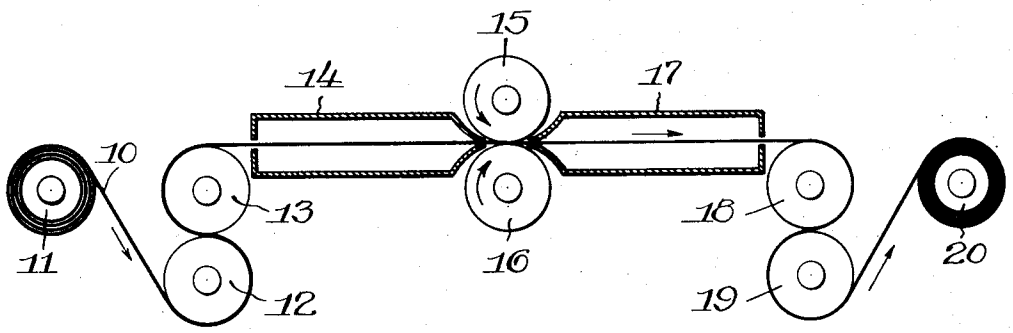
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METHOD OF ROLLING THIN SHEET METAL

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METHOD OF ROLLING THIN SHEET METAL

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This invention relates to improvements in the hot rolling of sheet metal to reduce the thickness and particularly to improvements in the hot rolling of sheet material of extremely small thickness composed of magnesium or magnesium-base alloys, by which is meant those alloys containing magnesium as the major constituent and which have metallographic properties generally similar to those of magnesium. For brevity, the specification will mention magnesium only, although magnesium-base alloys are also included within the purview of the invention.

The hot rolling of magnesium sheet or strip material having a thickness greater than .01 inch has been carried out successfully with ordinary hot rolling technique, in which the material is preheated in an oven before it is passed between the reducing rolls and is reheated if necessary before each succeeding passage between the rolls in the progressive reduction of the thickness of the material. However, attempts to hot roll magnesium strip material of a thickness of .01 inch or less has been attended with great difficulty, both with respect to the successful reduction of the thickness and the production of a final product having the desired properties. When the usual technique was followed, which is described heretofore, the strip became excessively hard and stiff and required unusual force for the rolling operation. In addition, the material was frequently fractured, usually in a direction transverse to the direction of rolling. Also, the rolled strip was excessively irregular and wavy. The rolled material became so hard, stiff and wavy that it was difficult to wind it into coils in the usual manner. If sufficient tension was applied by the coiler to level the irregularities and maintain the strip in proper alignment, the latter would frequently tear, apparently because of the presence of incipient cracks. These difficulties were encountered even though great care was taken to heat the material and also the reducing rolls so that under ordinary circumstances the material would be hot enough to readily undergo plastic flow under the influence of the rolls.

The results indicated that the metal, while it was between the rolls, was at a temperature lower than that required to produce plastic flow, and that the stress developed by the action of the rolls was sufficient to crack the strip.

The thin magnesium strip, because of its low specific gravity, has a low heat content and is subject to relatively rapid heat loss by two factors: radiation and the cooling effect of the rolls.

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Although the rolls are heated, it is not permissible to heat them to a temperature as high as is required to render the metal amenable to plastic flow, because at such temperature the rolls are likely to become annealed and lose their hardness, and it is difficult to control their contour so as to produce a flat rolled strip. The reducing rolls are usually maintained at a temperature of 200° F. to 300° F. The strip, therefore, loses heat while in contact with the rolls. The cooling effect is substantial because of the relatively great mass of the rolls as compared to the mass of the portion of thin magnesium strip between and immediately adjacent to the rolls. Strip material is usually handled in the form of coils, and considerable tension must be exerted upon it to keep it traveling in a straight line through the rolls so that it is wound into a uniform coil. If it is preheated and maintained at a temperature sufficiently high to compensate for the heat lost by radiation and the cooling effect of the rolls, the tensile strength of the strip becomes lowered to such an extent that it frequently is torn by the tension applied to it. Heating to such a high temperature also causes the growth of the grains of the metal to an objectionably large size. When the strip is heated while in the form of coils, as is the usual practice, the outer and inner layers are not maintained at the high temperature for the same length of time, with the further objectionable result that the grain growth is non-uniform.

In accordance with the present invention, the difficulties are overcome by bringing the strip material up to a satisfactory rolling temperature immediately before it reaches the reducing rolls and maintaining it at such a temperature for a relatively short time during which the passage between reducing rolls occurs. The process will be described more in detail in connection with the accompanying drawing, in which the single figure is a diagrammatic view of apparatus suitable for carrying out the invention.

A supply of the strip material 10, in the form of a coil, is carried upon the supply reel 11, and is pulled forwardly therefrom around a pair of freely rotating guide rolls 12 and 13. Means, which are not shown, are provided for resisting the motion of supply reel 11, so that the material passing around the guide rolls 12 and 13 is under tension, whereby the strip is fed forwardly at a steady rate and in a straight line. From the guide rolls 12 and 13 the strip passes through the entry heater 14 and then between the reducing rolls 15 and 16 where its thickness is reduced.

Rolls 15 and 16 are driven and are heated to a temperature of 200° to 300° F. by means which are not shown. The rolled strip then passes through the exit heater 17, around freely rotating guide rolls 18 and 19 and is then wound into a coil upon the reel 20. The exit heater serves to anneal the rolled strip and facilitates the leveling of irregularities under the influence of the tension exerted by reel 20. It also assists, by heat conduction through the strip, in maintaining the portion between the rolls at a satisfactory rolling temperature. Reel 20 is driven, by means which are not shown, at such a rate as to maintain the portion of the strip between it and the reducing rolls 15 and 16 under a definite constant tension such that irregularities in the strip are leveled and the direction of motion of the strip is constant and the edges of the layers in the final coil are even.

As is shown in the drawing, the exit end of the heater 14 is arranged so that it is in close proximity to the point where the strip 10 passes into contact with the reducing rolls 15 and 16. To accomplish this, said exit end portion is tapered, the tapered portion approaching closely to the surfaces of the rolls as they approach each other for the rolling of the strip. The purpose is to reduce to a minimum the time which elapses between the emergence of the strip 10 from the heater 14 and its passage between the rolls 15 and 16. The entrance end of the exit heater 17 is preferably also tapered and arranged to approach the reducing rolls as closely as possible.

The arrangement is such that the temperature of the strip 10 when it is between the reducing rolls, is between approximately 435° F. and 600° F. This is the range of temperature which is suitable for rolling, i. e., within which the material readily undergoes plastic flow and is not injuriously affected. There is a drop in temperature as the strip passes between the reducing rolls. The latter are at a temperature of 200° F. to 300° F., as described heretofore, which is lower than the temperature of the strip, and heat is transferred to the rolls by conduction. There may also be a drop in temperature by radiation during the interval from the time a portion of the strip leaves the heater 14 to the time it makes contact with the reducing rolls. The strip is, therefore, heated to a temperature somewhat above 435° F. in the entrance heater, preferably to a temperature between 500° F. and 600° F. Also, the arrangement is such that the interval from the time a portion of the strip leaves the heater 14 to the time it makes contact with the reducing rolls is short, i. e., preferably not more than one-half of a second, regardless of the speed of travel of the strip. Under such conditions, the strip is sufficiently hot that it readily undergoes plastic flow between the rolls and all of the difficulties mentioned heretofore are avoided. The temperature to which the strip should be heated, within the range of 500° F. to 600° F., depends on the length of time which elapses while the strip passes from the heater 14 to the rolls 15 and 16.

The arrangement is also such that the strip is heated for only a relatively short period of time. This is controlled by regulating the temperature of the heater 14 and the speed of travel of the strip. While the time factor may vary, depending upon the final temperature to which the strip is heated within heater 14, the arrangement is such that a portion of the strip is at the temperature of 435° F. to 600° F. for not more than three seconds prior to making contact with the reducing rolls. Restricting the interval during which the sheet is at a high temperature serves to restrict the grain growth in the metal and the consequent weakening of the strip.

The exit heater 17 is maintained at a temperature such that the rolled strip is heated at a temperature of approximately 435° F. to approximately 600° F. for a time sufficient to permit annealing and a leveling of the irregularities but insufficient to result in an undesirable grain growth or weakening of the strip. While the time factor may vary, depending upon the temperature to which the strip is heated, the total time during which a portion of the strip is at the temperature of 435° F. to 600° F., that is, the time from the moment it reaches such temperature in entrance heater 14 to the moment it drops below such temperature in or after leaving exit heater 17, should not exceed five seconds. It is preferred that the interval from the time a portion of the strip leaves the reducing rolls until it reaches the exit heater does not exceed one half of a second.

It has been found that with the improved technique described, magnesium sheet material having a thickness of as little as .002 inch can be successfully produced, and the method is useful for sheet material from this thickness up to approximately .01 inch in thickness. With thicknesses greater than .01 inch, the especial procedure of this invention may be convenient but is not essential since the ordinary conventional procedure is satisfactory.

If it is desired that the sheet pass directly from reducing rolls 15 and 16 to a second pair of reducing rolls, such second pair of reducing rolls may be arranged at the exit end of exit heater 17. This may be followed by a third set of reducing rolls with an intervening heater, and so forth until the sheet has been reduced to the desired final thickness. In each heating operation prior to a rolling operation, the strip is heated at a temperature of 500° F. to 600° F. for a period not exceeding three seconds.

While a single embodiment of apparatus suitable for carrying out the invention has been described, this is illustrative only and other apparatus may be used as well. For example, electric current may be passed through the strip material during its travel to the reducing rolls to heat it to the proper temperature, and also as it passes from the reducing rolls to anneal the rolled strip. Apparatus for the electrical heating of strip material either inductively or by contact while it is being rolled are well known and such apparatus may be used in carrying out the present invention.

What is claimed is:

1. In reducing the thickness of sheet material from the group consisting of magnesium and magnesium-base alloys having a thickness of not more than approximately .01 inch by passing said material between reducing rolls, the method which comprises heating said sheet material at a temperature of from approximately 435° F. to approximately 600° F. and maintaining said sheet material at said temperature for a period of time not exceeding approximately 5 seconds during which time said passage between said reducing rolls occurs.

2. The method as claimed in claim 1 in which the heating during passage to the rolls con-

tinues until a time not more than approximately one-half second prior to the time the sheet material reaches the rolls.

3. In the method of reducing the thickness of sheet material from the group consisting of magnesium and magnesium-base alloys having a thickness not exceeding approximately .01 inch by means of pressure rolls, the step which comprises heating said sheet material at a temperature of from approximately 500° F. to approximately 600° F. for a period of time not more than three seconds prior to the time said sheet material reaches said rolls.

4. In reducing the thickness of sheet material from the group consisting of magnesium and magnesium-base alloys having a thickness not exceeding approximately .01 inch by means of pressure reducing rolls, the method which comprises heating said sheet material at a temperature from approximately 500° F. to approximately 600° F. for an interval not exceeding approximately 3 seconds and continuing until a time not more than approximately one-half second prior to the time said sheet material reaches said reducing rolls.

5. In reducing the thickness of sheet material from the group consisting of magnesium and magnesium-base alloys having a thickness not exceeding approximately .01 inch by means of

reducing rolls, the method which comprises heating said sheet material while it is passing both to and from said rolls at a temperature of approximately 435° F. to approximately 600° F. for a total period not exceeding approximately 5 seconds, said heating during passage to said rolls continuing until a time not more than one-half second prior to contact with said rolls and said heating during passage from said rolls starting not more than one-half second subsequent to contact with said rolls.

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