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(71) Applicant: **Honor Device Co., Ltd.**
Shenzhen, Guangdong 518040 (CN)

(72) Inventors:
• **CHEN, Lei**
Shenzhen, Guangdong 518040 (CN)
• **QIAO, Yandang**
Shenzhen, Guangdong 518040 (CN)

(74) Representative: **Gill Jennings & Every LLP**
The Broadgate Tower
20 Primrose Street
London EC2A 2ES (GB)

(54) **INJECTION MOLDED ALLOY MATERIAL AND PROCESSING METHOD**

(57) This application provides an injection molded alloy material and a processing method, so as to improve strength of the alloy material, thin a structure of a terminal product, reduce production costs of the product, and improve production efficiency of the product. The injection molded alloy material includes the following components: carbon (C) occupying $\leq 0.10\%$ of a total weight of the alloy material, nickel (Ni) occupying 4.5-8.5% of the total

weight of the alloy material, chromium (Cr) occupying 5.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 4.5-7.5% of the total weight of the alloy material, cobalt (Co) occupying 13.0-18.0% of the total weight of the alloy material, vanadium (V) occupying $\leq 1.0\%$ of the total weight of the alloy material, and a remaining component of iron (Fe).

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Description

[0001] This application claims priority to Chinese Patent Application No. 202210325044.6, filed with the China National Intellectual Property Administration on March 30, 2022, and entitled "INJECTION MOLDED ALLOY MATERIAL AND PROCESSING METHOD", which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to the field of terminal devices, and in particular, to an injection molded alloy material and a processing method.

BACKGROUND

[0003] As a terminal mobile phone is more and more functional and integrated, people are no longer satisfied with a screen size of about 6 inches. Foldable-screen mobile phones are beginning to appear in the public eye and are becoming one of main directions for future smartphone development. Foldable-screen mobile phones are generally thick and heavy, which affects consumer experience to some extent. A design and a structure of a built-in metal structural part of the foldable-screen mobile phone significantly affect a thickness and a weight of the mobile phone. Therefore, weight reduction and thinning of the built-in structure of the foldable-screen mobile phone are important research topics in the industry.

[0004] In the industry, miniature and complex structural parts in the foldable-screen mobile phone are mostly made of injection molded stainless steel, but strength of the stainless steel is relatively low (yield strength is less than 1300 MPa). As the structural parts of the mobile phone continue to be thinned, strength of an existing material is difficult to meet a requirement, and the material is prone to a failure such as fracture. However, for conventional high-strength profile steel (yield strength 2000 MPa), a method of smelting and casting + plastic processing is used to prepare a blank, and a miniature and complex structural part is produced by using a machining method, which is low in efficiency and high in costs. Therefore, development of injection molded ultrahigh-strength alloy materials attracts much attention in the industry.

SUMMARY

[0005] To resolve the foregoing technical problem, this application provides an injection molded alloy material and a processing method. By using the alloy material molded by using the component, strength of the alloy material can be improved, a structure of a terminal product is thinned, production costs of the product are reduced, and production efficiency of the product is improved.

[0006] According to a first aspect, an embodiment of this application provides an injection molded alloy material. The injection molded alloy material includes the following components: carbon (C) occupying $\leq 0.10\%$ of a total weight of the alloy material, nickel (Ni) occupying 4.5-8.5% of the total weight of the alloy material, chromium (Cr) occupying 5.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 4.5-7.5% of the total weight of the alloy material, cobalt (Co) occupying 13.0-18.0% of the total weight of the alloy material, vanadium (V) occupying $\leq 1.0\%$ of the total weight of the alloy material, and a remaining component of iron (Fe). The alloy material prepared by using the alloy components in this solution can be used to prepare an alloy structural part with yield strength of more than 1800 MPa, which is beneficial to thinning of the product, that is, a size of an entire structure can be reduced, and user experience can be improved. In addition, production costs can be reduced, and production efficiency can be improved.

[0007] Based on the first aspect, the injection molded alloy material provided in this embodiment of this application may further include the following components: carbon (C) occupying $\leq 0.02\%$ of a total weight of the alloy material, nickel (Ni) occupying 5.5-6.5% of the total weight of the alloy material, chromium (Cr) occupying 8.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 5.5-6.5% of the total weight of the alloy material, cobalt (Co) occupying 14.5-15.5% of the total weight of the alloy material, and a remaining component of iron (Fe). The alloy material prepared by using the alloy components in this solution can be used to prepare a metal structural part with yield strength of 1800 MPa, tensile strength of 1860 MPa, an elongation rate of 5.0%, hardness of 520 HV, and corrosion resistance of 4 h in a neutral salt spray test.

[0008] Based on the first aspect, the injection molded alloy material provided in this embodiment of this application may further include the following components: carbon (C) occupying $\leq 0.08\%$ of a total weight of the alloy material, nickel (Ni) occupying 4.5-5.5% of the total weight of the alloy material, chromium (Cr) occupying 7.5-8.5% of the total weight of the alloy material, molybdenum (Mo) occupying 4.5-5.5% of the total weight of the alloy material, cobalt (Co) occupying 13.0-13.5% of the total weight of the alloy material, and a remaining component of iron (Fe). The alloy material prepared by using the alloy components in this solution can be used to prepare a metal structural part with yield strength of 1830

MPa, tensile strength of 1940 MPa, an elongation rate of 4.5%, hardness of 570 HV, and corrosion resistance of 4 h in a neutral salt spray test.

[0009] Based on the first aspect, the injection molded alloy material provided in this embodiment of this application may further include the following components: carbon (C) occupying $\leq 0.08\%$ of a total weight of the alloy material, nickel (Ni) occupying 6.5-7.5% of the total weight of the alloy material, chromium (Cr) occupying 8.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 6.5-7.5% of the total weight of the alloy material, cobalt (Co) occupying 15.5-16.5% of the total weight of the alloy material, and a remaining component of iron (Fe). The alloy material prepared by using the alloy components in this solution can be used to prepare a metal structural part with yield strength of 1850 MPa, tensile strength of 1970 MPa, an elongation rate of 4.0%, hardness of 600 HV, and corrosion resistance of 4 h in a neutral salt spray test.

[0010] According to a second aspect, this application provides a processing method for an injection molded alloy material, including the following steps:

- step 1: preparing a high-strength steel powder, including: preparing an alloy material powder described above;
- step 2: mixing, including: preparing an injection feed; and mixing the alloy material powder in step 1 and a polymer binder in a kneader, and obtaining a feed after mixing;
- step 3: injection molding, including: performing injection molding by using an injection molding machine and an injection mold; and pouring the feed obtained in step 2 into the injection molding machine for injection molding, to obtain a green body;
- step 4: degreasing, including: removing the polymer binder; and performing degreasing on the injection molded green body in step 3;
- step 5: sintering and performing sintering densification by using a sintering device;
- step 6: shaping; and
- step 7: performing heat treatment.

[0011] The alloy components in the solutions of the first aspect are separately prepared according to the steps of the processing method, so that effects of the foregoing solutions can be implemented. Details are not described herein again.

[0012] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, a granularity specification of the alloy material powder in step 1 includes: a laser granularity D50: 5-20 μm , and a tap density $\geq 4.20 \text{ g/cm}^3$.

[0013] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, the alloy powder and the polymer binder are poured into a Σ -type kneader for mixing according to a volume ratio of 1.2: 1-2.3: 1 in step 2, where a mixing temperature is 160-210°C, and a mixing time is 1-4 h.

[0014] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, the alloy powder and the polymer binder are poured into a Σ -type kneader for mixing according to a volume ratio of 1.27: 1-1.78: 1 in step 2, where a mixing temperature is 160-210°C, and a mixing time is 1-4 h.

[0015] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, degreasing processing in step 4 includes performing acid catalyst catalytic degreasing or solvent degreasing treatment on the injection molded green body to remove the polymer binder, where a degreasing temperature is 120-130°C, a catalytic time is 1-10 h; and a catalytic medium is nitric acid or oxalic acid, and a protective atmosphere is nitrogen.

[0016] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, sintering in step 5 includes two steps; the first step includes: thermal degreasing, and a process of thermal degreasing includes: increasing a temperature in a furnace chamber from a room temperature to 500-800°C, and preserving the temperature at 500-800°C for 30-180 minutes; and the second step includes: heating the temperature in the furnace chamber from 500-800°C to 1200-1400°C, and preserving the temperature at 1200-1400°C for 60-360 minutes, where an atmosphere is vacuum, a protective atmosphere is argon, and a partial pressure of the argon is 10-50 KPa.

[0017] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, shaping in step 6 includes performing cold shaping on a sintered product.

[0018] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, heat treatment in step 7 includes solution treatment and aging treatment.

[0019] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, the solution treatment includes: heating a temperature in a furnace chamber from a room temperature to 800-1100°C, and preserving the temperature at 800-1100°C for 30-180 minutes, where an atmosphere is vacuum; and after temperature preserving is completed, using a high-pressure inert gas to rapidly cool the furnace chamber to a temperature below 100°C, where the inert gas is nitrogen or argon, and a pressure is $> 6 \text{ bar}$.

[0020] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, the aging treatment includes: heating a temperature in a furnace chamber from a room temperature to

400-600°C, and preserving the temperature at 400-600°C for 60-360 minutes, where an atmosphere is vacuum, and the furnace temperature is cooled after temperature preserving is completed.

[0021] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, heat treatment in step 7 further includes subzero treatment.

[0022] Based on the second aspect, in the processing method for an injection molded alloy material provided in this application, the subzero treatment includes: performing cryogenic insulation at a temperature lower than -90°C, and a time of the cryogenic insulation is greater than 2 h.

[0023] By using the processing method in this solution and combining the alloy components in the first aspect, a metal structural part whose yield strength reaches 1800 MPa can be prepared. In addition, production costs of the metal structural part can be reduced, and production efficiency of the metal structural part can be improved.

DESCRIPTION OF EMBODIMENTS

[0024] The following clearly and completely describes the technical solutions in the embodiments of this application with reference to the accompanying drawings in the embodiments of this application. Apparently, the described embodiments are some but not all of the embodiments of this application. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of this application without making creative efforts shall fall within the protection scope of this application.

[0025] The term "and/or" in this specification merely describes an association relationship for describing associated objects, and represents that three relationships may exist. For example, A and/or B may represent the following three cases: Only A exists, both A and B exist, and only B exists.

[0026] The terms "first", "second", and the like in the specification and claims of embodiments of this application are used to distinguish between different objects, and are not used to indicate a specific sequence of objects. For example, a first target object and a second target object are used to distinguish between different target objects, but are not used to describe a specific sequence of the target objects.

[0027] In the embodiments of this application, words such as "an example" or "for example" are used to represent giving an example, an illustration, or a description. Any embodiment or design solution described as "example" or "for example" in embodiments of this application should not be construed as being more preferred or advantageous than other embodiments or design solutions. Specifically, the words such as "example" or "for example" are used to present related concepts in a specific manner.

[0028] In the descriptions of embodiments of this application, unless otherwise specified, "a plurality of" means two or more. For example, a plurality of processing units refer to two or more processing units. A plurality of systems refer to two or more systems; and a plurality of systems refer to two or more systems.

[0029] An injection molded alloy material provided in embodiments of this application may be used to prepare structural parts of various types of terminals, and is particularly applied to a structural part of a foldable-screen style terminal. As a terminal mobile phone is more and more functional and integrated, a user is no longer satisfied with a screen size of about 6 inches. A mobile phone is used as an example. Based on a requirement of a user for a large screen, a foldable-screen mobile phone emerges accordingly. However, a structural part of a foldable-screen mobile phone (especially a rotating shaft) obtained after production and assembly by using an existing structural material is relatively thick and heavy as a whole, and user experience is affected to some extent. As a result, the mobile phone is relatively thick and heavy.

[0030] To resolve the problem that the structure of the foldable-screen mobile phone is thick and heavy, an injection molding manner of a stainless steel material is mostly used currently. However, yield strength of the existing stainless steel material is lower than 1300 MPa, that is, the strength of the existing stainless steel material is relatively low. With improvements to continuous thinning of the mobile phone structural part, it is difficult for the strength of the existing stainless steel material to meet a requirement, and the structural part molded by using the existing stainless steel material is prone to failure problems such as fracture. If the existing stainless steel material is replaced with conventional high-strength profile steel, and a product blank is prepared by sequentially performing smelting and casting and plastic processing, it is further necessary to produce a required miniature and complex structural part by using a machining method, and there is a problem of low production efficiency and high production costs. For example, if a 420 stainless steel powder is used, mixing, injection molding, degreasing, sintering, shaping, heat treatment, and surface treatment are sequentially performed, and finally, a 420 stainless steel structural part is molded. Yield strength of the 420 stainless steel structural part is 1300 MPa, and the molded structural part is prone to a failure problem of deformation or fracture. For example, heat treatment includes quenching and tempering. For example, if a 17-4PH stainless steel powder is used, mixing, injection molding, degreasing, sintering, shaping, heat treatment, and surface treatment are sequentially performed, and finally, a 17-4PH stainless steel structural part is molded. Yield strength of the 17-4PH stainless steel structural part is 1100 MPa, and the molded structural part also is prone to a failure problem of deformation or fracture. If high-strength profile steel is used, the high-strength profile steel is sequentially melted and cast and plastically processed

to obtain high-strength profile, and then CNC processing, heat treatment, and surface treatment are performed to finally mold a high-strength profile steel structural part. Yield strength of the high-strength profile steel structural part is 2000 MPa. Although the strength of the structural part is increased, machining costs are high, machining efficiency is low, and it is difficult to process a micro and three-dimensional structural part.

[0031] Based on this, embodiments of this application may provide an alloy material and a processing method that can improve product production efficiency, reduce product production costs, and increase yield strength of a structural part. Specifically, a solution of an injection molded alloy material in this application is as follows:

[0032] Embodiments of this application provide an injection molded alloy material, including the following components: carbon (C) occupying $\leq 0.10\%$ of a total weight of the alloy material, nickel (Ni) occupying 4.5-8.5% of the total weight of the alloy material, chromium (Cr) occupying 5.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 4.5-7.5% of the total weight of the alloy material, cobalt (Co) occupying 13.0-18.0% of the total weight of the alloy material, vanadium (V) occupying $\leq 1.0\%$ of the total weight of the alloy material, and a remaining component of iron (Fe). For example, the remaining component may further include impurities, for example, trace Mn and Si. The alloy material in this solution is sequentially subjected to a high-strength steel powder, mixing, injection molding, degreasing, sintering, shaping, heat treatment, and surface treatment, and finally a high-strength alloy structural part is molded. After the foregoing series of molding processes and heat treatment, yield strength of the high-strength alloy structural part may reach more than 1800 MPa, and hardness of a surface material and hardness of a core material may reach 500-650 HV

[0033] For example, a molding method for injection molding of an alloy material powder in this embodiment of this application includes but is not limited to powder making, mixing, injection molding, degreasing, sintering, and heat treatment. For example, heat treatment includes quenching and tempering.

[0034] For example, a structural shape of a metal part obtained by means of injection molding of the alloy material powder in this embodiment of this application is corresponding to a cavity structure of a used injection mold. The molding method of injection molding, which eliminates a need for subsequent machining or requires only a small amount of machining, makes it ideal for bulk preparation of miniature and complex three-dimensional mobile phone metal structural parts.

[0035] For example, a high-strength steel powder is prepared by using a high-pressure water atomization method or a gas atomization method. Specifically, a granularity feature D50 of the high-strength steel powder is 5-20 μm , and a tap density of the high-strength steel powder is $\geq 4.20 \text{ g/cm}^3$.

[0036] For example, a mixing process includes: pouring the high-strength steel powder and a polymer binder according to a volume ratio of 1.2:1-2.3:1 into a mixing machine for mixing. Specifically, a mixing temperature is 160°C-210°C, and a mixing time is 1-4 h. For example, the polymer binder may be at least one of polyformaldehyde, high-density polyethylene, polypropylene, paraffin, ethylene-vinyl acetate copolymer EVA, polymethyl methacrylate PMMA, stearic acid SA, or an antioxidant.

[0037] For example, the mixing process may alternatively include: pouring the high-strength steel powder and a polymer binder according to a volume ratio of 1.27:1-1.78:1 into a mixing machine for mixing. Specifically, a mixing temperature is 160°C-210°C, and a mixing time is 1-4 h. For example, the polymer binder mainly includes a main filler, a skeleton agent, and a lubricant/an activator. The main filler is polyoxymethylene, which accounts for 65-90% by weight. The skeleton agent is one or more of high-density polyethylene, polypropylene, and the like, and accounts for 5-25% by weight. The lubricant/the activator is one or more of ethylene-vinyl acetate copolymer EVA, polymethyl methacrylate PMMA, stearic acid SA, and the like, and accounts for 1-10% by weight.

[0038] For example, an injection molding process includes: performing injection molding by using an injection molding machine and an injection mold, to obtain a green body. Specifically, an injection temperature is 160°C-210°C.

[0039] For example, a degreasing process includes catalytic degreasing. Specifically, catalytic degreasing includes: performing acid catalyst catalytic degreasing or solvent degreasing on the injection molded green body to remove the polymer binder. For example, a degreasing temperature is 120-130°C, a catalytic degreasing time is 1-10 h, and a catalytic medium may be nitric acid or oxalic acid.

[0040] For example, a sintering process is defined as follows: Sintering includes two steps; the first step includes: thermal degreasing, and a process of thermal degreasing includes: increasing a temperature in a furnace chamber from a room temperature to 500-800°C, and preserving the temperature at 500-800°C for 30-180 minutes; and the second step includes: heating the temperature in the furnace chamber from 500-800°C to 1200-1400°C, and preserving the temperature at 1200-1400°C for 60-360 minutes, where an atmosphere is vacuum, a protective atmosphere is argon, and a partial pressure of the argon is 10-50 KPa.

[0041] For example, a heat treatment process includes: sequentially performing solution treatment and aging treatment. Specifically, the solution treatment includes: heating a temperature in a furnace chamber from a room temperature to 800-1100°C, and preserving the temperature at 800-1100°C for 30-180 minutes, where an atmosphere is vacuum; and after temperature preserving is completed, using a high-pressure inert gas to rapidly cool the furnace chamber to a temperature below 100°C, where the inert gas is nitrogen or argon, and a pressure is $> 6 \text{ bar}$. Specifically, the aging

treatment includes: heating a temperature in a furnace chamber from a room temperature to 400-600°C, and preserving the temperature at 400-600°C for 60-360 minutes, where an atmosphere is vacuum, and the furnace temperature is cooled after temperature preserving is completed.

[0042] For example, the heat treatment process may alternatively include: sequentially performing solution treatment, subzero treatment, and aging treatment. Content of solution treatment and aging treatment is the same as that in the previous solution, and details are not described herein again. In addition, the subzero treatment includes: performing cryogenic insulation at a temperature lower than -90°C, and a time of the cryogenic insulation is greater than 2 h.

[0043] The foregoing alloy material composition and molding method can be used to prepare an alloy structural part with yield strength of more than 1800 MPa, which is beneficial to thinning of the product, that is, a size of an entire structure can be reduced, and user experience can be improved. By using the injection molding process, the preparation method is relatively low in costs and high in production efficiency, and is suitable for bulk preparation of miniature and complex three-dimensional mobile phone metal structural parts. In addition, a sintered structural part has hardness of < 300 HV and yield strength of < 800 MPa, and is easy for product shaping.

[0044] Further, to further show an effect of the solution of the alloy powder and the processing method for the alloy powder, an embodiment of this application provides a specific molding process of the following first solution:

Step a1: Prepare a high-strength steel powder, that is, prepare an alloy material powder.

[0045] This step may include: preparing a metal powder by using a high-pressure water atomization method, and sieving an alloy powder raw material with a specific powder characteristic by using an airflow classification method. Components and characteristics of the alloy powder are specifically as follows:

1) A composition of the alloy powder includes: carbon (C) occupying $\leq 0.02\%$ of a total weight of the alloy material, nickel (Ni) occupying 5.5-6.5% of the total weight of the alloy material, chromium (Cr) occupying 8.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 5.5-6.5% of the total weight of the alloy material, cobalt (Co) occupying 14.5-15.5% of the total weight of the alloy material, and a remaining component of iron (Fe).

2) A granularity specification of the alloy powder includes: a laser granularity is D50: 8-10 μm , and a tap density is $\geq 4.60 \text{ g/cm}^3$.

[0046] Step a2: Perform mixing, that is, prepare an injection feed.

[0047] This step may include: pouring the alloy powder and a polymer binder according to a volume ratio 1.27: 1 into a Σ -type kneader for mixing, and obtaining a feed after mixing. A mixing temperature is 190°C, and a mixing time is 1 h. After mixing is completed, the feed obtained after the mixing is poured into a mixing extruder and extruded for granulation. For example, the polymer binder may include at least one of polyformaldehyde, high-density polyethylene, polypropylene, paraffin, ethylene-vinyl acetate copolymer EVA, polymethyl methacrylate PMMA, stearic acid, or an antioxidant. It should be noted that the polymer binder is used in a process of preparing and molding, degreasing is performed after subsequent molding to remove the polymer binder from a green body, and the polymer binder does not belong to a composition of a metal product.

[0048] Step a3: Perform injection molding.

[0049] This step may include: performing injection molding by using an injection molding machine and an injection mold, to obtain a green body. An injection temperature is 190°C. A cavity of a used injection molding mold is machined in advance into a shape nearly coupled to a structural part product.

[0050] Step a4: Perform degreasing, that is, remove the polymer binder.

[0051] This step may include: performing acid catalyst catalytic degreasing or solvent degreasing on the injection molded green body to remove the polymer binder. A degreasing temperature is 120°C, and a catalytic time is 2 h. A catalytic medium is nitric acid, and a protective atmosphere is nitrogen.

[0052] Step a5: Perform sintering.

[0053] This step may include: performing a sintering process by using a sintering device. Specifically, the sintering device is a vacuum batch furnace. The sintering process is as follows:

1) Thermal degreasing: A temperature in a furnace chamber is increased from a room temperature to 600°C, a heating time is 240 minutes, and a heating rate is 2.5°C/minute. The temperature is preserved at 600°C for 120 minutes, to ensure that the polymer binder can be fully decomposed and removed; and the protective atmosphere is nitrogen or argon.

2) Sintering: The temperature in the furnace chamber is heated from 600°C to 1360°C, the heating time is 270 minutes, and the heating rate is 2.7°C/minute. The temperature is preserved at 1360°C for 180 minutes; and the atmosphere is vacuum, the protective atmosphere is argon, and a partial pressure of argon is 15 KPa.

[0054] Step a6: Perform shaping.

[0055] This step may include: performing cold shaping on the sintered product to ensure a part size and shape accuracy.

[0056] Step a7: Perform heat treatment.

[0057] This step may include: performing solution treatment and aging treatment on a shaped product.

[0058] Specifically, a solution treatment device uses a vacuum high-pressure gas quenching furnace. Solution treatment includes:

1) The temperature in the furnace chamber is increased from the room temperature to 1050°C, the heating time is 200 minutes, and the heating rate is 4.5°C/minute. The temperature is preserved at 1050°C for 120 minutes; and the atmosphere is vacuum.

2) After temperature preserving is completed, using a high-pressure inert gas to rapidly cool the furnace chamber to a temperature below 30°C, where the inert gas is nitrogen or argon, and a pressure is 8 bar.

[0059] Specifically, an aging treatment device uses a vacuum heat treatment furnace. Aging treatment includes:

The temperature in the furnace chamber is increased from the room temperature to 530°C, the heating time is 120 minutes, and the heating rate is 4.5°C/minute. The temperature is preserved at 530°C for 240 minutes; and the atmosphere is vacuum.

[0060] According to the alloy material and the processing method in the first solution, a metal structural part with yield strength of 1800 MPa, tensile strength of 1860 MPa, an elongation rate of 5.0%, hardness of 520 HV, and corrosion resistance of 4 h in a neutral salt spray test.

[0061] Further, to further show an effect of the solution of the alloy powder and the processing method for the alloy powder, an embodiment of this application provides a specific molding process of the following second solution:

Step b1: Prepare a high-strength steel powder, that is, prepare an alloy material powder.

[0062] This step may include: preparing a metal powder by using a high-pressure water atomization method, and sieving an alloy powder raw material with a specific powder characteristic by using an airflow classification method. Components and characteristics of the alloy powder are specifically as follows:

1) A composition of the alloy powder includes: carbon (C) occupying $\leq 0.08\%$ of a total weight of the alloy material, nickel (Ni) occupying 4.5-5.5% of the total weight of the alloy material, chromium (Cr) occupying 7.5-8.5% of the total weight of the alloy material, molybdenum (Mo) occupying 4.5-5.5% of the total weight of the alloy material, cobalt (Co) occupying 13.0-13.5% of the total weight of the alloy material, and a remaining component of iron (Fe).

2) A granularity specification of the alloy powder includes: a laser granularity is D50: 10-12 μm , and a tap density is $\geq 4.80 \text{ g/cm}^3$.

[0063] Step b2: Perform mixing, that is, prepare an injection feed.

[0064] This step may include: pouring the alloy powder and a polymer binder according to a volume ratio 1.78: 1 into a Σ -type kneader for mixing, and obtaining a feed after mixing. A mixing temperature is 200°C, and a mixing time is 2 h. After mixing is completed, the feed obtained after the mixing is poured into a mixing extruder and extruded for granulation. For example, the polymer binder may include at least one of polyoxymethylene, high-density polyethylene, polypropylene, paraffin, stearic acid, and an antioxidant. It should be noted that the polymer binder is used in a process of preparing and molding, degreasing is performed after subsequent molding to remove the polymer binder, and the polymer binder does not belong to a composition of a metal product.

[0065] Step b3: Perform injection molding.

[0066] This step may include: performing injection molding by using an injection molding machine and an injection mold, to obtain a green body. An injection temperature is 200°C. A cavity of a used injection molding mold is machined in advance into a shape nearly coupled to a structural part product.

[0067] Step b4: Perform degreasing, that is, remove the binder.

[0068] This step may include: performing acid catalyst catalytic degreasing or solvent degreasing on the injection molded green body to remove the polymer binder. A degreasing temperature is 130°C, and a catalytic time is 4 h. A catalytic medium is oxalic acid, and a protective atmosphere is nitrogen.

[0069] Step b5: Perform sintering.

[0070] This step may include: performing a sintering process by using a sintering device. Specifically, the sintering device is a vacuum batch furnace. The sintering process is as follows:

1) Thermal degreasing: A temperature in a furnace chamber is increased from a room temperature to 600°C, a heating time is 240 minutes, and a heating rate is 2.5°C/minute. The temperature is preserved at 600°C for 120 minutes, to ensure that the polymer binder can be fully decomposed and removed; and the protective atmosphere is nitrogen/argon.

2) Sintering: The temperature in the furnace chamber is heated from 600°C to 1370°C, the heating time is 270 minutes, and the heating rate is 2.7°C/minute. The temperature is preserved at 1370°C for 180 minutes; and the

atmosphere is vacuum, the protective atmosphere is argon, and a partial pressure of argon is 30 KPa.

[0071] Step b6: Perform shaping.

[0072] This step may include: performing cold shaping on the sintered product to ensure a part size and shape accuracy.

[0073] Step b7: Perform heat treatment.

[0074] This step may include: performing solution treatment and aging treatment on a shaped product.

[0075] Specifically, a solution treatment device uses a vacuum high-pressure gas quenching furnace. Solution treatment includes:

1) The temperature in the furnace chamber is increased from the room temperature to 1100°C, the heating time is 200 minutes, and the heating rate is 4.5°C/minute. The temperature is preserved at 1100°C for 120 minutes; and the atmosphere is vacuum.

2) After temperature preserving is completed, using a high-pressure inert gas to rapidly cool the furnace chamber to a temperature below 100°C, where the inert gas is nitrogen or argon, and a pressure is 10 bar.

[0076] Specifically, an aging treatment device uses a vacuum heat treatment furnace. Aging treatment includes:

The temperature in the furnace chamber is increased from the room temperature to 540°C, the heating time is 120 minutes, and the heating rate is 4.5°C/minute. The temperature is preserved at 540°C for 240 minutes; and the atmosphere is vacuum. After temperature preserving is completed, a fan is opened to cool the furnace temperature.

[0077] According to the alloy material and the processing method in the second solution, a metal structural part with yield strength of 1830 MPa, tensile strength of 1940 MPa, an elongation rate of 4.5%, hardness of 570 HV, and corrosion resistance of 4 h in a neutral salt spray test.

[0078] Further, to further show an effect of the solution of the alloy powder and the processing method for the alloy powder, an embodiment of this application provides a specific molding process of the following third solution:

Step c1: Prepare a high-strength steel powder, that is, prepare an alloy material powder.

[0079] This step may include: preparing a metal powder by using a gas atomization method, and sieving an alloy powder raw material with a specific powder characteristic by using an airflow classification method. Components and characteristics of the alloy powder are specifically as follows:

1) A composition of the alloy powder includes: carbon (C) occupying $\leq 0.08\%$ of a total weight of the alloy material, nickel (Ni) occupying 6.5-7.5% of the total weight of the alloy material, chromium (Cr) occupying 8.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 6.5-7.5% of the total weight of the alloy material, cobalt (Co) occupying 15.5-16.5% of the total weight of the alloy material, and a remaining component of iron (Fe).

2) A granularity specification of the alloy powder includes: a laser granularity is D50: 12-14 μm , and a tap density is $\geq 4.90 \text{ g/cm}^3$.

[0080] Steps c2-c6 are the same as a2-a6 in the first solution, and details are not described herein again.

[0081] Step c7: Perform heat treatment.

[0082] This step may include: sequentially performing solution treatment, subzero treatment, and aging treatment on a shaped product.

[0083] Specifically, content of solution treatment and aging treatment is the same as that in the first solution, and details are not described herein again. In addition, a temperature of subzero treatment is -90°C, and the temperature is preserved for 4 h.

[0084] According to the alloy material and the processing method in the third solution, a metal structural part with yield strength of 1850 MPa, tensile strength of 1970 MPa, an elongation rate of 4.0%, hardness of 600 HV, and corrosion resistance of 4 h in a neutral salt spray test.

[0085] Further, to further show an effect of the solution of the alloy powder and the processing method for the alloy powder, an embodiment of this application provides a specific molding process of the following fourth solution:

[0086] Content of steps d1-d6 is the same as content of a1-a6 in the first solution, and details are not described herein again.

[0087] Step d7 includes that a temperature of aging treatment is 540°C. Remaining content is the same as content of a7 in the first solution, and details are not described herein again.

[0088] According to the alloy material and the processing method in the fourth solution, a metal structural part with yield strength of 1820 MPa, tensile strength of 1930 MPa, an elongation rate of 4.5%, hardness of 580 HV, and corrosion resistance of 4 h in a neutral salt spray test.

[0089] Further, to further show an effect of the solution of the alloy powder and the processing method for the alloy powder, an embodiment of this application provides a specific molding process of the following fifth solution:

Content of steps f1-f6 is the same as content of a1-a6 in the first solution, and details are not described herein again.

[0090] Step f7 includes that a temperature of aging treatment is 550°C. Remaining content is the same as content of a7 in the first solution, and details are not described herein again.

[0091] According to the alloy material and the processing method in the fifth solution, a metal structural part with yield strength of 1805 MPa, tensile strength of 1899 MPa, an elongation rate of 4.8%, hardness of 550 HV, and corrosion resistance of 4 h in a neutral salt spray test.

[0092] Product performance comparison of the five solutions is shown in Table 1.0 below:

Table 1.0

	Yield strength (MPa)	Tensile strength (MPa)	Elongation rate (%)	Hardness (HV)	Neutral salt spray (h)
Specific embodiment 1	1800	1860	5.0	520	4
Specific embodiment 2	1830	1940	4.5	570	4
Specific embodiment 3	1850	1970	4.0	600	4
Specific embodiment 4	1820	1930	4.5	580	4
Specific embodiment 5	1805	1899	4.8	550	4

[0093] In conclusion, an alloy composition of a structural part material is designed, combined with a matching molding process and a heat treatment system, to implement full dispersion strengthening of a maraging MIM steel reinforcement phase, so that yield strength of the material can reach 1800 MPa, and counter bending/extrusion resistance of a metal structural part of a mobile phone is greatly improved, and the metal structural part is thinned/weight-reduced. Specifically, an effect of an alloy element is as follows: A design of nickel element (Ni) content ensures not only plasticity and corrosion resistance of the material, but also sintering activity and stability. A design of cobalt element (Co) content can maintain high dislocation content of martensite, provide more nucleation positions of a second phase strengthening phase, precipitate more strengthening phases, and have higher strength. A design of molybdenum element (Mo) content: Molybdenum is a synthetic element of a main strengthening phase Fe₂Mo. High molybdenum content can provide more precipitated strengthening phases, and molybdenum can also improve corrosion resistance. A design of chromium element (Cr) content improves corrosion resistance.

[0094] To realize comprehensive mechanical properties of high strength and high toughness of alloy materials, and meet requirements of mass production processability, the carbon content is set to be less than 0.1%, so as to ensure that a main structure of a base material is lath-shaped martensite, which is conducive to toughness and plasticity of the material, stability of a sintering process, and shapability after sintering; and

a proper content proportion of nickel, chromium, cobalt, and molybdenum is set to ensure that the structure at a room temperature is mainly lath-shaped martensite, containing a small amount of residual austenite and a small amount of ferrite; a proper content proportion of nickel, chromium, cobalt, and molybdenum is set to ensure that a martensite formation temperature (Ms point) is higher than 20°C after rapid cooling; and a proper content proportion of cobalt and molybdenum is set to ensure sufficient dispersion strengthening phase formation on the base material after heat treatment.

[0095] The foregoing describes the embodiments of this application with reference to the accompanying drawings. However, this application is not limited to the foregoing specific implementations. The foregoing specific implementations are merely examples, and are not restrictive. Under the enlightenment of this application, many forms may be further made by a person of ordinary skill in the art without departing from the objective of this application and the protection scope of the claims and shall fall within the protection scope of this application.

Claims

1. An injection molded alloy material, comprising the following components: carbon (C) occupying $\leq 0.10\%$ of a total weight of the alloy material, nickel (Ni) occupying 4.5-8.5% of the total weight of the alloy material, chromium (Cr) occupying 5.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 4.5-7.5% of the total weight of the alloy material, cobalt (Co) occupying 13.0-18.0% of the total weight of the alloy material, vanadium (V)

occupying $\leq 1.0\%$ of the total weight of the alloy material, and a remaining component of iron (Fe).

2. The injection molded alloy material according to claim 1, comprising the following components: carbon (C) occupying $\leq 0.02\%$ of a total weight of the alloy material, nickel (Ni) occupying 5.5-6.5% of the total weight of the alloy material, chromium (Cr) occupying 8.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 5.5-6.5% of the total weight of the alloy material, cobalt (Co) occupying 14.5-15.5% of the total weight of the alloy material, and a remaining component of iron (Fe).

3. The injection molded alloy material according to claim 1, comprising the following components: carbon (C) occupying $\leq 0.08\%$ of a total weight of the alloy material, nickel (Ni) occupying 4.5-5.5% of the total weight of the alloy material, chromium (Cr) occupying 7.5-8.5% of the total weight of the alloy material, molybdenum (Mo) occupying 4.5-5.5% of the total weight of the alloy material, cobalt (Co) occupying 13.0-13.5% of the total weight of the alloy material, and a remaining component of iron (Fe).

4. The injection molded alloy material according to claim 1, comprising the following components: carbon (C) occupying $\leq 0.08\%$ of a total weight of the alloy material, nickel (Ni) occupying 6.5-7.5% of the total weight of the alloy material, chromium (Cr) occupying 8.5-9.5% of the total weight of the alloy material, molybdenum (Mo) occupying 6.5-7.5% of the total weight of the alloy material, cobalt (Co) occupying 15.5-16.5% of the total weight of the alloy material, and a remaining component of iron (Fe).

5. A processing method for an injection molded alloy material, comprising the following steps:

step 1: preparing a high-strength steel powder, comprising: preparing an alloy material powder according to any one of claims 1-4;

step 2: mixing, comprising: preparing an injection feed; and mixing the alloy material powder in step 1 and a polymer binder in a kneader, and obtaining a feed after mixing;

step 3: injection molding, comprising: performing injection molding by using an injection molding machine and an injection mold; and pouring the feed obtained in step 2 into the injection molding machine for injection molding, to obtain a green body;

step 4: degreasing, comprising: removing the polymer binder; and performing degreasing on the injection molded green body in step 3;

step 5: sintering and performing sintering densification by using a sintering device;

step 6: shaping; and

step 7: performing heat treatment.

6. The processing method according to claim 5, wherein the method further comprises: a granularity specification of the alloy material powder in step 1 comprises: a laser granularity D50: 5-20 μm , and a tap density $\geq 4.20 \text{ g/cm}^3$.

7. The processing method according to claim 5, wherein the method further comprises: pouring the alloy powder and the polymer binder into a Σ -type kneader for mixing according to a volume ratio of 1.2:1-2.3:1 in step 2, wherein a mixing temperature is 160-210°C, and a mixing time is 1-4 h.

8. The processing method according to claim 5, wherein the method further comprises: pouring the alloy powder and the polymer binder into a Σ -type kneader for mixing according to a volume ratio of 1.27:1-1.78:1 in step 2, wherein a mixing temperature is 160-210°C, and a mixing time is 1-4 h.

9. The processing method according to claim 5, wherein the method further comprises: degreasing processing in step 4 comprises performing acid catalyst catalytic degreasing or solvent degreasing treatment on the injection molded green body to remove the polymer binder, wherein a degreasing temperature is 120-130°C, a catalytic time is 1-10 h; and a catalytic medium is nitric acid or oxalic acid, and a protective atmosphere is nitrogen.

10. The processing method according to claim 5, wherein the method further comprises: sintering in step 5 comprises two steps; the first step comprises: thermal degreasing, and a process of thermal degreasing comprises: increasing a temperature in a furnace chamber from a room temperature to 500-800°C, and preserving the temperature at 500-800°C for 30-180 minutes; and the second step comprises: heating the temperature in the furnace chamber from 500-800°C to 1200-1400°C, and preserving the temperature at 1200-1400°C for 60-360 minutes, wherein an atmosphere is vacuum, a protective atmosphere is argon, and a partial pressure of the argon is 10-50 KPa.

11. The processing method according to claim 5, wherein the method further comprises: shaping in step 6 comprises performing cold shaping on a sintered product.
- 5 12. The processing method according to claim 5, wherein the method further comprises: heat treatment in step 7 comprises solution treatment and aging treatment.
- 10 13. The processing method according to claim 12, wherein the solution treatment comprises: heating a temperature in a furnace chamber from a room temperature to 800-1100°C, and preserving the temperature at 800-1100°C for 30-180 minutes, wherein an atmosphere is vacuum; and after temperature preserving is completed, using a high-pressure inert gas to rapidly cool the furnace chamber to a temperature below 100°C, wherein the inert gas is nitrogen or argon, and a pressure is > 6 bar.
- 15 14. The processing method according to claim 12, wherein the aging treatment comprises: heating a temperature in a furnace chamber from a room temperature to 400-600°C, and preserving the temperature at 400-600°C for 60-360 minutes, wherein an atmosphere is vacuum, and the furnace temperature is cooled after temperature preserving is completed.
- 20 15. The processing method according to any one of claims 12-14, wherein the method further comprises: heat treatment in step 7 further comprises subzero treatment.
- 25 16. The processing method according to claim 15, wherein the subzero treatment comprises: performing cryogenic insulation at a temperature lower than -90°C, and a time of the cryogenic insulation is greater than 2 h.
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/144213

A. CLASSIFICATION OF SUBJECT MATTER

C22C38/44(2006.01)i;C22C38/46(2006.01)i;C22C38/52(2006.01)i;B22F3/10(2006.01)i;B22F3/22(2006.01)i;B22F3/24(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: C22C B22F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS: CNTXT: VEN; USTXT: WOTXT: EPTXT: CNKI; ISL WEB OF SCIENCE; 万方, WANFANG; 超星读秀, CHAOXING DUXIU: 华为, 荣耀, 注射, 成型, 成形, 马氏体, 时效, 镍, 铬, 钼, 钴, Ni, Cr, Mo, Co, inject+, mold+, maraging, martensite, age, nickel, chrome, chromium, molybdenum, cobalt

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 115255348 A (JIANGSU GIAN TECHNOLOGY CO., LTD.) 01 November 2022 (2022-11-01) description, paragraphs 5-29	1-16
X	CN 114086055 A (HUAWEI TECHNOLOGIES CO., LTD. et al.) 25 February 2022 (2022-02-25) description, paragraphs 145-189	1-16
Y	CN 111299589 A (JIANGSU GIAN TECHNOLOGY CO., LTD.) 19 June 2020 (2020-06-19) description, paragraphs 5-33	1-16
Y	CN 111299588 A (JIANGSU GIAN TECHNOLOGY CO., LTD.) 19 June 2020 (2020-06-19) description, paragraphs 5-33	1-16
A	CN 113969378 A (VIVO COMMUNICATION TECHNOLOGY CO., LTD.) 25 January 2022 (2022-01-25) description, paragraphs 47-93	1-16

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/
CN)
China No. 6, Xitucheng Road, Jimenqiao, Haidian District,
Beijing 100088

Facsimile No. (86-10)62019451

Authorized officer

Telephone No.

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PCT/CN2022/144213

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	CN 113560576 A (SHENZHEN ELEMENT TECHNOLOGY CO., LTD.) 29 October 2021 (2021-10-29) description, paragraphs 6-16	1-16

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2022/144213

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CN	115255348	A	01 November 2022		None			
CN	114086055	A	25 February 2022		WO	2022041993	A1	03 March 2022
CN	111299589	A	19 June 2020		None			
CN	111299588	A	19 June 2020		None			
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CN	113560576	A	29 October 2021		None			

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

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