United States Patent [19]
Bichsel et al.

[11] 3,891,433
[45] June 24, 1975

[54] INDUCTION-TYPE REACTION RAILS FOR HIGH SPEED TRAINS

[75] Inventors: Heinz F. Bichsel, Neuhausen am Rheinfall; Peter Furrer, Neunkirch, both of Switzerland; Jörg Maier, Steisslingen, Germany

[73] Assignee: Swiss Aluminium Ltd., Chippis, Switzerland

[22] Filed: Feb. 12, 1974

[21] Appl. No.: 441,761

[30] Foreign Application Priority Data
Feb. 16, 1973 Switzerland 2323/73

[52] U.S. Cl. .... 75/147; 75/148; 148/2; 191/22 R; 191/22 DM; 238/122; 238/150
[51] Int. Cl. C22c 21/00; C22c 21/02; C22f 1/04
[58] Field of Search....... 29/180 CH; 148/2; 75/147, 75/148; 191/22 R, 22 DM, 29 R, 29 DM; 238/122, 150

[56] References Cited
UNITED STATES PATENTS

2,296,866	9/1942	Moss	75/138
2,572,562	10/1951	Harrington	75/147
3,222,464	12/1965	Dehn	191/22 DM
3,582,575	6/1971	Scofield	191/29 DM
3,699,275	10/1972	Mayo et al.	191/29 R
3,709,337	1/1973	Payen	191/22 R
3,733,696	5/1973	Scofield et al.	191/22 DM

Primary Examiner—W. Stallard
Attorney, Agent, or Firm—Ernest F. Marmorek

[57] ABSTRACT

Induction-type reaction rail which can be easily shaped and welded and has a high electrical resistance, for use in conjunction with linear motors which power high speed trains, being made out of an alloy with the composition 0.7–3.5 % Mn rest aluminium which has a purity of at least 99.5 % in particular with an maximum impurity content of 0.1 % Fe and 0.15 % Si. For the production of induction-type reaction rails the alloy is rapidly cooled from the melt by continuous casting then heated to a temperature of 300°–500°C prior to extrusion and then extruded to shape and the emerging section rapidly cooled.

8 Claims, No Drawings

INDUCTION-TYPE REACTION RAILS FOR HIGH SPEED TRAINS

The invention concerns reaction rails of the aluminium-manganese type of alloys which because of their low electrical conductivity are used in conjunction with linear motor propulsion for high speed trains, and concerns also a process for the production of these rails.

It is known that certain transition metals, if added in such small quantities that they are in solid solution in the aluminium, lower the conductivity of the aluminium. In the case of addition of manganese however, up to now it has been a disadvantage that, because of various precipitation events, the conductivity can not be predicted with certainty. In keeping with the present state of technological development therefore, it has been considered necessary in addition to manganese to add at least one of the transition elements zirconium, vanadium, titanium, chromium or zinc so that uniform results can be achieved. These alloys have been used for example for armatures or housings for motors and measurement discs for measuring electrical power consumption.

It is also known that on annealing aluminium-manganese alloys Al_6Mn precipitates form and that this precipitation event is favoured by the presence of Fe and/or Si in the alloy.

The object of the invention is to produce induction-type reaction rails with a specific electrical resistivity of more than 5 $\mu\Omega$ cm out of medium strength aluminium-manganese alloys which can be easily shaped and easily welded.

The object is achieved in terms of the invention in that the reaction rail is made from an alloy with the composition 0.7–3.5 % Mn, the rest being aluminium which has a purity of at least 99.5 % and in particular with maximum impurities of 0.1 % Fe and 0.15 % Si and that the alloy is quickly cooled from the melt by means of continuous casting, heated to a hot-forming temperature of 300°–500°C then shaped by extrusion and the emerging extruded section rapidly cooled. If increased strength is required then Mg either by itself or together with Si may be added to the composition.

The following advantages are achieved by the process of the invention:

The supposition that AlMn alloys could be used as an alloy of high electrical resistance with reproducible properties only by the addition of a further transition metal, is disproved.

By the addition of Mg the strength can be increased without a noticeable influence on the electrical conductivity.

Further features and advantages of the invention are presented in the following description.

In addition to the actual conductor rails, induction-type reaction rails are also required in the construction of the high speed transportation systems which are presently undergoing extensive development and which are powered by means of linear motors. The material for the reaction rails should, moreover, be easy to shape, easy to weld and should have a good corrosion resistance. On the other hand, in keeping with present day concepts in general, the medium strength range of aluminium alloys is adequate i.e. a tensile strength of about 10–25 kp/mm² is usually sufficient for reaction rails.

Of the transition metals investigated, manganese has the largest solid solubility in aluminium at elevated temperatures and in the binary AlMn system it precipitates very slowly. Quenched from the melt, as for example in continuous casting, manganese can be strongly supersaturated in solid solution. If one or more of the alloying components contains impurities of Fe and/or Si then these elements accelerate the precipitation of the Mn atoms. The formation of a manganese-rich second phase can occur not only during solidification but also in the solidified state.

Measurements have shown that the precipitation of Mn results in two principle effects which are undesireable in the manufacture of reaction rails viz.,

- the electrical resistance is reduced i.e. the conductivity is increased.
- the formability becomes worse.

The casting of binary AlMn alloys having the smallest possible amount of impurities of Fe and Si must take place quickly so that a coarse precipitation of the phase Al_6Mn can, to a great extent, be suppressed; the Mn should, after solidification of the melt, as much as possible remain in solution in the aluminium. For the same reason high temperature annealing of the billet is omitted, this anneal normally taking place at a temperature of more than 500°C.

The reaction rails are given their desired geometrical shape by extrusion at an elevated temperature. In this treatment a too extreme heating of the cast billet is to be avoided, in no case may the temperature of 500°C be exceeded, otherwise considerable quantities of undersired precipitates form very quickly. On the other hand to achieve increased strength it is advantageous to hold the billet for some time at an elevated temperature. In order to prevent a precipitation of Al_6Mn effectively the metal should not exceed the following times and temperatures.

Temperature of Metal	Duration	
500°C	maximum	1 h
450°C	maximum	4 h
400°C	maximum	24 h
300–350°C	maximum	100 h

Since the temperature of the emerging section is considerably higher then the billet temperature the section must be cooled quickly on leaving the extrusion press. The emerging section can be water-quenched immediately, which is particularly advantageous in the case of large cross-sections or higher temperatures.

Binary alloys with aluminium of purity better than 99.5 % and 0.7–3.5 % Mn, preferably 0.7–2.5 % Mn produce, with respect to the specific electrical resistivity, reproducible results which lie above 5 $\mu\Omega$ cm, with a tensile strength of 12–16 kp/mm².

The addition of 0.1–2 % Mg allows the tensile strength to be increased without impairing the other advantageous properties. The addition of Mg has a further considerable advantage in that the thermal stability of the structure is improved whereby in particular the differences between the start and end of the extrusion are considerably reduced.

In the case of Mg-containing AlMn alloys a further increase in strength can be achieved by the addition of Si, the quantitiy of which is limited by the Mg content since as much as possible of the Si should be bound up as magnesium silicide. For yet a further increase in tensile strength the extruded section can be artificially aged.

In the following examples aluminium of a puritiy of 99.8 % was used to produce the alloy.

EXAMPLE 1

A 200 mm diameter, continuously cast billet which was not annealed at high temperature was analysed and the following results obtained.

Mn 2.04 %
Si 0.06 %
Fe 0.06 %
Al rest

The billet was inductively heated to 500°C in 15 minutes then extruded immediately at a speed of approximately 20 m/min and the resulting 50 × 3 mm flat section water-quenched directly on emerging from the extrusion press. The section has the following properties

Electrical resistance	7 – 7.5 μΩcm
Tensile strength	12.5 kp/mm²
Yield strength	8.5 kp/mm²

As a check on the weldability, an important property of material for reaction rails, resistance measurements were carried out on two section pieces which had been welded together end to end.

The resistance values were obtained by measuring before welding, after welding and across the weld seam. In this way it was found that the average values of these measurements always lay in the same range; in particular the weld seam had then the same electrical resistance as the rest of the metal before welding, namely 7–7.5 **μΩ cm.**

EXAMPLE 2

A continuously cast ingot of the alloy

Mn 2.06 %
Mg 0.98 %
Si 0.05 %
Fe 0.08 %
Al rest

was brought quickly to an extrusion temperature of 400°C, extruded at a rate of 4 m/min. to a flat section of 120 × 20 mm and water quenched.

The section has the following properties over its whole length:

Electrical resistance	8.5 μΩcm
Tensile strength	21 kp/mm²
Yield strength	13 kp/mm²

EXAMPLE 3

If the alloy described in example 2 is held at 400°C for 5 hours before extrusion then the quenched section has the following properties over its whole length:

Electrical resistance	7.0 μΩcm
Tensile strength	25 kp/mm²
Yield strength	17.5 kp/mm²

By the annealing before extrusion the strength can be improved, whereby the specific electrical resistivity is reduced only a little.

EXAMPLE 4

If a continuously cast ingot of the composition

Mn 2.02 %
Mg 1.05 %
Si 0.31 %
Fe 0.04 %
Al rest

is extruded as in Example 2 then the quenched and naturally aged section possesses the following properties along the whole of its length:

Electrical resistance	7.2 μΩcm
Tensile strength	23.5 kp/mm²
Yield strength	17.5 kp/mm²

After an artificial aging of the section for 8 hours at 150°C the following values were obtained:

Electrical resistance	7.0 μΩcm
Tensile strength	25 kp/mm²
Yield strength	16.5 kp/mm²

If the age hardening element Si is added to the Mg-containing AlMn alloy then with an artificial aging treatment of the quenched section an increase in the tensile strength is achieved without significantly lowering the specific electrical resistance.

What is claimed is:

1. Induction-type reaction rail which can be easily shaped and welded and has a high electrical resistance, for use in conjuction with linear motors which power high speed trains, characterised in that the reaction rail is made out of an alloy with the composition 0.7–3.5 % Mn, the rest being aluminium which has a purity of at least 99.5 % in particular with a maximum impurity content of 0.1 % Fe and 0.15 % Si.

2. Induction-type reaction rail in accordance with claim 1 characterised in that the alloy contains 0.7–2.5 % Mn.

3. Induction-type reaction rail which can be easily shaped and welded and has a high electrical resistance, for use in conjunction with linear motors which power high speed trains, characterised in that the reaction rail is made out of an alloy with the composition 0.7–3.5% Mn; 0.1–2% Mg; the rest being aluminum which has a purity of at least 99.5% in particular with a maximum impurity content of 0.1% Fe and 0.15% Si.

4. Induction-type reaction rail which can be easily shaped and welded and has a high electrical resistance, for use in conjunction with linear motors which power high speed trains, characterised in that the reaction rail is made out of an alloy with the composition 0.7–3.5% Mn; 0.1–2% Mg, as much silicon as can be bound up with the magnesium as magnesium silicide; the rest being aluminum which has a purity of at least 99.5% in particular with a maximum impurity content of 0.1% Fe and 0.15% Si.

5. Process for the production of induction-type reaction rails in accordance with claim **1**, characterised in that the alloy is rapidly cooled from the melt by continuous casting then heated to a temperature of 300°–500°C prior to extrusion and then extruded to shape and the emerging section rapidly cooled.

6. Process in accordance with claim **5** characterised in that the cast billet, on heating for extrusion, is annealed at a maximum temperature of 500°C for a maximum duration of 1 hour, at 450°C for a maximum of 4 hours, at 400°C for a maximum of 25 hours or at 300°–350°C for a maximum of 100 hours.

7. Process in accordance with claim **5** characterised in that the emerging extrusion is immediately quenched.

8. Process for the production of induction-type reaction rails in accordance with claim **4,** characterised in that the alloy is rapidly cooled from the melt by continuous casting then heated to a temperature of 300°–500°C prior to extrusion and then extruded to shape and the emerging section rapidly cooled and artificially aged.

* * * * *