SYSTEMS AND METHODS FOR PRODUCING HARDWEARING AND IMPACT-RESISTANT ALLOY STEEL

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ABSTRACT

Described herein are systems and methods for producing a hardwearing or wear-resistant alloy steel. In one aspect, a first group of materials comprising steel may be heated, and melted to liquid form. The melted first group may then be mixed with a second group of materials comprising carbon, chromium, nickel, manganese, silicon, molybdenum, titanium, rhenum, sulfur, and phosphorus, to yield a mixture. The mixture may then be cast, cooled, and heat-treated to yield the hardwearing or wear-resistant alloy steel.
Fig. 1
SYSTEMS AND METHODS FOR PRODUCING HARDWEARING AND IMPACT-RESISTANT ALLOY STEEL

[0001] This non-provisional application claims the benefit of priority to U.S. Provisional Patent Application No. 62/256,768, filed Nov. 18, 2015, which is expressly incorporated herein by reference.

FIELD OF THE DISCLOSURE

[0002] The embodiments relate generally to systems and methods for preparing hardwearing and impact-resistant alloy steel and, more specifically, systems and methods for producing alloy steel that is both impact-resistant and more wear-resistant than currently available composite steel.

BACKGROUND

[0003] In many contexts, including construction, mining, and industrial settings, heavy wear on equipment and/or machine components is an unavoidable reality. To extend the useful life of these components, they may be produced from hardwearing or wear-resistant materials. These hardwearing materials exhibit specific properties that enable them to withstand one or more forms of wear, including but not limited to, abrasion, stress, impact, fatigue, and corrosion.

[0004] Research and development surrounding the production of hardwearing materials has been steadily gaining in popularity for many years as new applications for the materials are found. Such materials are commonly incorporated into industrial and/or construction equipment, including heavy equipment, northeastern linemen, railway wheels, bucket teeth, helical blades, mixers, shovels, and pavers, just to name a few examples. Hardwearing materials have also been implemented in the context of composite pipes and roll machinery parts. Moreover, with the continual improvement and optimization of processes for producing these wear-resistant materials, they will only gain in popularity and be used in other contexts.

[0005] In fact, industry participants anticipate that the hardwearing materials market will grow steadily over the next decade and beyond. This growth will be propelled by the world’s ever-rising population and the corresponding need for infrastructure, which will result in higher demand for energy, railways, highways, transportation, housing, etc. Consequently, there will be a great need for construction and industrial equipment and components comprising hardwearing materials. For example, in 2019 alone, more than 15 million tons of wear-resistant material was used to produce excavator bucket teeth and more than 16 million tons of wear-resistant material was used for trash pump parts and piping.

[0006] Nonetheless, currently available hardwearing materials fail to exhibit satisfactory wear-resistant properties, particularly when subjected to harsh environments. When wearing parts fail or are in need of replacement, entire production lines may be shut down and/or equipment may be taken out of use. Thus, not only are losses incurred due to the direct cost of replacing the parts, but the loss resulting from reduced productivity or downtime can be significant.

[0007] Wear-resistant properties, lifetime, and price are the three main criteria used in the assessment and selection of hardwearing materials and corresponding hardwearing components. As demands for these hardwearing components increase and manufacturing technology improves, the desire for lower cost, longer lasting, and more wear-resistant materials will continue to grow.

[0008] Accordingly, systems and methods could benefit from improved devices and techniques for developing hardwearing materials and manufacturing hardwearing components. In particular, improved techniques and materials are needed to meet the demands of today’s economy, including the need for lower-cost, longer-lasting, and/or more wear-resistant materials, components, and equipment.

SUMMARY OF THE DISCLOSURE

[0009] In accordance with certain embodiments of the present disclosure, systems and methods for producing a hardwearing or wear-resistant material are disclosed. A process for producing wear-resistant alloy steel may comprise the melting of a first group of materials. In one embodiment, the first group of materials may comprise iron. In further embodiments, the first group of materials may use steel as an alternative material.

[0010] The first group of materials may then be mixed with a second group of materials to produce a mixture. The second group of materials may comprise carbon, chromium, nickel, manganese, silicon, molybdenum, titanium, rhenium, sulfur, and phosphorus.

[0011] In some embodiments, the mixture may then be insulated for a predetermined period of time and/or cooled to a solid state. In another embodiment, the mixture may be subject to a heat treating process to yield the wear-resistant and impact-resistant alloy steel.

[0012] Additional objects and advantages of the present disclosure will be set forth in part in the description which follows, and in part will become apparent from the description, or may be learned by practice of the disclosure. The objects and advantages of the disclosure will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

[0013] It is to be understood that both the foregoing general description and the following detailed description are illustrative and explanatory only and are not restrictive of the claims.

[0014] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments and together with the description, serve to explain the principles of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 depicts some aspects of an illustrative embodiment of a method as described herein.

[0016] FIG. 2 depicts some aspects of an illustrative embodiment of a material as described herein.

DESCRIPTION OF THE EMBODIMENTS

[0017] Disclosed herein are various embodiments of a system and method for producing a hardwearing or wear-resistant alloy steel. While the systems and methods described herein are primarily concerned with the development of hardwearing or wear-resistant alloy steel for use in a construction, mining, or industrial setting, one skilled in the art will appreciate that the systems and methods described below can be used in other contexts, including residential and commercial settings, or any other setting in which equipment or a component is exposed to wear.
[0018] Reference will now be made in detail to certain illustrative embodiments, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like items.

[0019] FIG. 1 depicts one illustrative embodiment of a method for producing a hardwearing material. In one aspect, the method comprises a series of mixing, heating, and cooling steps. At step 110, a first kind of material (the “Group A” materials) may be provided. In one embodiment, the Group A materials may comprise iron. In other embodiments, Group A may comprise alternative or additional materials.

[0020] At step 120, Group A may be subjected to a heating step. In one embodiment, an electromagnetic induction furnace may be used to heat Group A and melt the material. The electromagnetic induction furnace may comprise, for example, a small AC Electromagnetic Induction Furnace. Of course, an electromagnetic induction furnace is only one example of a device suitable for heating and/or melting Group A and any one or more suitable devices may be implemented in step 120. For example, one heating device or furnace may be used to pre-heat Group A and one or more additional heating devices or furnaces may be used to melt Group A.

[0021] In one aspect, regardless of whether the heating and melting of Group A is performed in one or more steps and/or using one or more heating devices or furnaces, Group A may be melted to liquid form.

[0022] At step 130, a second plurality of materials (the “Group B” materials) may be provided. In one embodiment, the Group B materials may comprise carbon (C), chromium (Cr), nickel (Ni), manganese (Mn), silicon (Si), molybdenum (Mo), titanium (Ti), rhenium (Re), sulfur (S), and phosphorus (P). In further embodiments, Group B may comprise alternative or additional materials.

[0023] In one embodiment, the percentage by mass of each of the materials within mixture 200 may be consistent with the ranges presented below in Table 1 or Table 2, wherein the rest percentage by mass may be iron. In alternative embodiments, the percentage by mass of one or more of the Group B materials may be greater or less than the ranges presented in Table 1 or Table 2.

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<tbody>
<tr>
<td>C</td>
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<td>0.65-0.78</td>
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<table>
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<th>TABLE 2</th>
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<tbody>
<tr>
<td>C</td>
</tr>
<tr>
<td>0.75-0.95</td>
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[0024] At step 150, the mixture 200 may be cast using a sandbox. Of course, a sandbox is only one device for casting mixture 140 and any one or more suitable devices may be implemented in step 150.

[0025] After casting, mixture 200 may be insulated for an amount of time. In one embodiment, the hot casted mixture 200 may be stored in an incubator for approximately 1 hour. Alternatively, mixture 200 may be insulated for an amount of time less than approximately 3 hours and longer than approximately 40 minutes. Of course, these insulation times are only illustrative of the possibilities and mixture 200 may be insulated for any suitable period of time.

[0026] Following step 150, casted mixture 200 may be cooled at step 160 to solidify the mixture. In one embodiment, casted mixture 200 may be cooled down naturally. Alternatively, casted mixture 200 may be cooled using any suitable one or more devices. In another aspect, casted mixture 200 may be cooled to approximately 21°C (70°F), i.e., approximately room temperature. Of course, such a temperature is only meant as illustrative and casted mixture 200 may be cooled to any suitable temperature at which casted mixture 200 solidifies, including a temperature between 21°C (70°F) and 30°C (86°F). In further embodiments, casted mixture 200 may be cooled to a temperature less than 21°C (70°F), including temperatures below 0°C (32°F).

[0027] At step 170, heat treatment may be applied to the casted mixture 200. In particular, a process comprising heating and cooling of the casted mixture 200 may be used to achieve one or more desired physical and/or mechanical properties through modification of its crystalline structure. The temperature, length of time, and rate of cooling after heat treatment may all impact the mixture’s properties. Among other things, the heat treatment may increase the strength or hardness, increase the toughness, improve the ductility, and/or maximize the corrosion resistance of casted mixture 200.

[0028] In one embodiment, the hardness of the casted mixture 200 may be controlled in the range of HB300 to HB450 for Table 1, and HB360 to HB420. Of course, such a range is only meant as illustrative and casted mixture 200 may be heat treating to any suitable hardness, including a hardness less than HB380 for Table 1 and HB360 for Table 2, or greater than HB450 for Table 1 and HB420 for Table 2.

[0029] FIG. 2 illustrates an embodiment of mixture 200 described above with respect to FIGS 1. As described above, mixture 200 may comprise iron 201, carbon 202, chromium 203, nickel 204, manganese 205, silicon 206, molybdenum 207, titanium 208, rhenium 209, sulfur 210, and phosphorus 211. In further embodiments, mixture 200 may comprise alternative or additional materials.
may be introduced into the Group A materials, Group B materials, or mixture 200, in order to influence the properties of the resulting hardwearing materials.

[0031] Other embodiments of the aforementioned systems and methods will be apparent to those skilled in the art from consideration of the specification and practice of this disclosure. It is intended that the specification and examples be considered as illustrative only, with the true scope and spirit of the disclosure being indicated by the following claims.

What is claimed is:

1. A process for producing a wear-resistant and impulse-resistant alloy steel, the process comprising:
   providing a first group of materials, the first group of materials comprising iron;
   providing a second group of materials, the second group of materials comprising carbon, chromium, nickel, manganese, silicon, molybdenum, titanium, rhenium, sulfur, and phosphorus;
   mixing the second group of materials with the first group of materials to produce a mixture; and
   casting the mixture to produce the wear-resistant and impulse-resistant alloy steel.

2. The process of claim 1, wherein the mixture comprises, by mass percentage, approximately 0.65% to 0.78% of carbon, approximately 2.2% to 2.8% of chromium, approximately 1.4% to 1.7% of nickel, approximately 0.6% to 1.1% of manganese, approximately 0.4% to 0.8% of silicon, approximately 0.5% to 0.7% of molybdenum, approximately 0.15% to 0.18% of titanium, approximately 0.10% to 0.12% of rhenium, approximately less than 0.035% of sulfur, and approximately less than 0.035% of phosphorus.

3. The process of claim 1, wherein the mixture comprises, by mass percentage, approximately 0.75% to 0.95% of carbon, approximately 2.2% to 2.5% of chromium, approximately 1.5% to 2.0% of nickel, approximately 0.6% to 1.1% of manganese, approximately 0.4% to 0.7% of silicon, approximately 0.5% to 1.0% of molybdenum, approximately 0.16% to 0.20% of titanium, approximately 0.10% to 0.14% of rhenium, approximately less than 0.035% of sulfur, and approximately less than 0.035% of phosphorus.

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