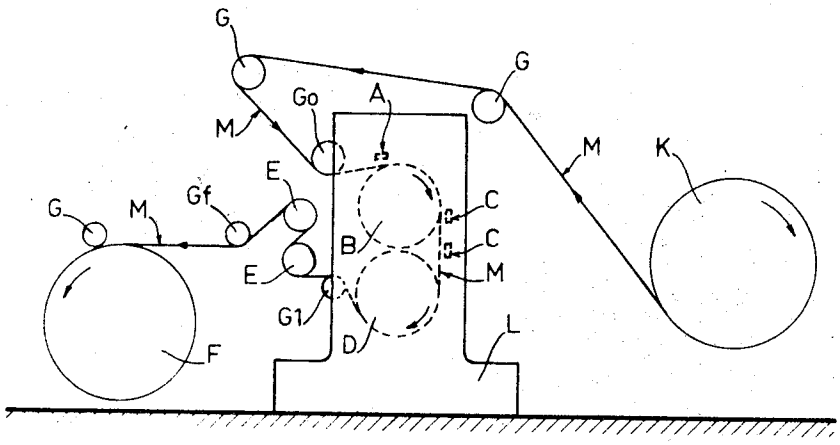
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PROCESS FOR CONTINUOUSLY ANNEALING ALUMINUM STRIP

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Fig. 1



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PROCESS FOR CONTINUOUSLY ANNEALING ALUMINUM STRIP

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ABSTRACT OF THE DISCLOSURE

The annealing of strips of aluminum and alloys of aluminum in the cold rolled state in which the strip is continuously advanced for sequential increase in temperature substantially uniformly crosswise of the strip by successively passing the strip before a first series of heating elements which introduce one increment of heat, over a portion of a heated drum which introduces an additional increment of heat, before a second series of heating elements which introduce a still further increment of heat, and then over a portion of a heated drum further to raise the temperature of the strip and finally over cooling rolls to reduce the temperature of the strip and supporting the strip on rollers between the cooling means and the wind-up roll to effect the desired gripping relationship for feeding the strip to the wind-up roll.

This invention relates to annealing thin strips of aluminum or alloys of aluminum.

It is known that, in annealing certain alloys of aluminum, the heating rate exerts a considerable influence on the grain size of the annealed metal. In order to obtain a fine grain structure, it is necessary rapidly to heat the thin strips of aluminum or alloys of aluminum, such as aluminum alloy A–M1.

On the other hand, it is known that strips of cold rolled metal can be annealed quickly and continuously by means of a heating drum, by unreeling and applying the strips to be annealed onto the periphery of the drum, as described in French Pat. No. 997,839, issued Aug. 7, 1945.

As described, it is necessary to bring the heating cylinder to a temperature which is at least equal to the desired high annealing temperature. This results in an abrupt heating of the metal with corresponding transverse expansion of the metal strip with the heating being localized at the zone which comes into contact with the heating drum.

When a thin strip of aluminum or alloy of aluminum is involved, which is fragile and easily wrinkled, especially while hot, this sudden transverse expansion results in the formation of folds or creases which render the strip unsuitable for subsequent use.

It is an object of this invention to provide a method and means for annealing thin strips of aluminum or alloys of aluminum without the disadvantages of the process heretofore described and in which the annealing process can be carried out in a simple and continuous fashion.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, an embodiment of the invention is shown in FIG. 1 of the drawing which is a vertical view partially in cross-section, showing the arrangement of elements for annealing metal strip in accordance with the practice of this invention.

The present invention is concerned with the process for annealing thin strips of aluminum or alloys of aluminum in the cold rolled state by means of heating cylinders characterized in that the strip M, which is to be annealed, is heated rapidly and progressively by unreeling the strip and then passing the strip at high speed successively before a first series formed of a plurality of gas burners A arranged

in crosswise extending longitudinally spaced rows, then over a peripheral portion of a heated metal cylinder or drum B mounted for rotational movement, then in front of a second series of a plurality of gas burners C arranged in one or more rows crosswise of the strip, then against a peripheral portion of a second rotating heating cylinder D, then over at least one rotating cooling cylinder E, and finally to a rewinder for winding the annealed strip into coil form in a conventional manner.

The strip is supported and maintained under tension between the gas burner section A and the heating cylinder D by means of tension rollers G, in a manner well known to the art. The rollers G and the cooling cylinders E which are located beyond the heating cylinder D provide a gripping system which insures the uniform rewinding of the metal strip. The speed of rotation of the rotating elements is such that the strip M is wound without slippage on the rotating elements.

The temperature of any portion of the strip is increased rapidly but progressively between the gas burners A and the heating cylinder D at a rate previously selected and in a manner that is achieved by regulating the intensity of the burners A and C and the temperatures of the cylinders B and D, coupled with the rate of linear travel of the strip. In the absence of burners A and C, progressive heating in the desired manner cannot be achieved. The burners A and C can, however, be replaced by hot gas heaters or injectors in which the hot gases are heated to the desired temperature by well known techniques.

Furthermore, by regulating the temperature of the cooling cylinders E, it is possible for the strip to be cooled at a desirable rate.

The following example is given by way of illustration, but not by way of limitation, of the practice of this invention.

With reference to the drawing, the apparatus comprises a supply reel K having a coil from which metal strip M to be annealed can be unwound. The strip is passed over guide rollers G, *Go*, *Gf*, and G1 which operate to guide and support the metal strip unwound from the coil. The strip is heated by means comprising a first series of rows formed of a plurality of crosswise aligned gas burners A, a first heating cylinder B, a second series of rows formed of a plurality of crosswise aligned gas burners C and a second heating cylinder C. Following traverse of the heating means, the strip is advanced to cooling means comprising two cooling cylinders E and then to a takeup reel F on which the annealed strip is rewound. The apparatus includes a device located at G1 for measuring the temperature of the strip M. The heating cylinders are heated by electrical means such as electrical resistance heaters, and the cooling cylinders E are cooled internally by circulation of cooling water in a manner well kown to the art. All of the cylindrical members K, G, B, D, E and F are equipped with means such as bearings which permit them to rotate at the desired speed. The arcs of contact between the strip and the cylinders B and D are selected to be equal to about 100° and 150°, respectively.

The relative dimensions of the different members of the apparatus are approximately as illustrated in the drawing. The distance between the axes of the supply reel K and the take-up reel F is equal to about 4 meters. Between the guide roller *Go*, which guides the strip M before it passes before the burners A, and the guide roller *Gf*, which guides the strip after it passes over the cooling cylinder E, the strip is supported in a manner such that it never remains without any support over a length of more than 500 mm. The assembly comprising the rollers F, G1, *Gf*, the rows of burners A, C, and heating cylinders B and D are supported by a single steel pedestal L adapted to be laxed to the floor. The lengths of the cylinders and rollers are of the order of about 1200 mm., which permits

strips having a width of about 1 meter to be processed through the apparatus. Disposed along the roller G1 at a number of different locations, are sensing devices for measuring the temperature in order to control the temperature of the strip M.

EXAMPLE 1

In this example of the invention, it is desired to anneal a coil M1 of A–M1 alloy in the cold rolled state, containing about 1.2% by weight manganese, 0.4% by weight iron, 0.3% by weight silicon, with the remainder being aluminum plus its usual impurities. The thickness of the strip is 0.12 mm. and its width is equal to 1 meter. The temperature of the heating cylinders B and D is adjusted to 250° C. and 360° C., respectively. The burners A, fed with propane gas, are regulated so that the temperature to which the strip is raised is of the order to about 200° C. The propane gas burners C are regulated so that the tempearture to which the strip is raised reaches about 350° C. The cooling cylinders E are cooled internally by cold water circulated through internal jackets at a rate of flow of the order of about 12 liters per minute per cylinder.

In practice, the coil is mounted on the supply reel K and the leading edge of the strip is unwound and threaded through the annealing apparatus to the take-up reel F for rewinding.

The strip is caused to travel from the supply reel K to the take-up reel F at a linear speed of 15 meters per minute while being maintained under slight tension by means well known to the art.

The temperature of the strip is progressively raised from a temperature of 20° C. to a temperature of 360° C. over a span of time of about 2 seconds and is held at 360° C. for approximately another 2 seconds. Thereafter, the temperature is brought down to the region of 20° C. in about 2 seconds during passage over the cooling drums. The rewound coil of annealed metal is free of creases which otherwise would be detrimental to its subsequent use.

By way of comparison, two other coils M2 and M3 of A–M1 alloy, similar to the previously described coils M1, are annealed as follows:

(a) The coil M2 is annealed while wound in coil form, in a static furnace, in accordance with conventional means.

(b) The coil M3 is continuously annealed while being unwound and processed through the apparatus of this invention but with a single heated cylinder B, the other heating cylinder D not being heated and the rows of gas burners B and C being extinguished, with the strip being processed through the unit at a linear speed of 15 meters per minute. The temperature of the strip M3 after contact with the heating cylinder B is raised to about 350° C.

The mechanical characteristics, namely, breaking load, elongation at break, grain size and smoothness were measured with the results being set forth in the following table:

TABLE I

Coil	Annealing conditions	Breaking load (h bar)	Elongation, percent	Grain size in μ	Smoothness
M1	With unwinding according to the invention.	11.7	24 to 26	30	No crease.
M2	In coil	11.7	15 to 17	150	Do.
M3	On unwinding with a single heating cylinder.	11.9	22 to 25	30	Several creases.

The process, according to the invention, makes it possible to obtain an aluminum or aluminum base strip having fine grains of only 30 microns and a high elongation of 24% to 26%. This greatly facilitates use of the strip in subsequent fabricating operations such as stamping or folding. The metal strip which has been annealed in coil form has a relatively coarse grain of 150 microns and low elongation which results in tears during the stamping of certain elements which are difficult to produce, such as bottle capsules.

The metal strip M3 annealed with the single heated cylinder, without auxiliary gas burners, has a fine grain size and satisfactory elongation but the resulting annealed strip is characterized by poor smoothness.

EXAMPLE 2

It is desired to anneal, in accordance with the invention, a strip of refined aluminum M4 containing less than 0.1% by weight of impurities. The strip has a thickness of 0.15 mm. and a width of 1 meter.

The apparatus is adjusted to the conditions set forth in Example 1. The strip is advanced through the apparatus at a rate of 14 meters per minute.

By way of comparison, another similar strip M5 is annealed in coil form. The following are the results which have been obtained from the tests:

TABLE II

Strip	Type of annealing	Breaking load (h bar)	Elongation, percent	Grain size in μ
M4	According to the invention	7.2	16 to 19	30
M5	In coil form	3.7	4 to 5	150

EXAMPLE 3

In this example of the invention, it is desired to anneal strips of A–M1 metal having thicknesses which are, respectively, 0.045 mm., 0.080 mm., 0.12 mm., 0.20 mm., and 0.25 mm. The flames of the burners and the temperature of the heating cylinders are adjusted to give a temperature rise which is the same as in Example 1 but the linear speed of travel of the metal through the apparatus is varied in accordance with the thickness of the strip to be annealed.

The following table gives the results of the measurement secured from the annealed strips:

TABLE III

Thickness	Unwinding speed, m./min	Resistance in (h bar)	Elongation, percent	Grain size, mm.	Stamping test, Erichsen index, mm.	Smoothness
0.045	35	10.9	9	30	6.3	Without crease.
0.080	25	11.4	20	25	7.8	Do.
0.12	15	11.3	25	30	8.3	Do.
0.20	12	11.1	34	30	8.5	Do.
0.25	10	11.2	45	30	8.5	Do.

All of the foregoing produce metal strip having excellent properties.

The thin strips of aluminum or alloys of aluminum which are annealed in accordance with the practice of this invention provide excellent material for use in the manufacture of stamped products, such as capsules for bottles, dishes for the food industry, and for domestic use, blades for heat exchangers and the like.

It will be understood that changes may be made in the details of construction, arrangement and operation without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. A process for annealing thin strips of aluminum or alloys of aluminum in the cold rolled state comprising the steps of continuously advancing the strip linearly at a uniform rate and successively exposing the moving strip to a first series of heating elements arranged crosswise of the strip to introduce an increment of heat into the strip substantially uniformly crosswise of the strip, advancing

the strip over a peripheral portion of a first heated drum rotating at a peripheral speed corresponding to the linear speed of the strip to introduce an additional increment of heat substantially uniformly crosswise of the strip, to a second series of heating elements arranged crosswise of the strip for adding and additional increment of heat to the strip and then over a peripheral portion of a second heated drum rotating at a peripheral speed corresponding to the linear speed of the strip, and then advancing the heated strip from the second heated drum about a peripheral portion of a cooling drum to reduce the temperature of the strip, winding the strip on a wind-up roll, and supporting the strip on rollers between the cooling drum and wind-up roll to grip the strip for feeding the strip at a uniform rate to the wind-up roll.

2. The process as claimed in claim 1 in which the heating elements comprise gas burners.

3. The process as claimed in claim 1 in which the heating elements comprise hot gas ejectors.

4. The process as claimed in claim 1 in which the heating elements comprise gas burners arranged in crosswise spaced relationship in longitudinally spaced rows.

References Cited

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RICHARD O. DEAN, Primary Examiner

U.S. Cl. X.R.

148—156

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,682,712 Dated August 8, 1972

Inventor(s) Jacques Vernier

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading column 1, line 6, after "France", insert -- assignors to Societe De Conditionnement En Aluminum (SCAL GP), Paris, France -- .

Signed and sealed this 1st day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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