BINDER FOR POWDER METALLURGICAL COMPOSITIONS

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Related U.S. Application Data

Provisional application No. 60/571,490, filed on May 17, 2004.

A binder for metallurgical powder compositions for powder metallurgy (P/M) applications includes styrene/maleic anhydride copolymers and their derivatives. Addition of such binders has improved resistance to dusting, and has improved flow properties of the compositions, even in high relative humidity environments. The compositions can be compacted either at cold or warm temperatures. A mechanical strength of a sintered product containing the binder-treated mix is similar to that of sintered products without the binder.
BINDER FOR POWDER METALLURGICAL COMPOSITIONS

[0001] This application claims benefit of U.S. Provisional Application 60/571,490 filed May 17, 2005.

FIELD OF THE INVENTION

[0002] The present invention relates to powder metallurgical compositions, and in particular to copolymer binders for ferrous powder compositions having binding properties and yielding powder formulation having improved dust resistance and flow.

BACKGROUND OF THE INVENTION

[0003] Processes for producing metal parts from ferrous powders using powder metallurgy (P/M) techniques are well known. Such techniques typically involve mixing ferrous powders with alloying components such as graphite, copper or nickel in powder form, filling the die with the powder mix, compacting and shaping the compact by the application of pressure, and ejecting the compact from the die. The compact is then sintered to develop metallurgical bonds by mass transfer under the influence of heat. It is known that the presence of an alloying element enhances the strength and other mechanical properties in the sintered part compared to the ferrous powders alone. When necessary, secondary operations such as sizing, coining, repressing, impregnation, infiltration, machining, joining, etc. are performed on the P/M part.

[0004] It is common practice to add a lubricant to the powder mix (i.e. metallurgical powder composition) to improve the compaction. The lubricant is required mainly to reduce the friction between metal powders and die walls. By ensuring a good transfer of the compacting force during the compaction stage, it improves the uniformity of densification throughout the part. Furthermore, it also lowers the force required to remove the compact from the die, thus reducing die wear and yielding parts with good surface finish.

[0005] In addition to the lubricant, other alloying powders and additives are also often added to the basic metal powders to achieve desired physical and metallurgical properties in the sintered products. These alloying powders and other additives (secondary powders) typically differ from the basic metal powders in particle size, shape and density making these powder mixtures susceptible to the undesirable separatory phenomena of segregation, and dusting, which is prone to happen, for example, during handling, storage or transfer of the mixtures. It will be appreciated that uniformity of the powder mixture is typically required to ensure consistent material properties of the sintered product. Dusting is a serious health concern. Dusting occurs when lighter and finer particles are entrained in air. The air-borne particles may be inhaled resulting in various health risks. In order to prevent segregation and dusting, organic binders can be added to the powder mixtures to bind the fine alloying powders and additives to the primary metallic powders.

[0006] Various organic binding agents have been suggested to prevent segregation and dusting of these powder mixtures. For example, in U.S. Pat. No. 4,483,905, it has been found that segregation and dusting can be reduced or eliminated if the powder contains a binding agent in solid or liquid state. It is preferred to add to the metal powder one of the agents polyethylene glycol, polypropylene glycol, glycerine, and polyvinyl alcohol, in a quantity of 0.005-0.2 percent by weight. U.S. Pat. No. 4,676,831 teaches iron based powder mixtures, which except iron or steel powder and one or more alloying elements in powder form also contain an addition of up to 0.5% of talc to prevent segregation/dusting. In U.S. Pat. No. 5,069,714, Gosselin discloses an improved metallurgical powder composition of a ferrous powder and at least one of an alloying powder, a lubricant or other additive. Lining, dusting and/or segregation of the composition is prevented by use of a polyvinyl pyrrolidone binding agent. In U.S. Pat. No. 5,286,275, Murakami discloses a powder mixture for powder metallurgy comprising a starting powder for powder metallurgy containing a metal powder, a powder of physical property improving ingredients and a lubricant and, blended therewith as a binder, a synthetic styrenic rubber copolymer comprising: 5 to 75 parts by weight of styrene and 95 to 25 parts by weight of butadiene and/or isoprene, as the monomer ingredient or a hydrogenation product thereof. The binder can suppress the segregation of the physical property improver and the lubricant, as well as dusting upon handling the powder. Also, for warm pressing applications, Lin discloses in U.S. Pat. No. 5,429,792 an improved metallurgical powder composition capable of being compacted at elevated temperatures comprising an iron-based powder, an alloying powder, a high temperature compaction lubricant, and a binder. The selected binders of this invention permit the bonded powder composition to achieve increased compressibility in comparison to unbonded powder compositions while reducing dusting and segregation of the alloying powders.

[0007] These binders are effective in preventing segregation and dusting, but they may adversely affect other physical properties such as compressibility and flow of the powder. Thus, a few patents provide specific binders for reduction or elimination of segregation and dusting while at the same time resisting degradation of physical properties of the powders and metallurgical properties of the sintered output. For example, in U.S. Pat. No. 5,432,223, Champagne discloses a novel high-performance binder system for the fabrication of segregation-free iron based powder blends. The blends are prepared by using a binder system comprising thermosetting resin polystyrenepyrrolidone (PVP) and a suitable compatible plasticizer such as polyethylene (PEG), and optional solid lubricants. The binder system enables the manufacture of segregation-free iron-based powder blends with high flow rate and compressibility, enhanced apparent density, green strength and transverse rupture strength, and low dimensional variations compared to unbonded powder blends and to blends made with PVP or PEG only as the binder. Also, in U.S. Pat. No. 5,976,215, Satoshi discloses an iron-based powder mixture for powder metallurgy, comprising: an iron-based powder, and from 0.05 to 0.5% by weight of a thermoplastic resin powder which comprises 50% or more by weight of units of at least one monomer selected from the group consisting of acrylic esters, methacrylic esters, and aromatic vinyl compounds, and whose average primary particle size is from 0.03 to 5 μm, whose average agglomeration particle size is from 5 to 50 μm, and whose average molecular weight is from 30000
to 5000000. The resin powder is used as a non-binder powder to further improve the flowability of the iron-based powder mixture.

[0008] There remains a need for another binder agent that mixed with a metallurgical powder mixture produces a metallurgical powder composition, wherein the binder agent imparts on the metallurgical powder composition: reduced segregation and dusting, and improved flow characteristics, without reducing the sintered properties of the sintered pieces.

SUMMARY OF THE INVENTION

[0009] It is an object of the invention to provide a binder suitable for use in a metallurgical powder mixture.

[0010] There is provided herein a metallurgical powder composition comprising a metal powder and from about 0.01 to about 3 wt. % of a specific binder based on the total weight of the metallurgical powder composition. Preferably the specific binder is from about 0.05% to about 1.5% of the weight of the metallurgical powder composition. This binder may be admixed to the metal powder in a solid state (commuted, usually as a powder) and subsequently melted to bind the secondary powders to the primary powder. It can also be admixed in emulsion, or in solution or in the melted state. The metallurgical powder composition may further comprise other solid lubricants or binders to improve the compressibility, lubrication performance, flowability, and/or the segregation of the metallurgical powder composition.

[0011] Typically, the metal powder is an iron-based powder. Examples of iron-based powders are pure iron powders, powders of iron pre-alloyed with other alloying elements, and powders of iron to which such other elements have been diffusion-bonded. The metallurgical powder compositions may further contain powders of such alloying elements in the amount of up to 15 wt. % of said metallurgical powder composition. Examples of alloying elements include, but are not limited to, elemental copper, nickel, molybdenum, manganese, phosphorous, metallurgical carbon (graphite) and alloys of the above with or without iron.

[0012] The specific binder of the invention is a styrene/maleic anhydride copolymer and/or one of its derivatives. In some embodiments the copolymer binder of the invention are soluble in standard solvents. Derivatives include, but are not limited to, partially esterified styrene/maleic anhydride copolymers and styrene/maleic imide copolymers, and mixtures thereof. The copolymer binder of the invention may have a styrene/maleic anhydride ratio that provides a glass transition temperature above the compaction temperature.

[0013] Metallurgical powder compositions of the invention can be compacted in a die to produce a green piece. The green piece can subsequently be heat treated at temperatures below 500° C. and/or sintered according to standard powder metallurgy techniques to produce a part.

[0014] The use of styrene/maleic anhydride copolymer, or one of its derivatives as a binder for metallurgical powder compositions is also provided.

[0015] A method of producing a compactable metallurgical powder composition is also provided. The method involves adding from about 0.01 wt. % to about 3 wt. % of one of a styrene/maleic anhydride copolymer and a deriva-

tive thereof to a metallurgical powder mixture, to produce a compactable metal powder composition. The method may further involve steps of: compacting to form a green piece, by either warm or cold compaction; curing the green piece to allow for green machining and/or sintering the green piece (cured or not). The powder composition, compacted, cured green piece, and sintered output are part of the invention provided.

[0016] A kit comprising a styrene/maleimide copolymer and/or a derivative thereof having a molecular weight between about 1000 and 30000, a metallurgical powder composition, and instructions for carrying out the method.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Several binder-treated powder compositions were prepared and tested for the fabrication of ferrous compacts for P/M applications. Exemplary metal powders suitable for the purpose of the present invention include iron-based powders used in the P/M industry, such as pure iron powders, pre-alloyed iron powders and diffusion-bonded iron-based powders. Substantially any ferrous powder having a maximum particle size less than about 600 microns can be used in the composition of the invention. Typical ferrous powders are iron and steel powders including stainless steel and alloyed steel powders. ATOMET® steel powders manufactured by Quebec Metal Powders Limited of Tracy, Quebec, Canada are representative of such iron and steel powders. Typical ATOMET® powders contain in excess of 99.6 wt. % iron and pre-alloyed metals, less than 0.3 wt. % oxygen and less than 0.1 wt. % carbon, and have apparent density of 2.50 g/cm³ or higher, and a flow rate of less than 30 seconds per 50 g.

[0018] Optionally, the iron-based powders can be admixed with alloying powders in the amount of preferably less than 15 wt. %. Examples of alloying powders include, but are not limited to, elemental copper, nickel, molybdenum, manganese, phosphorous, metallurgical carbon (i.e. graphite) and alloys of the above, with or without iron.

[0019] Powder compositions of the invention include a specific binder in an amount from about 0.01 wt % to about 3 wt % based on the total weight of the composition, preferably from about 0.05 wt. % to about 1.5 wt. %. This specific binder may be admixed to the metal powder in a solid state (e.g. commuted to a powder) and subsequently melted to bind the secondary powders to the basic metal powder. It can also be admixed in emulsion, or in solution or in the melted state. The admixture may be carried out in a single operation or step, or in several steps. The composition may further comprise other solid lubricants or binders and/or flow agents to further improve the compressibility and lubrication performance, the flow and/or the segregation of the powder mix. Additionally, the composition may contain one or more additional binders that can chemically interact with the specific binder, or can give rise to an association product, also known as an interpolymer complex, by strong intermolecular acid-base interactions, in order to improve the strength of compacted parts, as disclosed in applicant's U.S. Pat. No. 5,980,603, which is incorporated herein by reference.

[0020] The specific binder is a styrene/maleic anhydride copolymer, and/or one or more of its derivatives. Derivatives
include, but are not limited to, partially esterified styrene/maleic anhydride copolymers (preferably 20 to 90%), esterified styrene/maleic anhydride copolymers and styrene-maleimide copolymers, and combinations of the above.

[0021] The copolymer binder has a weight-average molecular weight (Mw) between 1,000 and 30,000. In some embodiments the Mw of the binder is preferably between about 2,000 and 25,000, and in some embodiments is between about 5,000 and 10,000. In some embodiments the copolymer binder has a styrene/maleic anhydride ratio, between 1:1 and 8:1. In some instances, the styrene/maleic anhydride ratio is selected to provide a binder having a glass transition temperature between about 30 and 200°C, preferably less than about 150°C.

[0022] The copolymer binder of the invention is soluble in standard solvents, which makes it possible to prepare the binder-treated powder composition using spray coating techniques, or by other known techniques.

[0023] The copolymer binders of the invention can be produced by the polymerization of styrene and maleic anhydride. Partially esterified styrene/maleic anhydride copolymers are obtained by partial esterification of styrene/maleic anhydride copolymers with compounds containing hydroxyl functional groups. Styrene/maleimide copolymers can be obtained by reacting styrene/maleic anhydride copolymers with compounds containing primary amino functional groups. These copolymers bond the fine secondary powders to the basic powder, thus improving dust resistance of the metallurgical powder composition. These copolymers in conjunction with an additional binder provide improved green strength of the cured green piece according to the mechanisms explained in U.S. Pat. #5,980,603. Furthermore these copolymers dissolve in readily available solvents (such as acetone), and therefore can be applied to the metallurgical powder in a wide range of known techniques.

[0024] Examples of commercially available styrene/maleic anhydride copolymers that are suitable as P/M binders in accordance with the present invention include Sartomer’s styrene maleic anhydride copolymers and their derivatives, which are commercially available from Atolina. Esterification of the styrene/maleic anhydride copolymers makes the binder more hydrophobic, resulting in less sensitivity to high humidity levels, and improving solubility in numerous readily available solvents.

[0025] The metallurgical powder compositions of the invention can be compacted under conventional powder metallurgy conditions. The compacting pressures are typically lower than 85 tsi and more specifically between 10 and 60 tsi. The compacting temperature suitable with the compositions of the invention is below about 200°C, preferably below 180°C, and more preferably between 40 and 160°C.

EXAMPLE 1

Flow

[0026] Tests were conducted to evaluate the flowability of binder-treated blends containing different binders of the invention. In this example, a styrene/maleic anhydride copolymer (Sartomer SMA® 1440) and a partially esterified styrene/maleic anhydride copolymer (Sartomer SMA® EF-40) having weight-average molecular weights close to 7,000 and 10,000 respectively (available from Atolina) were evaluated as binders. These two binders are referred as S1 and S2 in the text. Two binder-treated powder compositions were prepared by dissolving 0.2 wt. % of the binders in a solvent, by mixing this solution with a powder mixture, using a known spray coating technique, and finally by evaporating the solvent. The powder mixture was 97.4 wt. % ATOMET 1001 steel powder (Quebec Metal Powders Ltd.), 0.6 wt. % graphite powder (South Western 1651), 2 wt. % copper powder (MD 165) and 0.55 wt. % of atomized ACRAWAX C powder from Lonza Inc. (EBS). The flowability of the two binder-treated powder compositions of this invention was compared with the that of a dry mixture, referred as Control Mix. The Control Mix consisted of 97.4 wt. % ATOMET 4201 steel powder (Quebec Metal Powders Ltd.), 0.6 wt. % graphite powder (South Western 1651) and 2 wt. % copper powder (MD 165) and 0.75 wt. % of atomized ACRAWAX C powder from Lonza Inc. (EBS). The apparent density (MPIF Standard 04) and flow rate (MPIF Standard 03) of the powder compositions were determined.

[0027] The results illustrated in Table 1 show that adding either styrene/maleic anhydride or esterified styrene/maleic anhydride copolymer binders to the dry mixture, produces powder compositions (the binder-treated Mixes 1 and 2) that are free flowing, whereas the Control mix itself is not free flowing, even though the control mix contains a same amount (0.75%) of organic content (lubricant), as the binder-treated Mixes 1 and 2.

<table>
<thead>
<tr>
<th>Binder</th>
<th>Apparent density g/cm³</th>
<th>Flow rate c/s/50 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control mix</td>
<td>No binder</td>
<td>*</td>
</tr>
<tr>
<td>Binder-treated mix 1 S1</td>
<td>2.90</td>
<td>33</td>
</tr>
<tr>
<td>Binder-treated mix 2 S2</td>
<td>2.90</td>
<td>35</td>
</tr>
</tbody>
</table>

* Due to its non free flowing character, it cannot be measured according to MPIF standard 04

EXAMPLE 2

Flow and Separatory Properties

[0028] Tests were conducted to evaluate the binding efficiency of the binder of the invention. In this example, a partially esterified styrene/maleic anhydride copolymer having a weight-average molecular weight close to 7,000 (Sartomer SMA® 1440) was evaluated as a binder. A binder-treated metallurgical powder composition (Binder-treated
Mix) was prepared by dissolving 0.35 wt. % of the partially esterified styrene/maleic anhydride binder in a solvent, by mixing this solution with a powder mixture, using a known spray coating technique, and finally by evaporating the solvent. The powder mixture was 97.08 wt. % ATOMET 4201 steel powder (Quebec Metal Powders Ltd.), 0.92 wt. % graphite powder (South Western 1651), 2 wt. % copper powder (SCM 500RL) and 0.65 wt. % of atomized ACRA-WAX C powder from Lonza Inc. (EBS). The dusting resistance of this binder-treated powder composition was compared with the behavior of a dry mixture, referred as Control Mix. Control Mix consisted of 97.08 wt. % ATOMET 4201 steel powder (Quebec Metal Powders Ltd.), 0.92 wt. % graphite powder (South Western 1651) and 2 wt. % copper powder (MD 165) and 0.75 wt. % of atomized ACRA-WAX C powder from Lonza Inc. (EBS). The apparent density (MPIF Standard 04) and flow rate (MPIF Standard 05) of the powder compositions were also determined. Finally, the effect of humidity on the flow and the apparent density of the binder-treated powder composition of the invention were also evaluated.

[0029] The effect of the binder of the invention on the graphite and copper dusting resistances were determined by fluidization with a stream of gas (in this case air). Air was directed at a constant flow rate of 6.0 liters/minute for ten minutes at the bottom of a 2.5 cm diameter tube in which the test material was placed. This causes finer secondary powders, such as graphite, to be entrained, as a result of a large surface-to-volume ratio, and low specific gravity (in the case of graphite), and to be deposited in the dust collector. The mixture remaining on the screen plate was then analyzed to determine the relative amount of carbon and copper, which is a measure of the resistance to carbon and copper dusting when expressed as a percentage of the pre-test concentration. The apparent density and flow rate of the powder compositions were determined. The effect of humidity on the flow characteristic was assessed by measuring the apparent density of the powder compositions after exposure for 24 hours at a relative humidity (RH) of 90% and a temperature of 32°C. The flow rate was not measured during these experiments; only the attribute 'free' flow or 'no' flow was given to the powder composition.

[0030] As given in Table 2, the graphite and copper dusting resistances provided by the Binder-treated Mix is significantly improved as compared to the Control Mix containing no binder.

### Table 2

<table>
<thead>
<tr>
<th>Dusting resistance of the control and binder-treated mixes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphite dusting</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Control Mix</td>
</tr>
<tr>
<td>Binder-treated Mix</td>
</tr>
</tbody>
</table>

[0031] It can also be observed in respect of Table 3, that the flow rate of the binder-treated mix containing the binder of the invention is significantly improved compared to the Control Mix containing no binder. A significantly lower apparent density is also measured with the Control Mix.

### Table 3

<table>
<thead>
<tr>
<th>Relative Humidity (90%) - Temperature (25°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent density g/cm³</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Control mix</td>
</tr>
<tr>
<td>Binder-treated mix</td>
</tr>
</tbody>
</table>

[0032] As shown in Table 4, the Binder-treated Mix containing the binder of the invention remains free flowing after exposure for 24 hours at a humidity level of 90%. It will be also noted that the high relative humidity level does not affect the apparent density of the metallurgical composition containing the partially esterified styrene/maleic anhydride binder.

### Table 4

<table>
<thead>
<tr>
<th>Physical properties of the binder-treated mix at high relative humidity level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Humidity (90%) - Temperature (35°C)</td>
</tr>
<tr>
<td>Apparent density g/cm³</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Binder-treated mix</td>
</tr>
</tbody>
</table>

### Example 3

Effect of Heat Treatment

[0033] In a third example, a partially esterified styrene/maleic anhydride copolymers having a weight-average molecular weight close to 7,000 (Saritomer SMA® 1440) was evaluated as a binder. Three powder compositions were prepared. The first powder composition was prepared by mixing 97.4 wt. % ATOMET 4601 steel powder (Quebec Metal Powders Ltd.) with 0.6 wt. % graphite powder (South Western 1651) and 2 wt. % copper powder (MD165) and 0.75 wt. % of atomized ACRA-WAX C powder from Lonza Inc. This dry mixture is called REF Mix. The second powder composition was prepared by dry mixing 97.4 wt. % ATOMET 4601 steel powder (Quebec Metal Powders Ltd.) with 0.6 wt. % graphite powder (South Western 1651) and 2 wt. % copper powder (SCM 500RL) and 0.4 wt. % of oxidized polyethylene homopolymer lubricant powder (Acumist A6 from Honeywell). This dry mixture is called Control Mix. The third powder composition was prepared by dissolving in a solvent 0.1 wt. % of the same partially esterified styrene/maleic anhydride binder described in example 1, by mixing the binding solution with the dry mixture called Control mix, and by evaporating the solvent. This third powder composition is called Binder-treated Mix.

[0034] Rectangular bars (3.175x1.270x0.635 cm) were pressed at 25°C C. and 45 tsi in a floating compaction die. Some bars were heat treated in air at 175°C for 1 hour. Other bars were sintered in a 90% nitrogen based atmosphere at 112°C for 30 minutes. Cured green densities and mechanical strengths (transverse rupture strength (TRS) according to MPIF 15 Standard) were evaluated. The appar-
ent density (MPIF Standard 04) and flow rate (MPIF Standard 03) of the powder compositions were also determined. The results are reported in Tables 5, 6 and 7.

**TABLE 5**

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Apparent density g/cm³</th>
<th>Flow rate s/50 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref Mix</td>
<td>2.97</td>
<td>36</td>
</tr>
<tr>
<td>Control mix</td>
<td>2.97</td>
<td>No Flow</td>
</tr>
<tr>
<td>Binder-treated mix</td>
<td>2.97</td>
<td>36</td>
</tr>
</tbody>
</table>

*Due to its non free flowing character, it cannot be measured according to MPIF standard 04

**TABLE 6**

| Physical and mechanical properties of the dry and binder-treated mixes after curing. |
|--------------------------------------|------------------|
| Green density g/cm³ | Green strength after curing at 175°C |
| Ref Mix | 7.06 | 2575 |
| Control mix | 7.06 | 7000-8000 |
| Binder-treated mix | 7.06 | 7000-8000 |

**TABLE 7**

<table>
<thead>
<tr>
<th>Sintered properties of the dry and binder-treated mixes after sintering.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref Mix</td>
</tr>
<tr>
<td>TRS after sintering, psi</td>
</tr>
<tr>
<td>Sintered density g/cm³</td>
</tr>
<tr>
<td>Dimensional change from die size (%)</td>
</tr>
</tbody>
</table>

The results illustrated in Table 5 show that adding esterified styrene/maleic anhydride copolymer binder to the Control Mix, produces a powder composition (the binder-treated Mix) that is free flowing, whereas the Control mix itself is not free flowing. In addition, while exhibiting a green density similar to the Ref Mix containing the EBS powder, the binder-treated mix yield parts having similar high cured green strength (after curing at 175°C during 1 hour) to that of the Control mix shown in Table 6.

The fact that the control and binder-treated mixes containing the oxidized polyethylene homopolymer powder have a higher cured green strength than conventional powder compositions containing, for example EBS powder, may be attributed to the polymer flowing into open pores during the heat treatment, leading to a network of lubricant sufficiently strong to enhance the cured green strength.

The powder composition containing the binder of the invention has the advantage of being free flowing while maintaining a high cured green strength after curing at moderate temperature. Finally, as shown in Table 7, the binder of the invention does not hinder the sintering process of powder metallurgical compositions. Indeed, the mechanical strength after sintering the binder-treated mix is similar to that of the dry REF mix containing the EBS powder.

The invention has therefore been described in relation to a novel binder, a metallurgical powder composition including the binder, a compact, and a cured green piece formed therefrom, and a sintered metal piece product. A method of producing the above is also described.

1. A metallurgical powder composition comprising a metal powder and from about 0.01% to about 3% of the weight of the metal powder of one of a styrene/maleic anhydride copolymer binder and a derivative thereof.
2. The composition of claim 1 wherein the content of said copolymer is from 0.05 wt. % to about 1.5 wt. %.
3. The composition of claim 1 further comprising an alloying element powder in the amount of up to about 15 wt. % of the composition.
4. The composition of claim 3 wherein said alloying element is one or more selected from the group consisting of elemental copper, nickel, molybdenum, manganese, phosphorus, metallurgical carbon and alloys of the above, with or without iron.
5. The composition of claim 1.1 further comprising a lubricant.
6. The composition of claim 1 further comprising a second binder.
7. The composition of claim 6 wherein the second binder is selected to chemically interact with the styrene/maleic anhydride copolymer binder to produce an association product, by strong intermolecular acid-base interactions.
8. The composition of claim 1 wherein said copolymer is a partially esterified styrene/maleic anhydride copolymer.
9. The composition of claim 1 wherein said copolymer is a styrene/maleimide copolymer.
10. The composition of claim 1 wherein said copolymer has a weight-average molecular weight between 1,000 and 30,000.
11. The composition of claim 8 wherein said copolymer has a weight-average molecular weight between 5,000 and 10,000.
12. The composition of claim 1 wherein said copolymer has a glass transition temperature between 30 and 200°C.
13. The composition of claim 1 wherein said copolymer has styrene/maleic anhydride ratios between 1:1 and 8:1.
14. The composition according to claim 1 wherein said ferrous powder has a maximum particle size less than about 600 microns.
15. The composition according to claim 1 adapted to be compacted at temperatures below 200°C in a die to form parts that are subsequently heat treated at temperatures below 500°C and/or sintered according to standard powder metallurgy techniques.
16. A use of styrene/maleic anhydride copolymer and/or a derivative thereof, as a binder for binding a metallurgical powder mixture to form a compactable metal powder composition.
17. The use according to claim 16 wherein from about 0.01 wt. % to about 3 wt. % of the styrene/maleic anhydride copolymer or derivative is added to the metallurgical powder mixture.
18. A method of producing a compactable metal powder composition, the method comprising:
   providing a metallurgical powder mixture; and
   adding from about 0.01 wt. % to about 3 wt. % of a styrene/maleic anhydride copolymer and/or a derivative thereof to the metallurgical powder mixture, to produce a compactable metal powder composition.
20. A method of producing a green piece, the method comprising:
   placing a compactable metal powder composition according to claim 1 in a die;
   pressing the compactable metal powder composition to form a green piece.
21. The method according to claim 20 wherein pressing is applied at a temperature below 200 degrees Celsius.
22. The method according to claim 20 further comprising curing the green piece at a temperature below 500 degrees Celsius.
25. A method of producing a metal piece, the method comprising sintering the green piece according to claim 20.
26. A method of producing a metal piece, the method comprising sintering the green piece according to claim 22.
27. A kit comprising:
   a styrene/maleic anhydride copolymer or a derivative thereof having a molecular weight between about 1,000 and 30,000;
   a metallurgical powder composition; and
   instructions for carrying out the method of claim 17.

* * * * *