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(54) **ALUMINUM ALLOY FOR CASTING MOTOR ROTOR IN NEW ENERGY VEHICLE AND
PREPARATION METHOD THEREFOR**

(57) The present application belongs to the technical field of new energy vehicle motors, and discloses an aluminum alloy for casting a motor rotor in a new energy vehicle and a preparation method thereof. The aluminum alloy includes 0.05 wt%-0.06 wt% titanium, 0.04 wt%-0.06 wt% boron, 0.15 wt%-0.5 wt% silicon, 0.01 wt%-0.08 wt% iron, 0.5 wt%-0.7 wt% copper, 0.3 wt%-0.5

wt% magnesium, 0.01 wt%-0.2 wt% zinc, 0.02 wt%-0.12 wt% manganese, and the balance of aluminum. By adding new elements and adjusting the ratio of the elements, the strength of the cast aluminum alloy is enhanced, and meanwhile, the excellent electricity conductivity can also be kept.

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Description**TECHNICAL FIELD**

[0001] The present application relates to an aluminum alloy for casting a motor rotor in a new energy vehicle and a preparation method therefor, and belongs to the technical field of new energy vehicle motors.

[0002] This application claims priority to Chinese Patent Application No. 202111400150.8 filed with CNIPA on November 19, 2021 and entitled "ALUMINUM ALLOY FOR CASTING MOTOR IN NEW ENERGY VEHICLE AND PREPARATION METHOD THEREFOR", the entire content of which is incorporated herein by reference.

BACKGROUND

[0003] With intensification of energy problems and environmental pollution problems in the world, development of new energy vehicles has gradually become a mainstream of modern vehicle companies, and motor rotors in new energy vehicles are generally cast with pure aluminum, because aluminum has excellent electricity and heat conductivity, and low density, and meets the requirements of lightweight. The new energy vehicles develop rapidly and have higher and higher requirements for the motor rotors, for example, a cast aluminum alloy is required to be large in strength and high in elongation, and meanwhile is required to have good electricity conductivity, the speed of updating and iterating requirements for parameters such as strength is very high, and technological innovation needs to be carried out after one year and even six months to meet the latest standards.

[0004] In a traditional technology, a crystallization nucleus is increased mainly by adding titanium and boron, the strength of the alloy is improved, and iron, copper, magnesium and zinc have the effect of solid solution strengthening. However, strength, elongation and other parameters of the aluminum alloy prepared by adding aluminum titanium boron additives cannot meet the current needs still, in order to reduce production, research and development costs as much as possible, process adjustment is reduced generally as much as possible, but in formulation adjustment, the strength is often improved, but elongation, electricity conductivity and other parameters are sacrificed, and it is difficult for all aspects of performance to be improved synchronously and to be in a good range.

SUMMARY

[0005] In order to solve the above problems, an aluminum alloy for casting a motor rotor in a new energy vehicle and a preparation method thereof are provided. By adding new elements and adjusting the ratio of the elements, the strength of the cast aluminum alloy is enhanced significantly, and meanwhile, the excellent electricity conductivity can also be kept.

[0006] According to one aspect of the present application, an aluminum alloy for casting a motor rotor in a new energy vehicle is provided. The aluminum alloy includes 0.05 wt%-0.06 wt% titanium, 0.04 wt%-0.06 wt% boron, 0.15 wt%-0.5 wt% silicon, 0.01 wt%-0.08 wt% iron, 0.5 wt%-0.7 wt% copper, 0.3 wt%-0.5 wt% magnesium, 0.01 wt%-0.2 wt% zinc, 0.02 wt%-0.12 wt% manganese, and the balance of aluminum.

[0007] Optionally, tensile strength of the aluminum alloy is in a range from 80 MPa to 95 MPa.

[0008] Optionally, tensile strength of the aluminum alloy is in a range from 85 MPa to 95 MPa.

[0009] Optionally, yield strength of the aluminum alloy is in a range from 60 MPa to 80 MPa.

[0010] Optionally, elongation of the aluminum alloy is in a range from 45% to 55%.

[0011] Optionally, electricity conductivity of the aluminum alloy is in a range from 30 MS/m to 33 MS/m.

[0012] Optionally, the aluminum alloy is composed of 0.05 wt%-0.06 wt% titanium, 0.04 wt%-0.06 wt% boron, 0.15 wt%-0.5 wt% silicon, 0.01 wt%-0.08 wt% iron, 0.5 wt%-0.7 wt% copper, 0.3 wt%-0.5 wt% magnesium, 0.01 wt%-0.2 wt% zinc, 0.02 wt%-0.12 wt% manganese, and the balance of aluminum.

[0013] Optionally, the aluminum is high purity aluminum, and the high purity aluminum is pure aluminum with purity greater than 99.8%. 0.2% unavoidable impurities in the high purity aluminum will not affect the technical effect of the present application.

[0014] According to yet another aspect of the present application, a preparation method of the above aluminum alloy for casting the motor rotor is provided and includes the following steps: (1) melting an aluminum ingot, adding each elemental constituent, and performing even stirring; and (2) preheating a rotor cavity, and performing centrifugal casting to prepare the aluminum alloy for casting the motor rotor.

[0015] Optionally, a temperature in step (1) is in a range from 700°C to 760°C, and a preheating temperature in step (2) is in a range from 680°C to 720°C.

[0016] Beneficial effects of the present application include but are not limited to:

1. According to the aluminum alloy for casting the motor rotor in the present application, titanium and boron can enhance a crystallization nucleus and refine grains, but if excessive titanium and boron are added, a second phase

formed by titanium and boron will increase, and there will be too much migration focusing, which will significantly reduce the electricity conductivity. Titanium in the present application is limited to 0.05 wt%-0.06 wt%, boron is limited to 0.04 wt%-0.06 wt%, the titanium content is increased significantly, final strength is improved significantly, but the good electricity conductivity may be still maintained, because the present application newly adds the manganese element, limited to 0.02 wt%-0.12 wt%, and meanwhile reduces the content of the iron element, limited to 0.01 wt%-0.08 wt%, and microalloying of manganese can improve the strength and meanwhile change a microscopic phase of iron, so that iron changes from an original needle-like form to a block shape, a harmful effect of iron is neutralized, and meanwhile the elongation and electricity conductivity of the alloy are improved.

2. According to the aluminum alloy for casting the motor rotor of the present application, magnesium is limited to 0.3 wt%-0.5 wt%, which significantly increases the content of the magnesium element, silicon is limited to 0.15 wt%-0.5 wt%, which improves the content of silicon, casting performance and corrosion resistance are improved, the tendency of welding cracks is reduced, and part of magnesium also plays a role of solid solution strengthening. The other part of magnesium can form a new heterogeneous crystal nucleus with a high content of silicon to form a Mg_2Si phase, which is conducive to crystallization refinement and further improves the tensile strength and yield strength.

3. According to the aluminum alloy for casting the motor rotor of the present application, copper is also limited to 0.5 wt%-0.7 wt%, which significantly increases the copper content and enhances the precipitation strengthening effect. A high content of copper and aluminum can form more $\theta-CuAl_2$ precipitation strengthening phases, excess magnesium and excess copper can also form a part of $S-CuMgAl_2$ precipitation strengthening phase with better strengthening, meanwhile, the dispersion of each precipitation phase is improved, a coarse brittle phase containing manganese and a grain boundary mesh-shaped brittle phase are eliminated, a keeping effect is reduced, and therefore, the alloy strength is improved.

4. According to the aluminum alloy for casting the motor rotor of the present application, the electricity conductivity is required to reach 30 MS/m or more to meet the needs, but existing manufacturers require the tensile strength of the motor rotor aluminum alloy to at least reach more than 70 MPa, 80 MPa and above according to different product levels, and the present application significantly improves the strength and other mechanical property parameters of the motor rotor aluminum alloy in a case of slightly reducing the electricity conductivity to make the electricity conductivity still meet the needs.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0017] The present application is detailed below in conjunction with embodiments, but the present application is not limited to these embodiments.

[0018] Unless otherwise specified, raw materials in embodiments of the present application are purchased commercially, a preparation method adopts existing centrifugal casting and melting processes, and other undisclosed parameters such as a stirring rate are parameters used in the prior art.

Embodiment 1: Preparation of aluminum alloy 1#

[0019] The composition of an aluminum alloy 1# is: 0.05 wt% titanium, 0.05 wt% boron, 0.2 wt% silicon, 0.05 wt% iron, 0.6 wt% copper, 0.4 wt% magnesium, 0.1 wt% zinc, 0.08 wt% manganese, and the balance of high purity aluminum, and the high purity aluminum is pure aluminum with purity greater than 99.8%.

[0020] A preparation method is: (1) an aluminum ingot is melted at 720°C, each elemental constituent is added, and even stirring is performed; and (2) a rotor cavity is preheated to 700°C, and a conventional centrifugal casting process is adopted to prepare the aluminum alloy 1# for casting a motor rotor.

Embodiment 2: Preparation of aluminum alloy 2#

[0021] The composition of an aluminum alloy 2# is: 0.05 wt% titanium, 0.04 wt% boron, 0.15 wt% silicon, 0.01 wt% iron, 0.5 wt% copper, 0.3 wt% magnesium, 0.05 wt% zinc, 0.02 wt% manganese, and the balance of high purity aluminum, and the high purity aluminum is pure aluminum with purity greater than 99.8%.

[0022] A preparation method is: (1) an aluminum ingot is melted at 700°C, each elemental constituent is added, and even stirring is performed; and (2) a rotor cavity is preheated to 680°C, and a conventional centrifugal casting process is adopted to prepare the aluminum alloy 2# for casting the motor rotor.

Embodiment 3: Preparation of aluminum alloy 3#

[0023] The composition of an aluminum alloy 3# is: 0.06 wt% titanium, 0.06 wt% boron, 0.5 wt% silicon, 0.08 wt%

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iron, 0.7 wt% copper, 0.5 wt% magnesium, 0.2 wt% zinc, 0.12 wt% manganese, and the balance of high purity aluminum, and the high purity aluminum is pure aluminum with purity greater than 99.8%.

[0024] A preparation method is as follows: (1) an aluminum ingot is melted at 760°C, and each elemental constituent is added, and even stirring is performed; and (2) a rotor cavity is preheated to 720°C, and a conventional centrifugal casting process is adopted to prepare the aluminum alloy 3# for casting the motor rotor.

Comparative examples 1-6: Preparation of aluminum alloys 4#-9#

[0025] Preparation methods of aluminum alloys 4#-9# are the same as the preparation method of the aluminum alloy 1#, and composition differences are shown in Table 1.

Table 1: Elementary composition (mass fraction wt%) of aluminum alloys 1#-9#

Elements Serial Number	Titanium	Boron	Silicon	Iron	Copper	Magnesium	Zinc	Manganese	Aluminum
1#	0.05	0.05	0.2	0.05	0.6	0.4	0.1	0.08	The balance is high purity aluminum
2#	0.05	0.04	0.15	0.01	0.5	0.3	0.05	0.02	
3#	0.06	0.06	0.5	0.08	0.7	0.5	0.2	0.12	
4#	0.01	0.01	0.06	0.1	0.005	0.004	0.005	0	
5#	0.05	0.05	0.2	0.05	0.6	0.4	0.1	0.01	
6#	0.05	0.05	0.2	0.05	0.6	0.4	0.1	0.15	
7#	0.05	0.05	0.2	0.1	0.6	0.4	0.1	0.08	
8#	0.05	0.05	0.2	0.05	0.6	0.1	0.1	0.08	
9#	0.05	0.05	0.2	0.05	0.2	0.4	0.1	0.08	

Embodiment 4: Property characterization of aluminum alloys 1#-9#

[0026] Aluminum alloys 1#-9# for casting the motor rotor are sampled respectively on their respective end faces, an electricity conductivity sample size meets the requirements of GB/T12966-2008, and an electricity conductivity test is carried out. A mechanical property test sample size meets ASTM E8, tensile property analysis is carried out, and mechanical property and electricity conductivity test results are shown in Table 2.

Table 2 Mechanical property and electricity conductivity test results of motor rotor aluminum alloys 1#-9#

Project Group	Tensile strength (MPa)	Yield strength (MPa)	Elongation (%)	Electricity conductivity (MS/m)
Aluminum alloy 1#	95	80	55	33
Aluminum alloy 2#	85	68	46	32.7
Aluminum alloy 3#	90	70	50	32.8
Aluminum alloy 4#	63	35	37	34
Aluminum alloy 5#	65	40	37	28
Aluminum alloy 6#	66	42	47	30
Aluminum alloy 7#	63	43	34	26
Aluminum alloy 8#	61	40	45	31
Aluminum alloy 9#	60	37	42	28

[0027] The results show that the aluminum alloys 1#-3# for casting the motor rotor prepared by using the elemental constituents defined by the present application have excellent tensile strength and yield strength, the maximum tensile strength can reach 95 MPa, the maximum yield strength can reach 80 MPa, the requirement that the latest manufacturer's tensile strength is 70 MPa and above is fully met, meanwhile, by adding a limited ratio of manganese element, the elongation is also significantly improved, the electricity conductivity can still meet the needs of 30 MS/m and above, the electricity conductivity is excellent, ratios of copper and magnesium elements are also limited, and the tensile strength, yield strength and elongation are significantly improved finally by scarifying a small amount of electricity conductivity, which meets the higher need for strength of the manufacturer, and may also ensure the excellent electricity conductivity of the aluminum alloy.

[0028] The aluminum alloy 4# is a formula in the prior art, and significantly differs from element types and ratios of the present application, the final results show that although the electricity conductivity of the aluminum alloy 4# is excellent, the strength and other mechanical properties cannot meet the latest needs, and the tensile strength and the yield strength are both low. The content of manganese in the aluminum alloy 5# is lower than the range limited by the present application, the final properties are far lower than those of the aluminum alloy 1#, and it is specifically analyzed that the amount of manganese is too little and cannot eliminate the harmful effect of iron; and the content of manganese in the aluminum alloy 6# is higher than the range limited by the present application, the final elongation and electricity conductivity are good, but the strength is not enough, it is analyzed that the amount of manganese is more, and more coarse brittle phases (Mn, Fe)Al₆ are generated, which ultimately affects the strength.

[0029] The content of iron in the aluminum alloy 7# exceeds the range limited by the present application, which ultimately indicates that its electricity conductivity is low, and the strength and other parameters are not up to standard; the content of magnesium in the aluminum alloy 8# is lower than the range limited by the present application, which ultimately indicates that its strength is not enough, and far lower than that of the aluminum alloy 1#; and the content of copper in the aluminum alloy 9# is lower than the range limited by the present application, which ultimately indicates that its parameters are not as good as those of the aluminum alloy 1#, and it is analyzed that the copper content cannot generate more precipitation strengthening phases.

[0030] The above are only embodiments of the present application, and the scope of protection of the present application is not limited by these specific embodiments, but is determined by the claims of the present application. For those skilled in the art, the present application may have various changes and variations. Any modification, equivalent replacement, improvement, etc. made within the technical ideas and principles of the present application shall be included in the scope of protection of the present application.

Claims

1. An aluminum alloy for casting a motor rotor in a new energy vehicle, comprising 0.05 wt%-0.06 wt% titanium, 0.04 wt%-0.06 wt% boron, 0.15 wt%-0.5 wt% silicon, 0.01 wt%-0.08 wt% iron, 0.5 wt%-0.7 wt% copper, 0.3 wt%-0.5 wt%

magnesium, 0.01 wt%-0.2 wt% zinc, 0.02 wt%-0.12 wt% manganese, and the balance of aluminum.

2. The aluminum alloy for casting the motor rotor according to claim 1, wherein tensile strength of the aluminum alloy is in a range from 80 MPa to 95 Mpa.
3. The aluminum alloy for casting the motor rotor according to claim 2, wherein tensile strength of the aluminum alloy is in a range from 85 MPa to 95 Mpa.
4. The aluminum alloy for casting the motor rotor according to claim 1, wherein yield strength of the aluminum alloy is in a range from 60 MPa to 80 Mpa.
5. The aluminum alloy for casting the motor rotor according to claim 1, wherein elongation of the aluminum alloy is in a range from 45% to 55%.
6. The aluminum alloy for casting the motor rotor according to claim 1, wherein electricity conductivity of the aluminum alloy is in a range from 30 MS/m to 33 MS/m.
7. The aluminum alloy for casting the motor rotor according to claim 1, composed of 0.05 wt%-0.06 wt% titanium, 0.04 wt%-0.06 wt% boron, 0.15 wt%-0.5 wt% silicon, 0.01 wt%-0.08 wt% iron, 0.5 wt%-0.7 wt% copper, 0.3 wt%-0.5 wt% magnesium, 0.01 wt%-0.2 wt% zinc, 0.02 wt%-0.12 wt% manganese, and the balance of aluminum.
8. The aluminum alloy for casting the motor rotor according to claim 7, wherein the aluminum is high purity aluminum, and the high purity aluminum is pure aluminum with purity greater than 99.8%.
9. A preparation method of an aluminum alloy for casting a motor rotor, wherein the method uses the elemental constituents according to the claim 1 and the method comprises the following steps:
 - (1) melting an aluminum ingot, adding each elemental constituent, and stirring evenly; and
 - (2) preheating a rotor cavity, and performing centrifugal casting to prepare the aluminum alloy for casting the motor rotor.
10. The preparation method according to claim 9, wherein the step (1) is performed at a temperature in a range from 700°C to 760°C, and a preheating temperature in step (2) is in a range from 680°C to 720°C.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/070557

A. CLASSIFICATION OF SUBJECT MATTER

C22C 21/18(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)

C22C

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)

WPI, EPODOC, CNPAT, CNKI, IEEE: 铝合金, 钛, Ti, 硼, B, 硅, Si, 铁, Fe, 铜, Cu, 镁, Mg, 锌, Zn, 锰, Mn, 铝, Al, aluminium w alloy, titanium, boron, silicon, iron, copper, magnesium, zinc, manganese

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 112853160 A (WEIRAN (NANJING) POWER TECHNOLOGY CO., LTD.) 28 May 2021 (2021-05-28) description, paragraphs [0004]-[0077]	1-10
A	CN 110592435 A (ANHUI XIN PLATINUM ALUMINUM ID. CO., LTD.) 20 December 2019 (2019-12-20) entire document	1-10
A	CN 110952002 A (FAN WEIZHONG) 03 April 2020 (2020-04-03) entire document	1-10
A	CN 110730827 A (ZOLLERN BHW GLEITLAGER GMBH & CO. KG) 24 January 2020 (2020-01-24) entire document	1-10
A	US 2019390301 A1 (BRUNEL UNIVERSITY LONDON) 26 December 2019 (2019-12-26) entire document	1-10

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

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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CN	110592435	A	20 December 2019	None			
CN	110952002	A	03 April 2020	None			
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REFERENCES CITED IN THE DESCRIPTION

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- GB 129662008 T [0026]