METHOD FOR PRODUCING FLAT SOLUTION HEAT TREATED TITANIUM AND ZIRCONIUM ALLOY SHEETS

Harold D. Kessler, Las Vegas, and Raymond S. Richards, Henderson, Nev., assignors to Titanium Metals Corporation of America, New York, N. Y., a corporation of Pennsylvania

No Drawing. Application February 7, 1956
Serial No. 563,836
3 Claims. (Cl. 148—10)

This invention relates to the heat treatment of metal sheets, and more particularly to solution heat treatment of sheets of refractory metals such as titanium and zirconium.

Heat treatment of metal sheets is employed to impart specific and desirable properties thereto. In a solution heat treatment the temperature of the sheet is raised sufficiently to insure solution of certain alloy constituents, and the heating is generally followed by rapid cooling such as quenching. Such sequence of steps often results in distortion of the sheet so that it is no longer flat and makes necessary an additional straightening operation to provide heat treated sheet in flat, useful form.

A principal object of this invention is to provide a simple, economical and rapid method for solution heat treating metal sheets. A further object is to provide a method which will produce flat, solution heat treated metal sheets of refractory metals such as titanium and zirconium. Another object is to provide a method for producing flat, solution heat treated metal sheets in which scaling of the sheet surface is materially reduced. A still further object is to provide a rapid, combined method for flattening and solution heat treating metal sheets. These and other objects of this invention will be apparent from the following detailed description thereof.

This invention, in its broadest aspects, contemplates a method for producing flat, solution heat treated sheets of metals such as titanium and zirconium in which the sheet is heated to the required temperature by passage of an electric current through the sheet and also to application of temperature to the sheet at a point of greatest deviation. The method involves a straightening operation, it is not necessary that the original sheet be flat. The sheet is held by clamps or jaws engaging opposing edges, preferably the ends, and the clamps maintain the sheet in a suitable apparatus, which may include the sheet between the clamps. The electrical and mechanical features of the apparatus may be of any suitable type to produce these effects, and may vary considerably depend-

ing on the size, thickness and composition of the sheet to be treated, as well as other factors which will be obvious to those skilled in the art.

Sufficient electric current should be passed through the sheet to heat it rapidly to the required solution heat treatment temperature. This temperature will vary according to the composition of the alloy and the properties desired, but will generally lie within the range of 1300° to 1800° F. The sheet is maintained at solution heat treatment temperature for a short time to insure proper solution effect. However, this time should not be excessively long, preferably not more than one minute and generally not more than ten minutes. Holding the sheet at solution heat treatment temperature longer than about ten minutes to to be avoided since this will result in heavy scale formation, which is not readily removed and which becomes a serious problem.

The sheet is stretched while it is at solution heat treatment temperature. The stretching is preferably accomplished towards the end of the period at which the sheet is maintained at such temperature. The sheet is stretched to eliminate unflatness originally in the sheet, or caused by distortion during the heating step. Preferably the sheet is stretched longitudinally to an extent not more than about 5% of its original length. Elongation of 5% will be found to remove even gross unflatness, and less elongation may be employed when the condition of the sheet needs only a lesser amount to provide substantial flatness.

After stretching the sheet is rapidly cooled; preferably quenched by application of water sprays or other equivalent heat extracting means, which may include brine, cooled brine, and high velocity gases. During quenching the sheet is maintained under tension to prevent sagging or distortion due to the quenching operation, but the tension at this stage is sufficient only to maintain the sheet flatness previously obtained and no additional stretching is necessary or desirable. Therefore, the tension maintained on the sheet during quenching should generally be less than the yield strength of the sheet, and preferably it will be substantially less. It may occur, primarily because of nonuniform quenching, that a slight additional stretching may be required during quenching. Under these conditions the tensile force applied at times during quenching may slightly exceed the yield strength of the sheet. The amount of work performed on the sheet should, however, be kept at a minimum at this stage. Since the sheet will contract during cooling, the tension maintaining apparatus should include hydraulic or spring mechanisms to provide tensile relief to prevent contraction from increasing the force applied above that necessary or desirable. The quenched sheet will be found to be uniformly solution heat treated, flat, and lightly scaled so that a simple, aqueous scale remover applied at relatively low temperature will restore an acceptable surface condition.

Flatness in metal sheet products of the type to which this invention relates, is generally measured as a percentage figure obtained by placing a straight edge in any direction on the sheet and measuring the length between contact points and the distance from the straight edge to the material at the point of greatest deviation. The relation of the deviation expressed as a percentage of the distance between contact points is considered flatness. Since flatness is a relative quality, it will vary somewhat according to the use requirements and other factors. Specifications often call for flatness not exceeding two or three percent for some applications, while others use a seven or eight percent flatness may be acceptable. Often rolled products without straightening will show a serious unflatness determined as high as 15% or higher flatness.
The following example will illustrate the practice of an embodiment of this invention.

**Example 1**

An unflattened sheet (flatness 16%), 20 inches by 30 inches, rolled from a titanium base alloy containing 6% aluminum and 4% vanadium and of thickness .075" was clamped securely in a frame by its end edges. One end of the frame and its associated clamp was arranged to be movable with respect to the opposite clamp, and arranged to be actuated by a hydraulic cylinder to apply tension to the sheet maintained by the clamps. A source of direct current electric power was connected to each of the clamps, which were insulated from the rest of the structure, and a current of 14,000 amperes and 10 volts was applied to the sheet. The temperature of the sheet was thereby raised to 1550° F. in about 30 seconds. On reaching this temperature the power source was cut back to 10,000 amperes to maintain the sheet at 1550° F. for two minutes. Stretching was initiated just prior to the end of the two minute holding period by application of a tensile force of 4,000 pounds between the clamps until an elongation of 3% in the length of the sheet was obtained. At this stage the sheet was essentially flat. The electric heating current was then turned off and simultaneously water sprays were applied to quench the sheet. At the same time a relief valve in the hydraulic cylinder actuating the stretching mechanism was adjusted so as to automatically maintain a residual tension on the sheet during the cooling of about 1,000 pounds. After the sheet was cooled, it was removed from the frame and a simple washing at about 160° F. with an aqueous solution containing 20% nitric acid and 2% hydrofluoric acid was effective in removing the light scale which had formed. After descaling, the sheet was rinsed and dried, and flatness determined to be 2%.

The method of solution heat treating and flattening, according to this invention, has several important advantages. Stretching the sheet at solution heat treating temperature accomplishes flattening under conditions which do not affect the mechanical properties of the sheet. In this respect the method of this invention is unique and does not introduce disadvantageous effects such as work hardening which occurs when stretching is accomplished cold or at moderately elevated temperature such as 500° to 700° F. When metal sheets are worked, as by stretching, at temperatures much below the solution heat treating temperature, appreciable and deleterious hardening, increase in yield strength, and reduction in ductility and formability inevitably result. In the method of this invention, however, since the deformation of the sheet is accomplished at solution heat treatment temperature, these disadvantages are not encountered and the mechanical properties of the solution heat treated sheet are essentially the same as if it had not been subjected to any stretching or straightening work.

The ability to heat treat and straighten thin metal sheets in an extremely short period of time is another important feature of this invention. Exposure to the atmosphere of alloys of the type to which this invention relates at high temperatures inevitably results in scaling of the sheet surface. If the scaling is severe, it cannot be removed except by application of strong descaling agents such as molten alkali applied at temperatures of the order of 800° F. or higher. Such treatment is expensive and difficult to apply to thin sheets and, moreover, exposure of the solution heat treated and quenched sheet again to a temperature as high as 800° F. or higher results in substantial change in mechanical properties. Since the heat treatment and flattening operation, according to this invention, is carried out in an extremely short space of time, never longer than a few minutes, the scale formed under these conditions is of such character that it may be readily removed by an aqueous descaling agent at temperatures below that at which any deleterious effect on the sheet properties occur.

We claim:

1. A method for producing flat, solution heat treated sheets of a metal selected from the group consisting of titanium and zirconium base alloys which comprises: heating said sheet by passage of an electric current therethrough until the temperature thereof reaches between 1300° F. and 1800° F., maintaining said sheet at said temperature of a period not exceeding ten minutes, stretching said sheet to provide an elongation thereof of not more than 5% in one direction during the time that said sheet is maintained at said temperature and quenching said sheet while maintaining it under tension.

2. A method for producing flat, solution heat treated sheets of a metal selected from the group consisting of titanium and zirconium base alloys which comprises: heating said sheet by passage of an electric current therethrough until the temperature thereof reaches between 1300° F. and 1800° F., maintaining said sheet at said temperature for a period not exceeding two minutes, stretching said sheet to provide an elongation thereof of not more than 5% in one direction during the time that said sheet is maintained at said temperature and quenching said sheet while maintaining it under tension.

3. A method for producing flat, solution heat treated sheets of a metal selected from the group consisting of titanium and zirconium base alloys which comprises: heating said sheet by passage of an electric current therethrough until the temperature thereof reaches between 1300° F. and 1800° F., maintaining said sheet at said temperature for a period not exceeding ten minutes, stretching said sheet to provide an elongation thereof of not more than 5% in one direction during the time that said sheet is maintained at said temperature and quenching said sheet while maintaining it under tension less than its yield strength.

**References Cited in the file of this patent**

**UNITED STATES PATENTS**

55 1,570,815 Wylie ---------------- Jan. 26, 1926
50 1,887,339 Strobile ---------------- Nov. 8, 1932
2,550,474 Harrington ------------- Apr. 24, 1951

**OTHER REFERENCES**