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SILICON ELECTRICAL STEEL

Alvin R. Williams, Cleveland, Ohio, assignor to The American Steel and Wire Company of New Jersey, a corporation of New Jersey

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This invention relates to silicon electrical steel, the object being to provide the higher silicon grades of such steel with magnetic properties suiting it for use in laminated core magnetic equipment, by a process that is simpler and more economical than prior art processes.

In carrying out this invention, the first step is to produce a silicon steel with a silicon content of from 2% to 5% and otherwise of a composition suitable for electrical strip, it being understood that although the carbon content is normally reduced to as low a factor as is practical, the steel of necessity contains an appreciable amount of carbon, such as around .06%, in view of the limitations of current commercial steel refining practices. In some instances, the steel may contain small amounts of aluminum or otherwise have its composition varied within the limitations necessary to provide silicon steel with the magnetic properties required of the type of product here involved.

This steel may be worked into either strip or sheet form by any method. When worked by the strip method, the steel may be produced as hot rolled strip which is subsequently cold rolled to gage, it being unnecessary to maintain the cold reductions within any predetermined limits. Ordinary hot pack rolling methods are applicable if the steel is to be produced as hot rolled sheet. As so far described, the method is conventional, it being at this point that the prior art teaches the application of sundry elaborate processing for imparting the necessary magnetic properties. A feature of the present invention is that a single simple step is sufficient to provide the necessary magnetic properties, although it is to be understood that if this step is followed by more elaborate processing as taught by the prior art, the magnetic properties are further improved.

The simple step mentioned above which features the present invention consists in continuously annealing the steel whether in strip or sheet form in a decarburizing atmosphere with the annealing temperature and time factors adjusted to remove all the strain from the strip or sheet and to also cause the decarburizing atmosphere to remove substantial amounts of the carbon from throughout the thickness of the strip or sheet, the decarburizing atmosphere being oxidizing to a degree regulated to cause the formation of a thin, tightly adherent oxide film on the strip or sheet without the production of a heavy, loose scale. The term "annealing" as it is used here is intended to cover any heat treatment effecting the removal from the strip or sheet of the strain that was imparted when it was worked to gage. Also, it is to be understood that the scale formed during the hot rolling phase of the strip and which is naturally present on hot rolled sheet, may be removed and, in general, that the steel may be subjected to any of the various processing steps inherent in the production of strip or sheet.

As a result of the above step, the carbon content of the strip or sheet is decreased from that dictated by steel making economies to one that is comparatively extremely low. This is effected simultaneously with the annealing recognized as being necessary to remove strain and, at the same time, the described thin, tightly adherent oxide film is imparted, this film being suitable for use as interlamellar insulation.

Steel strip or sheet having a composition within the range of the higher grades of silicon electrical steel, such as those containing 2% or more silicon, and which has been subjected to this single step, may be sold as suitable for the uses to which this type of product is placed and the steel will be found to compare favorably with steel produced by the elaborate processing taught by the prior art. In some instances the magnetic properties of this simply treated steel will be found to be better than the properties obtainable by the more complicated prior art processing.

The decarburizing atmosphere that has been found to work best is one consisting of from 8% to 15% carbon dioxide, with the balance mainly nitrogen and sufficient water to saturate the atmosphere with water vapor at from 50° F. to 85° F. This atmosphere may be produced very economically by burning a hydrocarbon gas under such conditions as to result in a mixture consisting mainly of carbon dioxide and nitrogen, a gas being chosen having a composition such that its combustion products provide the gas described.

As a specific example of the invention, steel was produced with a composition suitable for electrical silicon steel of the grade containing around 3.25% silicon, the steel being produced by conventional steel making practices and, therefore, containing about .05% carbon. This steel was hot rolled into strip, pickled, and cold rolled to .014" thick by means of a cold rolling mill. The resulting cold rolled strip was then degreased, and put through a continuous annealing furnace at such a rate that it remained within the furnace for from 5 to 8 minutes, the temperature in

the furnace being about 2000° F. The furnace was of the type adapted to confine the strip in a gaseous atmosphere, and an atmosphere of the previously described composition was used. It is to be understood that in the commercial production of this atmosphere the analysis may vary slightly, small amounts of what may be considered as impurities causing no material harm. The temperature given may be varied within the range of from 1750° F. to 2200° F. providing the time period is suitably adjusted.

The steel resulting from the above practice had a core loss of .568 watt per pound at 60 cycles with a flux density of 10,000 gausses. This value was obtained in the case of samples cut from the steel and, therefore, containing the strain inherent in such instances. It will be noted that this core loss value is better than that commonly accepted as a maximum in the case of silicon electrical steel of grades having silicon contents in the neighborhood of 3.25%. The maximum permeability of the steel likewise was better than is commonly required of this grade. The chemical analysis of the ultimate product showed that the carbon content had been dropped to less than .02% and an examination of its surface showed that the product possessed a thin, tightly adherent oxide film of a type suitable for use as interlamellar insulation.

In some instances it may be desirable to stabilize strip or sheet produced in accordance with this invention so as to prevent change in its magnetic properties through aging. Such stabilizing may be effected in the conventional way, this involving the usual heat treatment of around 1450° F. for a few hours. This stabilizing treatment in some instances also functions to further improve the magnetic properties of the material.

I claim:

1. A method of making silicon steel electrical strip or sheet, said method comprising the steps of producing a silicon steel with a composition suitable for said product and containing an appreciable amount of carbon, working said steel to strip or sheet, and continuously annealing said strip or sheet in a decarburizing atmosphere for from five to eight minutes at temperatures of from 1750° F. to 2200° F., said atmosphere being oxidizing to a degree regulated to cause the formation of a thin, tightly adherent oxide film on said strip or sheet without the production of a heavy, loose scale and consisting of from 8% to 15% carbon dioxide with the balance mainly nitrogen and sufficient water to saturate said atmosphere with water vapor at from 50° F. to 85° F.

2. A method of making silicon steel electrical strip or sheet, said method comprising the steps of producing a silicon steel with a composition suitable for said product and containing substantially more than about .02% carbon, working said steel to strip or sheet, and continuously annealing said strip or sheet in a decarburizing atmosphere at temperatures of from 1750° F. to 2200° F. to reduce the carbon to less than about .02%, said atmosphere being oxidizing to a degree regulated to cause the formation of a thin, tightly adherent oxide film on said strip or sheet without the production of a heavy, loose scale and consisting of from 8% to 15% carbon dioxide with the balance mainly nitrogen and sufficient water to saturate said atmosphere with water vapor at from 50° F. to 85° F.

ALVIN R. WILLIAMS.