature	330
200 degrees F	330
300 degrees F	320
400 degrees F	310
500 degrees F	290
600 degrees F	280
700 degrees F	280
800 degrees F	280
900 degrees F	275
1000 degrees F	225
1100 degrees F	160
1200 degrees F	120

In order to increase the hardness of the alloy at elevated temperatures, particularly the hot hardness and attendant tensile and yield strength, the foregoing alloy can be modified as follows:

	Per cent
Carbon	.10
Silicon	.30
Manganese	.55
Chromium	13.00
Tungsten	3.00

Hot Brinell hardnesses taken at the same 100 degree intervals from room temperature to 1200 degrees F., on pieces of this material which have been hardened in oil from 1800 degrees F. and tempered to 1000 degrees F., are as follows:

Temperature	Brinell
Room temperature	277
200 degrees F	269
300 degrees F	255
400 degrees F	248
500 degrees F	235
600 degrees F	241
700 degrees F	235
800 degrees F	235
900 degrees F	235
1000 degrees F	223
1100 degrees F	159
1200 degrees F	129

This is virtually a ferritic alloy, resulting from the potency of tungsten so stabilizing the alpha-phase as to prevent any significant thermal hardenability.

Pursuing the foregoing line of investigation, a composition has now been discovered which, as stated above, embodies heat resisting qualities substantially above those already recited. This composition falls within the following average chemistry range:

	Per cent
Carbon	.05– .25
Tungsten	1.00– 4.00
Chromium	10.00–17.00
Nickel	.75– 2.75

with the balance of the alloy substantially iron, except for such customary additive elements as silicon, manganese and the like.

It has been found that this material has physical properties radically different than would be indicated by the mere difference of composition. The nickel present crystallizes with a face centered cubic lattice as does gamma iron (austenite) and thus stabilizes this phase. Added in sufficient quantity to the ferritic tungsten-chromium alloy, it extends the gamma loop, permitting phase change and attendant hardenability. Thus the benefits of tungsten, in decreasing the softening rate at high temperature and increasing the elevated temperature hardness, are secured in a hardenable alloy.

A specific composition falling within the general range set forth above may be recited as a preferred example.

	Per cent
Carbon	.12
Silicon	.30
Manganese	.60
Tungsten	3.00
Chromium	13.00
Nickel	1.75

This material can be hardened in oil or air from 1725 to 1825 degrees F. Hot Brinell hardness tests on the material quenched from two different temperatures are as follows:

1725 degrees F. quenched in air, tempered at 1000 degrees F.

Temperature	Brinell
Room temperature	401
200 degrees F.	401
300 degrees F.	388
400 degrees F.	375
500 degrees F.	375
600 degrees F.	375
700 degrees F.	375
800 degrees F.	388
900 degrees F.	363
1000 degrees F.	321
1100 degrees F.	187
1200 degrees F.	163

1800 degrees F. quenched in oil, tempered at 1000 degrees F.

Temperature	Brinell
Room temperature	418
200 degrees F.	418
300 degrees F.	402
400 degrees F.	402
500 degrees F.	402
600 degrees F.	402
700 degrees F.	402
800 degrees F.	402
900 degrees F.	402
1000 degrees F.	363
1100 degrees F.	192
1200 degrees F.	166

In addition to the greatly improved hot hardness, tensile strength and yield strength at high temperatures, the room temperature physical properties, after quenching in air from 1725 degrees F. and tempering to 1240 degrees F., are distinctly superior over material (stainless iron) now in current use. This new alloy, after the above treatment, has the following properties:

Proof stress	Tensile strength	Percent elongation	Percent reduction of area	Brinell
81,400	135,500	19.5	59.08	269

Stainless iron, the currently used material, has the following properties after the same treatment:

Proof stress	Tensile strength	Percent elongation	Percent reduction of area	Brinell
64,200	101,000	24.0	73.3	207

It may be stated from one standpoint that the instant invention relates primarily to the introduction of a combination of nickel and tungsten as necessary ingredients into an alloy steel having a chromium content lying within the stainless range. The introduction of nickel and tungsten in the manner described herein results in the production of a steel that remains stable at high temperatures. Heretofore it has been suggested that molybdenum be employed with or without nickel for this purpose, but I have discovered that molybdenum has a tendency to oxidize from the steel surface when the steel is heated to elevated temperatures, and I have discovered further that this is not true of tungsten. Accordingly, if the steel is to be employed at high temperatures the stability of tungsten is such that in many instances it cannot be replaced by molybdenum.

Having thus described my invention, I claim an alloy steel adapted to be employed at elevated temperatures, said steel being of the following general composition:

1. A heat and corrosion resisting ferrous alloy, containing from .05% to .25% carbon, from 10.00% to 17.00% chromium, from 1.00% to 4.00% tungsten, from .75% to 2.75% nickel, a silicon content of less than 1.5%, and a manganese content of less than 1.5%, with the remainder of the alloy all iron.

2. A heat resisting ferrous alloy, containing approximately .12% carbon, approximately 13.00% chromium, approximately 1.75% nickel, approximately 3.00% tungsten, approximately .30% silicon, and approximately .60% manganese, with the remainder of the alloy all iron.

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