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WORKING ALUMINUM-MAGNESIUM ALLOY

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The invention relates to the mechanical working of aluminum base alloys and is more particularly directed to a successful method of working aluminum base alloys containing substantial amounts of magnesium with or without lesser amounts of other alloying constituents. The term "aluminum base alloy", as used herein and in the appended claims, refers to alloys containing 75 per cent or more of aluminum.

Until recently, wrought alloys of aluminum containing from about 5 to 15 per cent of magnesium have not been available in commercial quantities despite the fact that the low specific gravity and other favorable properties of such alloys make them particularly suited to fulfill the demand for lighter alloys of equal or greater strength than those heretofore available. Although the innate potentialities of the aluminum-magnesium alloys have been appreciated prior to the date of the present invention, it has been found commercially impractical to develop them by reason of the fact that the alloys are difficult to cast and mechanically deform. Intensive efforts recently directed to the development of methods of casting and working by which the aluminum-magnesium alloys might be commercially produced encountered almost insuperable difficulties even when sound ingots for working were provided. Attempts to work aluminum-magnesium alloy ingots into wrought commercial forms, particularly where the alloys contain more than about 5 per cent of magnesium, have for the most part completely failed. Moreover, the aluminum-magnesium alloys have been found to be very susceptible to cracking or complete breaking up even during working operations designed to form the simpler shapes from ingots.

The situation outlined above has led us to devise the present invention, which provides a method of working ingots made of aluminum base alloys containing 5 to 15 per cent of magnesium with or without lesser amounts of other alloying constituents, hereinafter referred to as aluminum-magnesium alloys. Heretofore, the art of working ingots of aluminum base alloys has consisted, briefly, in a thermal treatment or preheating prior to working to homogenize the internal structure of the alloy ingot, and a subsequent hot working of the alloy ingot into a form usually preliminary to the finally desired form which is thereafter obtained by either a further hot or cold working. The temperatures of the preheating and the initial hot working have been in prior processes substantially the same, the preheating temperature being as close as commercially practicable to the melting point of the most fusible eutectic, and in actual practice the alloy ingots are worked at temperatures substantially equal to or somewhat below the temperature of the ingot as it comes from the preheating operation.

Our invention is predicated upon the discovery that the difficulties heretofore incident to the working of aluminum base alloys containing substantial amounts of magnesium have been the result of the attempted application of these well known thermal and working methods which, in relation to aluminum base alloys generally, have proved satisfactory. We have discovered that whereas all other aluminum alloys with which we are familiar can be most efficiently hot worked at temperatures above about 800° F., the aluminum-magnesium alloys can only be successfully hot worked at temperatures below about 600° F. The appreciation of this unusual characteristic of the aluminum-magnesium alloys has resulted in the successful commercial method of working these alloys as herein described.

While the aluminum-magnesium alloys may be preheated at temperatures considerably in excess of 600° F. but lower than the temperature of the most fusible eutectic in the alloys, they may not be worked at this preheating temperature but must be cooled to the indicated working temperature range, and they may be worked at or near the preheating temperature only when the preheating temperature is 600° F. or lower. Upon these discoveries, we have predicated our novel working processes which will now be specifically described as practiced in the preferred manner.

In any working process, it is necessary to the success thereof that the ingot initially cast be sound and free from substantial defects. Aluminum-magnesium alloy ingots of proper soundness may be produced if cast in metal molds according to known technique. Since, however, these alloys are in some cases particularly susceptible to casting defects, we prefer, in the commercial practice of our invention, to employ the well known expedients of the art, such as treating the metal with a flux or gas or remelting the metal one or more times before casting, which expedients are known to be conducive to ingot soundness. The temperature of the metal during the melting, alloying, and casting operations should be maintained, for best results, at as low a temperature as is consistent with proper metal fluidity and good casting practice.

A sound aluminum-magnesium alloy ingot having been obtained, it is preheated at a suitable temperature above about 550° F. but below the

point of incipient fusion of the constituents of the alloy. The preheating imparts workability by producing a more or less uniform internal structure in the alloy ingot, and the preheating should therefore be continued for a period of time sufficient to accomplish this purpose. In the case of an alloy ingot containing about 6 per cent of magnesium, the balance being aluminum, and having a thickness of 3¾ inches, a width of 12 inches, and a length of 24 inches, preheating for 20 hours will be ample. The time of preheating varies substantially, however, with the size of the ingot, with the concentration of the magnesium and alloying elements in the alloy used, and with the temperature at which the ingot is maintained. The proper preheat-treatment time with reference to any particular working operation may be determined without difficulty by simple trial within the stated temperature range. While aluminum-magnesium alloys containing about 5 to 15 per cent of magnesium may be satisfactorily preheated above about 550° F. but below the temperature of incipient fusion of the most fusible constituents of the alloy, we have found that where the alloys contain about 10 per cent or more of magnesium better and more certain results are obtained if the preheating is carried out at temperatures above 750° F. In the case of any aluminum base alloy containing from about 5 to 15 per cent of magnesium, a preheating temperature of about 800° F. is good practice although treatment within a preheating range above about 550° F. but below the point of incipient fusion of the most fusible constituents in the alloy will produce good results.

The alloy ingot having been preheated in accordance with the principles above described, the ingot is cooled to the temperature of working. As hereinbefore mentioned, when the preheating range is higher than 600° F., there is a temperature interval in which satisfactory working may not be accomplished. In the interests of speed and economy, the cooling of the ingot through the range should be as rapid as convenient and we have discovered that such rapid cooling to the working temperature does not at all impair the ease of working of the alloy.

We have found that aluminum-magnesium alloys containing in the neighborhood of 6 per cent of magnesium may be preheated at temperatures not substantially in excess of the working temperature, and that such alloys may preferably be preheated at 600° F. and worked at 550° F. As the magnesium content in the alloys is increased, for example in alloys containing more than about 7 per cent of magnesium, we have found the most efficient practice to consist in preheating the alloys at temperatures substantially in excess of 600° F., cooling rapidly to 600° F., and working the alloys between about 500° F. and 600° F. The word "rapid", as used herein and in the appended claims, has, however, only a comparative sense, as for example a cooling in air as compared with a cooling in or with a slowly cooling preheating means or furnace. The time of transition from the preheating temperature to the working temperature may be artificially accelerated but it is our usual practice to remove the ingot from the preheating means and allow it to cool in air under such conditions that there is no substantial restriction of heat radiation or convection.

We have discovered that the temperature range within which the working of the properly preheated ingot may be successfully practiced lies between about 475 and 600° F. Here also, as in the case of the preheating temperature, the preferred working temperature range becomes smaller with increasing amounts of magnesium in the alloy, and where the alloy ingot contains about 10 per cent or more of magnesium, the working temperature range is preferably restricted to about 500 to 575° F. Good results may, however, be obtained when the alloys are worked within the temperature range previously stated. In the practice of our preferred method, comprising preheating at temperatures above 550° F., cooling rapidly to the working temperatures, and working the ingots between 475 and 600° F., we have uniformly obtained much superior results to those heretofore possible and we have succeeded in producing in substantial and commercial quantities fabricated shapes and forms of aluminum-magnesium alloys.

As is well known in the art, few of the aluminum base alloys which contain substantial amounts of alloying constituents can, after preheating, be hot worked from ingot form to the finally desired shape, and it often happens that at some point during the hot working operation the amount of reduction which the alloy ingot has undergone precludes further satisfactory working. This is true in the case of the aluminum-magnesium alloys with which our invention is concerned, and in the reduction of the aluminum-magnesium alloy ingot to the finally desired form, it may be necessary at one or more points to stop the working process and reheat the metal. The determination as to when such further reheating is necessary is quickly made by experienced operators and depends not only upon the composition of the alloy but also upon the severity of the previous working operation and the particular type of working operation, whether rolling, forging, extruding, or the like. The behavior of the metal under the applied working forces is indicative of the amount of further working which is permissible before further reheating is necessary. In the case of aluminum-magnesium alloys, it is especially probable, when working with the higher magnesium contents, that one or more intermediate reheating treatments will be required, such alloy being less ductile or plastic than one containing, say, 5 or 6 per cent of magnesium. Regardless of the magnesium content of the alloy, however, as soon as experience indicates that further working may cause injury the metal should be again submitted to at least the reheating step of our process, followed by rapid cooling to the proper working temperature where work may be again applied upon it to obtain the finished size or until a further submission of the metal to the reheating treatment is necessary or desirable.

We have found that the working operation is facilitated by a proper choice of alloying ingredients of high purity and the restriction of the impurity content of the final product to less than about 0.4 per cent is preferred whenever commercially feasible. These impurities consist usually of slight inclusions of iron, silicon, copper, or other constituents not intentionally added in compounding the alloy and to some extent existing in the first instance in the aluminum ingot. While the best results can be obtained with alloys which contain less than about 0.4 per cent of the impurities, our invention, nevertheless, is not limited in that respect since alloys having a higher impurity content may be successfully worked in accordance therewith.

We claim—

1. In the working of aluminum-base alloys containing from about 5 to 15 per cent of magnesium, the steps comprising preheating the alloy at a temperature above about 550° F. but below the temperature of incipient fusion, cooling the alloy rapidly to a working range which is below about 600° F. and is also below the preheating temperature but is not lower than about 475° F. and working the alloy within said range.

2. In the working of aluminum-base alloys containing from about 10 to 15 per cent of magnesium, the steps comprising preheating the alloy at a temperature above about 750° F. but below the temperature of incipient fusion, cooling the alloy rapidly to a working range not lower than about 500° F. and not higher than about 575° F., and working the alloy within said range.

3. In the working of aluminum-base alloys containing from about 5 to 7 per cent of magnesium, the steps comprising preheating the alloy at a temperature above about 600° F. and below incipient fusion, cooling the alloy rapidly to a working range below about 600° F. but not lower than 475° F., and working the alloy within said range.

4. In a method of working of aluminum-base alloys containing from about 5 to 15 per cent of magnesium in which the alloy is preheated and subsequently worked at a lower temperature, the improvement comprising preheating the alloy at a temperature below incipient fusion and not less than about 600° F., and cooling the alloy rapidly from the preheating temperature to a predetermined working temperature which lies within 600° F. and 475° F. inclusive to leave the alloy in workable condition when the working temperature is reached.

5. In a method of working of aluminum-base alloys containing from about 5 to 15 per cent of magnesium in which the alloy is worked at a lower temperature which is not higher than about 600° F. and not lower than about 475° F., the improvement comprising preheating the alloy below the point of incipient fusion but not below about 550° F., in which the internal structure of the alloy becomes substantially uniform, and cooling the alloy to the working temperature at a rapid rate adapted to maintain the alloy in workable uniformity of internal structure.

6. In a method of working aluminum-base alloys containing from about 5 to 15 per cent of magnesium in which the alloy is preheated at a temperature above 600° F. but below incipient fusion to impart workability and is subsequently worked at a temperature between about 600° F. and 475° F., the improvement comprising rapidly cooling the alloy from the preheating temperature to the working temperature whereby to preserve in substantial amount the workability imparted by the preheating.

7. In a method of working aluminum-base alloys containing from about 5 to 15 per cent of magnesium, wherein the alloy is preheated at a temperature below incipient fusion and not less than about 600° F. and is cooled to a working range, the step of working the alloy within the range of about 475° to 600° F.

8. In the working of aluminum-base alloys containing from about 5 to 15 per cent of magnesium, the steps comprising preheating the alloy at a temperature not less than about 550° F. but below incipient fusion, cooling the alloy rapidly to within a predetermined range which is not lower than 475° F. and not higher than 550° F., and working the alloy within said range.

9. In the working of aluminum-base alloys containing about 6 per cent of magnesium, the steps comprising preheating the alloy at a temperature of about 600° F., cooling the alloy to about 550° F., and working the alloy.

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CERTIFICATE OF CORRECTION.

Patent No. 1,926,057. September 12, 1933.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, line 87, claim 6, after "above" insert "about"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 24th day of October, A. D. 1933.

F. M. Hopkins

(Seal) Acting Commissioner of Patents.