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PROCESS FOR CHANGING THE PROPERTIES OF SILICON STEEL

No Drawing. Original application filed September 19, 1924, Serial No. 738,714. Patent No. 1,677,139. Divided and this application filed May 4, 1928. Serial No. 275,262.

This invention relates to an improved process for changing the properties of silicon steel, more particularly to an improved process for increasing the permeability thereof, and is a division of my copending application, Serial No. 738,714, filed September 19, 1924 issued as Patent 1,677,139, July 17, 1928.

A process heretofore employed commercially for heat treating silicon steel for the purpose of increasing its magnetic permeability has been to anneal the silicon steel at a temperature above 788° C. and up to 1006° C. It is known that silicon steel is susceptible to greater permeability increase than is obtainable by this method. Improved methods have been proposed, such as the annealing of the silicon steel in vacuo, but in general these improved processes have not been adopted commercially, because although small lots of silicon steel may in the various manners proposed be treated in the laboratory, the proposition of applying the same process to the commercial treatment of large masses of the material has not been solved in the same way.

The principal object of this invention is to provide a simple, improved method for increasing the permeability of silicon steel.

The invention consists in heating the silicon steel at a temperature considerably higher than its magnetic transformation point, or Curie point, and cooling quickly from a temperature above 550° C.

Other objects and features of the invention will appear in the following description and will be particularly pointed out in the appended claims.

The process consists in heating the silicon steel to a temperature above 1000° C., but preferably not higher than 1250° C., cooling to a temperature not lower than 550° C., and then cooling quickly from this temperature to a temperature sufficiently low so that controlling the rate of cooling from that temperature will have substantially no effect. The temperature can be controlled down to room temperature, but in general, controlling the cooling to 200° C. or 250° C. is sufficient.

In some instances a double heat treatment may be employed by means of which the process and temperatures can in some cases, particularly when comparatively large sized pieces of the metal are treated, be more efficaciously controlled. The double heat treatment comprises a first annealing above 1000° C., and a second annealing at a temperature not lower than 550° C., and then cooling the metal rapidly from this temperature. When treating silicon steel according to this method, it is necessary to take cognizance of the composition of the silicon steel, and also of the shape and size of the pieces treated, the temperature and time of the two treatments, and also of the cooling after the heat treatments which is slightly different for each change in composition, shape or size.

The process can be carried on in a number of ways, depending upon the conditions present, but the process embodying the present invention comprises three steps.

The first step is the subjecting of the silicon steel to a sufficiently high temperature for a long enough time to accomplish a thorough annealing. In general the annealing can be gauged by the growth of crystals in the material annealed. Where the gowth of crystals is rapid the time of annealing can apparently be reduced. For most silicon steels a temperature from 1000° C. to the melting point can be employed, although it is not desirable to use a temperature very much above 1250° C. because on account of limitations of present commercial equipment, higher temperatures are not practicable. In general if a temperature of 1000° C. is employed, the annealing time will vary from one to twelve hours, depending upon the conditions present, but where higher temperatures are employed, the time can be shortened accordingly. If a large mass of material is being treated the annealing time can be lengthened to insure having all of the mass up to high enough temperature for a sufficient length of time. The added time will not deleteriously affect the parts which are in a position to receive the most heat unless the temperature becomes too high.

The second step is cooling the material to a temperature not lower than 550° C., and the rate of cooling depends considerably upon the shape and dimension of the pieces treated. In general, it is better to cool slowly than

quickly. It is thought that quick cooling either causes a change in the structure of the metal or sets up mechanical strains due to unequal cooling, but the reason is not well established. It is known, however, that greater permeability is obtained by slow cooling than by quick cooling in this step of the process. A rate of cooling which has shown uniformly good results is 2° C. per minute. Good results may be obtained by cooling to a temperature of about 718° C.

The third step in the process is rapidly cooling the material after the first cooling step outlined above. It is desirable to accomplish this as quickly as possible without setting up mechanical strains which occur when unequal contraction of the metal takes place. As an example, unequal contraction of the metal takes place when the exterior of the piece treated is cooled more rapidly than the interior or when one side of the piece, as of a flat sheet is cooled more quickly than the opposite side. If, for instance, one side cools quickly it contracts the metal so as to cause a concave surface on the cool side and a convex one on the hot side. Then when the convexed surface cools it contracts but being unable to bend back the now rigid concave surface it is stretched beyond its elastic limit. This stretching acts in the same way as if the metal is affected directly by a mechanical force sufficient to stretch or bend it, and will have the effect of destroying, at least in part, the "built up" permeability of the part affected.

For the purpose of cooling flat strips of silicon steel good results are obtained by cooling between two copper plates. This is a more rapid cooling than normal cooling in open air, but is still slower than quenching in water.

The important improvement in this process is the rapid cooling of the silicon steel from a temperature above 550° C. Silicon steel which has been treated by the old process referred to above, by the application of this process, particularly when in the form of a double heat treatment, can be made to show an increase of 50 to 100% in permeability. As an example, a piece of 3½% silicon steel, which had a permeability of 6000 units when treated according to the old process, was treated by the improved process in the form of a double heat treatment and then showed a permeability of over 10,000. The particular temperature employed in the first heating does not seem to be of importance, except that it must be sufficiently high to cause the result which is desired; that is to say, the important thing is to secure a thorough annealing, (and this can be gauged by the size of the crystals), and any temperature capable of causing that result can be employed if maintained for a sufficient length of time.

Reference has been made throughout to changing the permeability of silicon steel, but it is apparent that other properties of the material will also be changed by the use of this treatment. It is, therefore, not desired to confine the invention to a method for increasing the permeability of silicon steel, and the invention is only to be limited by the scope of the appended claims.

By "heat conductivity" of the metallic material placed in contact with the silicon steel is meant the ability of the material to lower the temperature of the silicon steel or the ability of the material to withdrawn heat from the silicon steel.

What is claimed is:

1. A process for increasing the permeability of silicon steel, which consists in heating the silicon steel at a temperature between 1000° C. and 1250° C., cooling at a rate of not more than 10° C. per minute to a temperature between 550° C. and 800° C. and then cooling the steel slower than quenching in water but faster than quenching in open air.

2. A process for increasing the permeability of silicon steel, which consists in heating the silicon steel at a temperature between 1000° C. and 1250° C. for between one and twelve hours, cooling at the rate of not more than 10° C. per minute maximum to a temperature between 550° C. and 880° C., and then cooling the steel slower than quenching in water but faster than quenching in open air.

3. A process for increasing the permeability of silicon steel, which consists in heating the silicon steel at a temperature between 1000° C. and 1250° C., cooling slowly to a temperature between 550° C. and 800° C., and then cooling the steel slower than quenching in water but faster than quenching in open air.

4. A process for increasing the permeability of silicon steel, which consists in heating the silicon steel at a temperature between 1000° C. and 1250° C., cooling slowly to a temperature between 550° C. and 800° C., and then cooling by placing it in contact with a metallic material having a higher heat conductivity than air and a lower heat conductivity than water.

5. A process for increasing the permeability of silicon steel, which consists in heating the silicon steel at a temperature between 1000° C. and 1250° C. for between one and twelve hours, cooling slowly to a temperature between 550° C. and 718° C., and then cooling by placing it in contact with a metallic material having a higher heat conductivity than air and lower heat conductivity than water.

6. A process for increasing the permeability of silicon steel, which consists in heating the silicon steel between a temperature of 1000° C. and 1250° C. for between one and twelve hours, cooling at the rate of not more than 10° C. maximum to a temperature between 550° C. and 718° C., and then cooling by placing it in contact with a metallic ma-

terial having a higher heat conductivity than air and a lower heat conductivity than water.

7. A process for increasing the permeability of silicon steel, which consists in heating the silicon steel at a temperature between 1000° C. and 1250° C., cooling slowly to a temperature between 550° C. and 800° C., and then cooling the steel by placing it in contact with copper plates which have a higher heat conductivity than air and a lower heat conductivity than water.

8. A process for increasing the permeability of silicon steel, which consists in heating the silicon steel at a temperature between 1000° C. and 1250° C., cooling slowly to a temperature of approximately 718° C., and then cooling the steel by contacting it with copper plates which have a higher heat conductivity than air and a lower heat conductivity than water.

9. A process for changing the properties of silicon steel, which consists in heating the silicon steel at a temperature between 1000° C. and 1250° C. for between one and twelve hours, cooling at the rate of not more than 10° C. per minute maximum to a temperature of about 8° C. below the magnetic transformation point of the silicon steel, and then cooling the steel by contacting it with the material which has a higher heat conductivity than air and a lower heat conductivity than water.

In witness whereof, I hereunto subscribe my name this 1st day of May, 1928.

JOHN CLARENCE KARCHER.