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# FERROUS ALLOYS

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## ABSTRACT OF THE DISCLOSURE

A sintered ferrous alloy has the composition chromium 10.5–15%, carbon 0.5–2.5%, molybdenum 0.25–5.0%, copper 3–25%, the remainder being iron except for usual impurities and trace elements. The alloy can also contain up to a total of 5% titanium, vanadium and/or cobalt. The chromium is introduced in the form of a pre-alloy of 87% iron and 13% chromium, and the copper can be introduced in the form of a pre-alloy of 90% copper, 5% iron and 5% manganese. The alloy is useful for the production, by powder metallurgy, of valve seat inserts for internal combustion engines.

This invention relates to sintered ferrous alloys.

According to the invention, a sintered ferrous alloy has the composition chromium 10.5–15%; carbon 0.5–2.5%; molybdenum 0.25–5.0%; copper 3–25%; optionally manganese, titanium, vanadium and/or cobalt in total 0–5%; remainder iron, except for usual impurities and trace elements.

Preferably the alloy is formed by mixing powders in the required proportions, pressing these to form a compact, and sintering the compact.

The alloy has particular application to valve seat inserts for reciprocating internal combustion engines.

Preferably the percentage of chromium is in the range 11.5–13.0.

A number of examples of the invention will now be described. All percentages are by weight.

In a first example the following powders were mixed together and sintered to give an alloy of the composition: Fe 80.6%; Cr 12.0%; Cu 6.0%; C 1.0%; Mo 0.4%; viz:

6% of —300 mesh atomised elemental copper (N.B. —300 mesh indicates powder which passes a 300 mesh screen),
0.4% of —300 mesh elemental molybdenum,
1.0% of Bavarian graphite,
92.6% of pre-alloyed 87% iron, 13% chromium alloy (—100 mesh nominally),
plus 0.75% by weight addition of zinc stearate lubricant (which disappears in the sintering process).

The powders were mixed together for one hour in a double cone rotary mixer. The mixture was then compacted in a press with double-sided pressing action at 40 t.s.i. The compact was then sintered in a cracked ammonia atmosphere (less than —35° C. dew point) at 1100° C. for one hour. The resulting component was heat-treated to attain the required properties by heating for 15 minutes at 1000° C. and quenching into an oil bath, and finally tempering at 600° C. for one hour in air. The resulting component had the following properties:

Hardness:
Macro-hardness (Rockwell C): 35–40



Micro-hardness (Vickers Pyramid Number, 30 gm. load): average 550–600
Density: 6.6–6.7 gm./cc.
Percentage elongation at fracture: 1%
Tensile strength: 15–20 t.s.i. (tons per square inch)
Thermal conductivity (room temperature): 0.027 cgs. units (calories/cm.$^2$/cm./sec./° C.)
Thermal expansion coefficient (20–500° C.): $11.4\times10^{-6}$ per ° C.
Compressive proof stress (0.1% plastic strain): 60 t.s.i.
Elasticity number (p.s.i.$\times10^6$): 17–18.

Alternatively, the sintered compact may be heat-treated for 2½ hours at 1025° C., cooled to room temperature and then heated to 700° C. for one hour in air.

In a second example the following powders were mixed together and sintered to give an alloy of the composition: Fe 71.9%; Cr 10.7%; Cu 15.0%; C 2.0%; Mo 0.4%; viz:

15% of —300 mesh atomised elemental copper,
0.4% of —300 mesh elemental molybdenum,
2.0% of Bavarian graphite,
82.6% of pre-alloyed 87% iron, 13% chromium alloy (—100 mesh nominally)
plus 0.75% addition of zinc stearate lubricant

(which disappears in the sintering process). The powders were processed identically with Example 1.

The resulting properties were:

Hardness:
Macro-hardness (Rockwell C): 30–35
Micro-hardness (Vickers Pyramid Number, 30 gm. load): 480–520
Density: 6.7–6.8 gm./cc.
Percentage elongation at fracture: 1%
Tensile strength: 25–35 t.s.i.
Thermal conductivity (room temperature): 0.038 cgs. units
Thermal expansion coefficient (20–700° C.): $13.1\times10^{-6}$ per ° C.
Compressive proof stress (0.1% plastic strain): 60 t.s.i.
Elasticity number (p.s.i. $10^6$): 17–18

In a third example, a sintered alloy having the composition:

Fe 73%; Cu 13.5%; Cr 10.8%; C 1.7%; Mn 0.8; Mo 0.3% is produced by the following method. The following powders, viz:

0.4% elemental molybdenum
2.0% Bavarian graphite

97.6% pre-alloyed 87% iron, 13% chromium alloy were mixed and processed as Examples 1 and 2 as far as the heat-treatment (hardening) stage. At this point, the material is subjected to an infiltration process. This consists of placing a 90% copper+5% iron+5% manganese pre-alloyed powder compact (15% by weight of the compact) in contact with the stainless compact and repeating the sintering cycle wherein the copper alloy melts and flows into and alloys with the ferrous skeleton. This process is well known in the industry. The resulting compact is then heat-treated as in Examples 1 and 2. The subsequent properties are:

Hardness:
Macro-hardness (Rockwell C): 30–35
Micro-hardness (Vickers Pyramid Number, 30 gm. load): 480–520
Density (gm./cc.): 7.3–7.5
Percentage elongation: 1%
Tensile strength: 5–60 t.s.i.

Thermal conductivity (room temperature): 0.034 cgs. units

Thermal expansion coefficient (20–700° C.): $13.7 \times 10^{-6}$ per ° C.

Compressive proof stress (0.1% plastic strain): 60 t.s.i.

Elasticity number (p.s.i. $10^6$): 17–18

Three further examples were made in the manner described in relation to the first example above, and having the following compositions:

| | Percent | | |
|---|---|---|---|
| Example number | 4 | 5 | 6 |
| Chromium | 15 | 12 | 11.5 |
| Carbon | 1 | 1 | 1 |
| Molybdenum | 2 | 1 | 4 |
| Copper | 6 | 6 | 6 |
| Iron | Remainder (except for impurities) | | |

The green compacts had densities respectively of 6.2, 6.5, and 6.6 gm./cc.

The compacts were heat-treated by heating for 2½ hours at 1,025° C., cooling to room temperature, and then heating to 700° C. for one hour. The heat-treatments were carried out in a substantially inert atmosphere.

The physical properties of the sintered compacts are given by the following table:

| Example number | 4 | 5 | 6 |
|---|---|---|---|
| Density, gm./cc | 5.95 | 6.5 | 6.6 |
| Macro-hardness (Rockwell C) | 30 | 24 | 26 |
| Micro-hardness (Victors Pyramid Number, 30 gm. load) | 440 | 380 | 440 |

We claim:

1. A sintered ferrous alloy having the composition

| | Percent |
|---|---|
| Chromium | 10.5–15 |
| Carbon | 0.5–2.5 |
| Molybdenum | 0.25–5.0 |
| Copper | 3–25 |

the remainder being iron except for usual impurities and trace elements.

2. A sintered ferrous alloy according to claim 1 containing at least one of the substances selected from the group comprsing manganese, titanium, vanadium and cobalt up to a total of 5%.

3. A sintered ferrous alloy according to claim 1 or claim 2 wherein the content of chromium is in the range 11.5–13.0%.

4. A sintered ferrous alloy according to claim 1 containing

12% of chromium
1% of carbon
0.4% of molybdenum and
6% of copper.



5. A sintered ferrous alloy according to claim 1 containing

10.7% of chromium
2% of carbon
0.4% of molybdenum and
15% of copper.

6. A sintered ferrous alloy according to claim 1 containing

10.8% of chromium
1.7% of carbon
0.3% of molybdenum
13.5% of copper and
0.8% of manganese.

7. A sintered ferrous alloy according to claim 1 containing

15% of chromium
1% of carbon
2% of molybdenum and
6% copper.

8. A sintered ferrous alloy according to claim 1 containing

12% of chromium
1% of carbon
1% of molybdenum
6% of copper.

9. A sintered ferrous alloy according to claim 1 containing

11.5% of chromium
1% of carbon
4% of molybdenum and
6% of copper.

10. A sintered ferrous alloy according to claim 4 wherein the iron and chromium have been introduced in the form of a pre-alloy of 87% iron and 13% chromium.

11. A sintered alloy according to claim 6 wherein the chromium has been introduced in the form of a prealloy of 87% iron and 13% chromium and the copper and manganese have been introduced in the form of a pre-alloy of 90% copper, 5% iron and 5% manganese.


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