April 30, 1968 A. HETKE ETAL 3,380,820

METHOD OF MAKING HIGH IRON CONTENT ALUMINUM ALLOYS

Filed Sept. 15, 1965

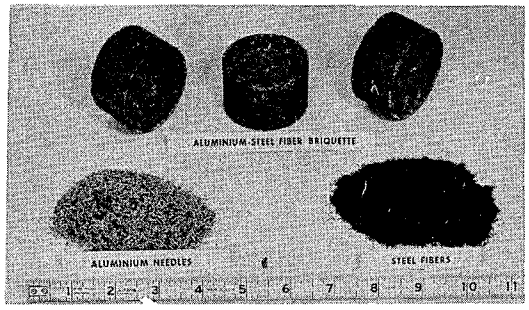


Fig. 1

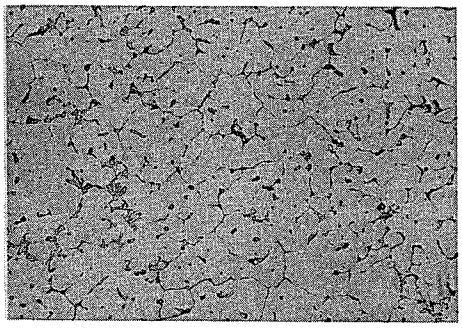


Fig. 2

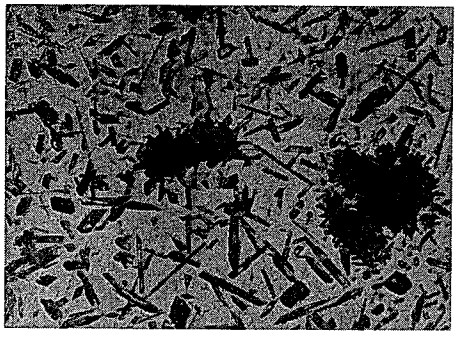


Fig. 3

INVENTORS
Adolf Hetke &
BY Robert H. Zimmerman
Peter P. Kozak
ATTORNEY

United States Patent Office

3,380,820

Patented Apr. 30, 1968

3,380,820

METHOD OF MAKING HIGH IRON CONTENT ALUMINUM ALLOYS

Adolf Hetke and Robert H. Zimmerman, Saginaw, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Filed Sept. 15, 1965, Ser. No. 487,553

5 Claims. (Cl. 75—138)

This invention relates to iron-aluminum alloys and more particularly to a process for preparing high iron content aluminum alloys.

Iron is a common low concentration impurity in commercial aluminum alloys. It dissolves in molten aluminum but is almost completely insoluble when the aluminum has solidified. Iron and aluminum form a compound, $FeAl_3$, which is very hard and brittle. It is a constituent of aluminum based alloys containing appreciable amounts of iron. The presence of this compound in an aluminum alloy renders the alloy hard and brittle. An increase in the iron content of such an alloy simply enhances these characteristics.

Until recently high iron content (2% to 25%) aluminum alloys have found very little application. However, they are now being considered for use in situations where relatively light weight and good surface wear properties are desired. Examples of such an application are certain types of brake linings and motor blocks.

It has also proved to be difficult to form high iron content aluminum based alloys. Because their melting points are quite far apart the usual techniques have been to dissolve a solid block of iron in a molten bath of aluminum under which conditions the iron dissolves very slowly. During this period much of the aluminum reacts with oxygen in the air and forms a dross which is wasted. Thus, this technique proved to be expensive. Furthermore, it was inconvenient in that it was difficult to predict the composition of the final alloy. One could not start out with specific amounts of aluminum and iron and end up with alloy of predictable composition. Allowance had to be made for the aluminum that would be oxidized.

Accordingly, it is an object of this invention to provide a more satisfactory method of making high iron content aluminum alloys. It is a further object of this invention to provide a method of making a high iron content aluminum based alloy wherein the aluminum content is predictable and the dross formulation is minimized.

These and other objects and advantages are accomplished by mixing particles of aluminum and ferrous metal, said ferrous metal comprising 2% to about 25% of the mixture by weight; compressing these particles into a composite briquette under a pressure of at least 12½ tons per square inch; heating the briquette until it is melted; and casting the molten metal into an ingot or other suitable form. Whenever desired the melt may be protected from the oxygen in the air by the use of a flux or of an inert or protective atmosphere.

These and other objects and advantages will become more apparent from a detailed description of the method and a specific example which follows, reference being had to the following figures.

FIGURE 1 is a photograph of typical briquettes and the aluminum needles and steel fibers from which they were formed.

FIGURE 2 is a photomicrograph of the aluminum alloys as used in needle form for the briquetting process (0.5 HF Etch, 50×).

FIGURE 3 is a photomicrograph showing the microstructure of an iron-aluminum alloy containing 22.8% iron (unetched, 50×).

In our invention, the iron and aluminum starting materials are initially in a fine particulate form. In this way, they may readily be combined into a fairly uniform mixture. Thus, a large surface area common to both components is provided through which heat may be efficiently conducted to melt the respective constituents and at which aluminum and iron atoms may react to form $FeAl_3$ even while the melting is taking place. The starting materials may be used as needles, flakes, granules, powders, chips or other particles. The important factor is that both the iron and the aluminum be in a solid form which has a relatively large surface area per unit of weight and in which each element may easily be mixed with the other so that upon briquetting a large surface common to each is created. The exact geometry is not critical as long as this result is obtained. Thus, if the particles are in a more or less spherical configuration the maximum dimension is preferably about ½" or less. However, where the particles are fibers or needles having a diameter of a few hundredths of an inch their length should preferably be less than one inch. Greater particle sizes are operable in our process, but in their use some of the advantages of our invention are lost.

In a specific example of which the briquettes and respective starting materials are shown in FIGURE 1, the aluminum is in the form of fine needles and the steel is in the form of fibers about ¼" long and about 0.01" in diameter.

The required purity of starting materials in our process depends upon the use to which the alloy is to be put. Normally, the iron may be supplied using a low carbon steel where the carbon content is 0.5% or less. The aluminum might typically be any alloy assaying 90% aluminum or higher. The aluminum needles shown in FIGURE 1 comprised 94.5% aluminum together with small amounts of manganese, copper, zinc, magnesium, chromium, silicon, and iron. The iron content was 0.16%. The iron fibers were from a typical low carbon steel containing about 0.4% carbon and small amounts of manganese, sulfur and phosphorous.

If in the preparation of the iron and aluminum particles they have been contaminated with oil or grease, a more pure alloy may be prepared if these contaminants are removed. The particles may be cleaned in a suitable solvent bath such as trichloroethylene at a temperature of about 180° F.

Five parts by weight aluminum needles and one part by weight iron fibers were mixed in a twin shell blender to obtain a uniform particle dispersion. The mixture was weighed into half pound portions and each compressed at 45 tons pressure in a 2⅛" diameter die. The briquettes that were formed are shown in FIGURE 1. Sufficient pressure must be applied during compression to form a relatively high density briquette. By this, we mean that the actual density of the briquette preferably is greater than 80% of the true or calculated density of an ideal nonporous mixture of its component parts. This true density figure is determined by summing the product of the density of the aluminum alloy starting material with its weight fraction in the briquette and the product of the density of the ferrous metal starting material with its weight fraction in the briquette. Such a high density is preferable in achieving a faster melt and in minimizing dross formation.

These briquettes were charged to an induction furnace and melted at a temperature of 1350° F. The normal melting range is from about 1100° F. to 1400° F., depending upon the iron content of the briquette. Once the melting briquettes had reached a soft, mushy stage they were compacted to provide a continuous surface and

covered with an aluminum salt flux to prevent excessive metal oxidation. Alternatively, a protective atmosphere such as nitrogen could have been used. The melting proceeded quite rapidly and soon a complete solution was obtained. The molten material was cast into small ingots for further examination.

FIGURE 2 shows a photomicrograph of the aluminum alloy as used in needle form for this briquetting process. It may be compared with FIGURE 3, which is a photomicrograph showing the microstructure of the cast ingots. Since the alloy had been prepared at a low temperature relative to the melting point of steel, it was not certain just what form the iron would take in the alloy. It was felt that possibly the iron would not completely dissolve or melt, but would remain as fibers suspended in the aluminum in the solid state. To determine this a specimen was first etched with a dilute solution of nitric acid in alcohol (nital). The nital etch did not attack the constituents. Thus it was concluded that the constituents were not of steel composition. A second etch, hydrofluoric acid, did attack the dark particles in the aluminum matrix and it was indicated that the iron was present as an iron aluminum compound. FIGURE 3 is a photomicrograph of an unetched specimen which shows the presence of the iron aluminum compounds. An assay of the specimen showed the ingots to be uniformly 22.8% iron.

It will be observed that the iron content of the ingots is about 6% higher than was incorporated into the composite briquettes. Despite the rapid melt some of the aluminum was oxidized; however, much less was lost than in prior art techniques. A second melt was obtained using the same briquettes wherein the melting operation was conducted under a protective atmosphere of nitrogen. In this case, the iron content was only about 18%, as very little aluminum was lost as dross.

It can be seen that virtually any iron-aluminum alloy could be prepared in this manner. As a practical matter, aluminum based alloys containing more than 25% iron have yet to find commercial applications. However, as the need arises, they may be prepared by our process. Iron-aluminum alloys containing less iron than the composition of the specific example may, of course, be prepared in one of two ways. Briquettes may be prepared using the appropriate amount of iron particles and a melt obtained directly. Alternatively, once a high iron content alloy (20%–25% iron) has been prepared it may be used as a master alloy to be subsequently diluted with aluminum to prepare a desired alloy.

While this invention has been described in terms of a specific example and preferred embodiment, it is to be understood that other applications would be apparent to

those skilled in the art and are within the scope of this invention as defined by the following claims:

We claim:

1. A method of preparing an aluminum alloy of high iron content wherein said iron content is in the range of from 2% to about 25% by weight, said method comprised of mixing aluminum and ferrous metal particles having a maximum dimension of less than one inch in accordance with said iron content to achieve a uniform mixture, compressing said mixture into a composite briquette having an actual density greater than 80% of the true density of an ideal nonporous mixture of its components, heating said briquette until melted, and casting said molten metal into a desired shape.

2. A method as in claim 1 wherein said briquette is melted at a temperature in the range of 1100° F. to about 1400° F.

3. A method as in claim 1 wherein said composite briquette is compressed under a pressure of at least 12½ tons per square inch.

4. In a method for the preparation of a high iron content aluminum alloy wherein said iron content is in the range of from 2% to 25% by weight, said method comprised of melting said aluminum and iron together to form a solution and subsequently casting said molten metal into a desired shape, the improvement of mixing aluminum and ferrous metal particles having a maximum dimension of less than one inch in accordance with said iron content to achieve a uniform mixture and compressing said mixture into a composite briquette under a pressure of at least 12½ tons per square inch, said mixing and compressing steps being performed prior to said melting step.

5. A high density briquette comprised of finely divided particles of aluminum and iron, said particles originally having a maximum dimension of less than one inch, said briquette comprised of from 2% to 25% iron and having a density of more than 80% of the true density of an ideal nonporous mixture of said aluminum and said iron particles.

References Cited

UNITED STATES PATENTS

1,227,174	5/1917	Morris	75—138
1,870,732	8/1932	Iytaka	75—147
2,574,318	11/1951	Burkhardt	75—138
2,967,351	1/1961	Roberts et al.	75—138
3,010,824	11/1961	Herenguel et al.	75—138

HYLAND BIZOT, *Primary Examiner.*

R. O. DEAN, *Assistant Examiner.*