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ROLLING EXTRUDED MAGNESIUM ALLOY

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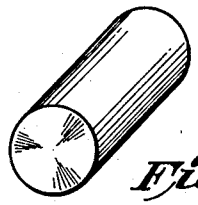


Fig. 1

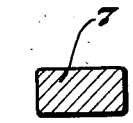


Fig. 3

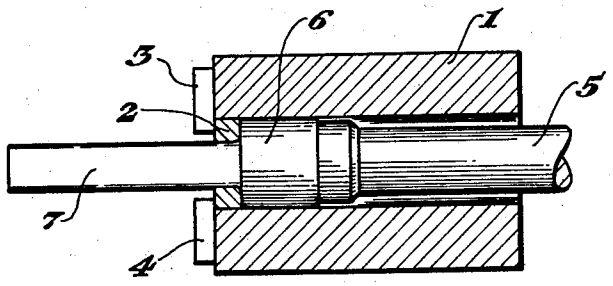


Fig. 2

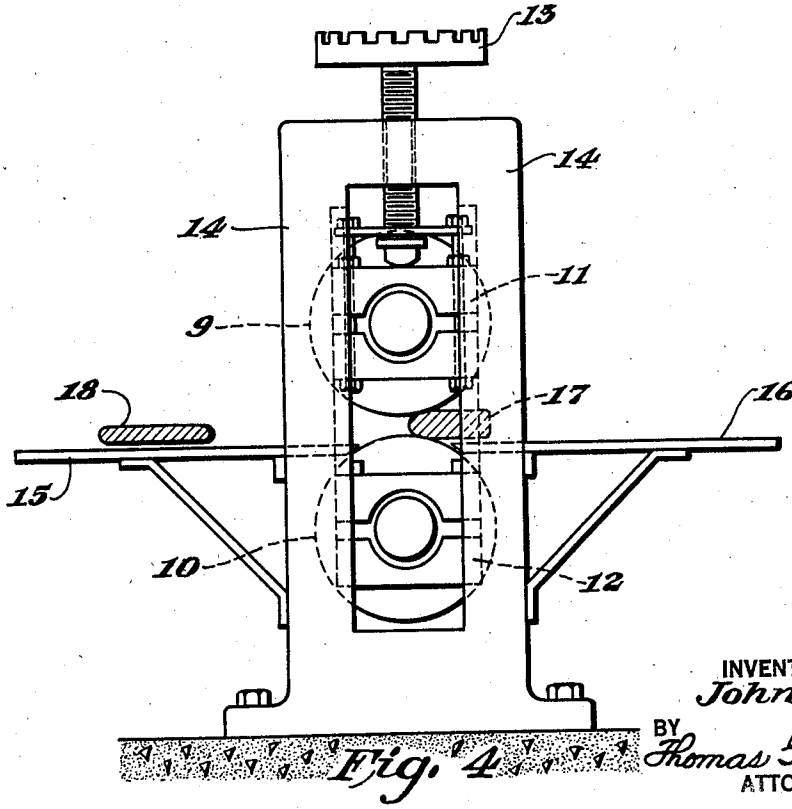


Fig. 4

INVENTOR
John E. Hoy
BY
Thomas Griswold, Jr.
ATTORNEY

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ROLLING EXTRUDED MAGNESIUM ALLOY

John E. Hoy, Midland, Mich., assignor to The Dow Chemical Company, Midland, Mich., a corporation of Michigan

Application May 4, 1932, Serial No. 609,279

5 Claims. (Cl. 148—11.5)

In a copending application Serial No. 281,548, filed May 29, 1928, now Patent No. 1,878,240, I have described a method of producing fabricated parts of magnesium or alloys thereof in which magnesium is a predominating constituent, by first casting an ingot of said metal followed by extruding the same in heated condition and then further shaping the extruded part by compression. One example of the application of the method described therein shows the formation of a magnesium alloy propeller in which a cast ingot of the alloy is extruded from a die to form a blank and then the blank is wrought into the finished shape between compression dies in a forging press. Certain especial advantages of this procedure are the improved tensile strength and yield point obtained in the finished product.

The present invention relates to a modification of the aforementioned method for the production of fabricated magnesium or magnesium alloy metal in the form of sheets or plates or the like wherein the shaping operation is carried out by rolling an extruded billet of the metal. The terms "magnesium" and "magnesium alloy" are used herein and in the appended claims to mean not only pure magnesium, but also alloys of the same wherein magnesium is the predominating constituent.

Heretofore the production of flat metal stock such as sheets and plates of magnesium and its alloys has been based upon the method employing the well known steps of first forming a rolling billet of a suitable volume of metal by casting and then rolling the same in heated condition in a number of passes according to the usual practice of hot rolling metals. While such a procedure may be satisfactory for rolling metals which crystallize in the cubic system, such as aluminum, iron, copper, etc., it is not wholly satisfactory for metals which crystallize in the hexagonal system, such as magnesium and alloys thereof. For example, when the magnesium or magnesium alloy rolling billet is heated to the temperature at which the metal reaches a suitable degree of plasticity, and rolling is commenced, the billet is liable to develop superficial cracks under the pressure of the rolls. In some instances these cracks are plainly visible while in others the cracks are quite minute and are not evident on a visual inspection. On continuing the rolling operations, the cracks once formed in the metal remain therein, thus producing sheets or plates which, due to such flaws, lack proper mechanical properties such as tensile strength. Said cracks also promote corrosion where such rolled metal is exposed to atmospheric or other corrosive influences. During the rolling a certain amount of splitting or cracking also occurs at the edges of the rolled stock. These cracks vary in depth, measured from the edge of the sheet, from about 0.5 inch to a foot or more and, once such a crack has formed, further rolling usually results in increasing the depth thereof. In order to minimize the tendency for such cracks to increase in depth, it is customary to trim off the cracked edges prior to each rolling pass. These trimming operations not only entail increased labor costs, but also result in a considerable wastage of metal, besides reducing the ultimate width of the sheet.

At present the only available method for overcoming cracking and attendant defects is to produce relatively small percentage reductions in thickness per pass, and to employ therewith a reheating step between the passes so as to insure the metal being at a suitable working temperature. This procedure has the disadvantage that the large number of passes employed, when the reductions in thickness per pass are small, requires a correspondingly large number of reheatings, which not only increase the cost of the process, but also increase the quantity of oxide film formed upon the heated metal. Furthermore, each additional pass promotes further cracking at the edges, thus necessitating further trimming which decreases the effective width of sheet. Even when employing carefully regulated reductions at each pass and the optimum working temperature, the ultimate mechanical properties of the resulting rolled metal are not always equal to those obtainable by other methods of shaping magnesium and its alloys by compressive forces. In addition to such difficulties, it is generally necessary to machine off or otherwise obtain a smooth surface of cast billet before rolling in order to avoid producing an imperfect surface on the rolled product.

One object of the present invention is to provide a process of producing sheets or plates of magnesium and its alloys in which the aforementioned tendency to develop cracks is avoided. Another object is to provide a rolling process in which the percentage thickness reduction per pass is greater than heretofore obtained. Other objects and advantages will appear as the description proceeds. To the accomplishment of the foregoing and related ends, said invention, then, consists in the steps, methods, and procedures hereinafter fully described and particularly pointed out in the claims. The annexed drawing and the following description set forth in de-

tail but one of the various ways in which the principle of the invention may be carried out.

In said annexed drawing:—

Fig. 1 shows a cast ingot suitable for extrusion; Fig. 2 is a vertical section through an extrusion apparatus; Fig. 3 is a section of an extruded billet; Fig. 4 is an end elevation of a rolling mill.

In Fig. 2 is shown a billet container 1, a die 2, end blocks 3 and 4 which prevent the displacement of the die, a ram 5 actuated by hydraulic or other suitable means, not shown. Placed within the bore of the container is an ingot 6 of a magnesium alloy in the process of being extruded through the die into a billet 7, shown in section in Fig. 3.

In Fig. 4 is shown a pair of cylindrical rolls 9 and 10 with journals supported in bearings 11 and 12, the upper roll 9 being provided with screw-downs 13 which operate in the frames 14. Tables 15 and 16 are provided on either side of the rolls. A rolling billet 17 is shown entering between the rolls, also a plate 18 formed from the rolling billet by passing the same between the rolls.

The extrusion and rolling equipment shown are of conventional design and form no part of the present invention.

My invention is based upon the discovery of the fact that magnesium and its alloys may be shaped by compression using an apparatus such as a rolling mill without danger of fracturing the metal, if instead of employing cast metal stock, I employ the metal in the extruded condition as a starting point for rolling operations. I am enabled thereby also to reduce the number of passes under the rolls in obtaining a given thickness of metal, compared to the number of passes when cast metal stock is employed, and also to dispense with a number of reheating operations.

The following examples will serve to show various preferred modes of carrying out my present invention and the improved effect produced upon the structure and properties of the rolled extruded metal as compared to those of rolled cast metal.

Example 1

Magnesium-manganese alloy, containing 1 to 1.5 per cent of manganese, balance magnesium.

(*a*) The alloy was cast into an ingot and the ingot was extruded at 750° F. into a rectangular rolling billet ½'' × 4'' × 12''. The billet was then rolled into sheet at 700° to 750° F., with 15 per cent reduction in thickness at each pass, to a thickness of 0.10 inch. Properties of sheet:—sound sheet was produced without cracking; tensile strength 39,000 lbs./sq. in.

(*b*) The same alloy was cast into a rolling billet ½'' × 4'' × 12'' and rolled at 700° to 750° F. using only 10 per cent reduction in thickness at each pass (greater thickness reduction than 10 per cent caused failure of the billet) to a thickness of 0.10 inch. Properties of sheet:—the sheet produced showed superficial cracks and edge cracking to a depth of 2 inches; tensile strength of soundest part of sheet 35,000 lbs./sq. in.

Example 2

Magnesium-aluminum-manganese alloy, containing 6 to 8 per cent of aluminum and 0.2 to 0.3 per cent of manganese, balance magnesium.

(*a*) The alloy was cast into an ingot and the ingot was extruded at 800° F. into a rectangular rolling billet ½'' × 4'' × 12''. The billet was then rolled into sheet at 700° to 750° F., with 15 per cent reduction in thickness at each pass, to a thickness of 0.10 inch. Properties of sheet:—sound sheet was produced without cracking; tensile strength 37,600 lbs./sq. in.

(*b*) The same alloy was cast into a rolling billet ½'' × 4'' × 12'' and rolled at 700° to 750° F. with only 10 per cent reduction in thickness at each pass. Severe cracking occurred and sufficient sheet for test specimens was not available for tension tests.

Example 3

Magnesium-aluminum-manganese alloy, containing approximately 4 per cent of aluminum and approximately 0.3 per cent of manganese, balance magnesium.

(*a*) The alloy was cast into an ingot and the ingot was extruded at 800° F. into a rectangular rolling billet ½'' × 4'' × 12''. The billet was then rolled into sheet at 700° to 750° F., with 15 per cent reduction in thickness at each pass, to a thickness of 0.10 inch. Properties of sheet:—sound sheet free from cracking was produced; tensile strength 36,700 lbs./sq. in.

(*b*) The same alloy was cast into a rolling billet ½'' × 4'' × 12'' and rolled at 700° to 750° F. into sheet employing 10 per cent reduction in thickness at each pass. Properties of sheet:—severe edge cracking occurred as well as superficial cracking; tensile strength test specimens were not available owing to the unsoundness of the sheet.

Example 4

Magnesium - aluminum - cadmium - zinc alloy, containing the said metals in the following approximate amounts:—magnesium 97 per cent, aluminum 1 per cent, cadmium 1 per cent, zinc 1 per cent.

(*a*) The alloy was cast into an ingot and the ingot was extruded at approximately 800° F. into a rectangular rolling billet ½'' × 4'' × 12'' and rolled into sheet at approximately 750° F. employing about a 30 per cent reduction in thickness at each pass to a thickness of 0.10 inch. Properties of sheet:—sound sheet was produced without cracking.

(*b*) The same alloy was cast into a rolling billet ½'' × 4'' × 12'' and rolled at approximately 750° F. employing about a 30 per cent reduction in thickness at each pass to a thickness of 0.10 inch. Properties of sheet:—sheet developed cracks.

Example 5

Magnesium-tin-zinc alloy, containing approximately 4 per cent of tin, 1 per cent of zinc, balance magnesium.

(*a*) The alloy was cast into an ingot and the ingot was extruded at approximately 800° F. into a rectangular rolling billet ½'' × 4'' × 12'' and rolled into sheet at approximately 750° F. employing about a 30 per cent reduction in thickness at each pass to a thickness of 0.10 inch. Properties of sheet:—sound sheet was produced without cracking.

(*b*) The same alloy was cast into a rolling billet ½'' × 4'' × 12'' and rolled at approximately 750° F. into sheet employing about a 30 per cent reduction in thickness at each pass to a thickness of 0.1 inch. Properties of sheet:—sheet developed cracks during the rolling.

Example 6

Magnesium-tin-zinc-manganese alloy, containing approximately 4 per cent of tin, 1 per cent of zinc, 1 per cent of manganese, balance magnesium.

(a) The alloy was cast into an ingot and the ingot was extruded at approximately 800° F. into a rectangular rolling billet ½'' × 4'' × 12'' and rolled at approximately 750° F. into sheet employing about a 30 per cent reduction in thickness at each pass to a thickness of 0.1 inch. Properties of sheet:—sound sheet was obtained, free from cracks.

(b) The same alloy was cast into a rolling billet ½'' × 4'' × 12'' and rolled at approximately 750° F. into sheet employing about a 30 per cent reduction in thickness at each pass to a thickness of 0.1 inch. Properties of sheet:—cracks developed during the rolling operations.

In carrying out my improved process for producing rolled metal I may proceed with the steps thereof already mentioned which include the three operations, viz., (1) casting, (2) extrusion, (3) rolling, in the maner set forth below. Step (1), for example, may be carried out by casting the metal in sand or metal molds according to any satisfactory method for casting magnesium. Following the casting step, the ingot may be subjected to heat treatment, in which the metal is maintained at from about 400° C. to a temperature below the melting point of the most fusible constituent of the alloy for from one-half to twenty hours, in accordance with the processes described in United States Patents Nos 1,712,988, 1,712,989, and 1,712,990, although such procedure is not essential.

The cast ingot, heat treated or otherwise, is extruded at a suitable temperature. This may be accomplished by inserting a cast magnesium alloy ingot (Fig. 1), previously heated, into the container 1 of the extrusion apparatus and then applying pressure to the ingot, as shown in Fig. 2, by means of the ram 5 so as to extrude a billet 7 through the die 2. As is well known in extruding magnesium base alloys, the pressure required for extrusion decreases with increasing temperature, while the mechanical properties of the extruded metal are usually the better the lower the temperature of extrusion. Furthermore, the composition of the alloy is a factor and it is preferable to employ extrusion temperatures below the melting point of the most fusible constituent thereof. The temperature, therefore, at which the rolling billet may be extruded will be a comprise between the above-mentioned factors and is to be chosen in accordance with the nature of the alloy employed. For magnesium base alloys (those having a magnesium content in excess of 75 per cent) suitable temperatures in general will lie between 500° and 950° F., while preferred temperatures are between 700° and 850° F. Following the extrusion operation, I may employ another heat treating step as above described. Ordinarily, however, the rolling operation may be carried out directly after extrusion, provided the metal is preheated to the rolling temperature.

The extruded rolling billet, heat treated as above described or otherwise, is then rolled. The rolling operations consist of passing the rolling billet between the rolls of a mill repeatedly so as to produce a reduction in thickness at each pass. A rolling billet just entering the rolls of the mill is shown at 17 (Fig. 4) and after repeated passes is shown at 18 reduced in thickness. The temperature at which the metal is to be rolled is dependent upon the alloy composition and is to be chosen in accordance with the proportions and kind of alloying metals present with magnesium as a base. In general, a temperature of from 425° to 850° F. is suitable in most instances. The reduction in thickness per pass is adapted to the plasticity of the alloy. A reduction of approximately 10 to 15 per cent may be produced per pass, but I do not wish to limit myself to any specific per cent reduction inasmuch as the reduction per pass varies with the composition of the alloy and other factors.

While I have described my invention more particularly in terms of the formation of sheet metal, I wish it to be understood that I do not limit myself thereto inasmuch as my new improved method of shaping magnesium and its alloys may be applied to the formation of other shapes of finished product having a uniform cross section, for example, strip metal, rods, bars, channels, and the like, such shapes, as is well known, may be obtained by employing suitably profiled rolls for the rolling operation. For the cylindrical rolls shown in the drawing by way of illustration, therefore, may be substituted any other suitable rolls, such as profiled rolls.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the method and the steps herein disclosed, provided those stated by any of the following claims or their equivalent be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. In a method of producing rolled shapes of magnesium or an alloy thereof, the steps which consist in casting an ingot of said metal, extruding said ingot into a billet at a temperature between 500° and 950° F., and rolling said extruded billet at a temperature between 425° and 850° F.

2. In a method of producing rolled shapes of magnesium or an alloy thereof, the steps which consist in extruding an ingot of said metal into a billet, and rolling said billet.

3. In a method of producing rolled shapes of magnesium or an alloy thereof, the steps which consist in extruding an ingot of said metal at a temperature between 500° and 950° F., and rolling said extruded billet at a temperature between 425° and 850° F.

4. A process of producing rolled articles from magnesium and high percentage magnesium alloys, which comprises subjecting the metal as cast to a plastic deformation by extruding and then rolling such deformed metal.

5. A process of producing rolled articles from magnesium and high percentage magnesium alloys, which comprises subjecting the metal as cast to a plastic deformation by extruding the metal into a section of flat rectangular shape, and then rolling such deformed metal.

JOHN E. HOY.