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PRODUCTION OF SILICON STEEL SHEET STOCK HAVING HIGH SURFACE RESISTIVITY AND RESISTANCE TO ADHESION

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This invention relates to the production of silicon steel sheet stock characterized by high surface resistivity and resistance to adhesion. By sheet stock I mean material of sheet gauge, either in the form of coils of strip of indefinite length, or in the form of individual sheets. This material is useful in the production of laminated cores for electrical purposes.

It is an object of my invention to provide such silicon steel sheet stock which will not only have a high surface resistivity, but which in a laminated condition will have a high space factor. Cores wound from silicon steel sheet stock must be reannealed after winding to relieve strains. Trouble has been encountered during this operation in that prior coatings have fused and caused adhesions between adjacent laminae, thereby hindering the penetration of the bonding plastic with which such cores are impregnated in certain types of transformers. It is therefore an object of my invention to provide such sheet stock which will have great resistance to adhesion. Further objects of my invention include the provision of silicon steel sheet stock as outlined above, by means of a process and treatment which is extremely simple and requires substantially no additional labor or equipment and which is relatively inexpensive in cost.

Reference is made to my copending application, Serial No. 620,055, filed October 3, 1945, in which I have disclosed and claimed a process for the treatment of silicon steel sheet stock for the production of high surface resistivity with a high space factor. The treatment taught in said copending application has been highly successful for the purposes for which it was intended, but there have been instances where some tendency toward adhesion between the laminae has been observed, and it is the principal object of the present invention to modify the treatment disclosed in the said copending application to overcome any tendency to adhesion.

These and other objects of my invention which will be pointed out more specifically hereinafter or which will be apparent to one skilled in the art upon reading these specifications, I accomplish by that certain series of process steps of which I shall now describe exemplary embodiments.

In my said copending application, I disclosed a treating solution comprising free phosphoric acid in water and my preferred range was stated as being between about 7.25% of free phosphoric acid based on the weight of the solution to substantially 50% by weight of the free acid, with

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a preferred proportion of about 35% of free acid. The solution strength may vary between substantially 7% and 50% by weight. According to my present invention, I add to this solution finely divided mica. There are a number of forms of mica available currently, but I prefer to use common white mica, commercially known as muscovite. Such mica can be obtained in varying degrees of fineness and for my purposes it should be at least of a fineness to pass through a 200 mesh screen, i. e., a standard screen of 200 meshes to the linear inch. Since the mica will be in a mechanical suspension in the phosphoric acid solution, if the particles of mica are too coarse they will tend to settle out, and the finer the particles are, the better they will stay in suspension. I have found that mica of a given fineness will stay in suspension in the solution better than silica flour or alumina, and I believe that this is because of the flaky structure of the mica.

The amount of mica added to the solution will depend upon the conditions involved, but as a guide I have found that excellent results are obtained with the addition of about .6 pound of common white mica per gallon of the phosphoric acid solution.

In practice, I pass the silicon sheet stock through a bath of the mica-containing phosphoric acid solution and pass it between gauging or calendering rolls, which may be rubber covered as taught in said copending application, and then pass the sheet stock directly and without drying through a baking furnace where the principal chemical reactions take place.

For this treatment, the furnace should be maintained at a temperature of at least 700° F., and depending upon the ultimate use to be made of the sheet stock, I have found two preferred operating temperatures. I have found that if the temperature is maintained at 900° F. for the heat treatment, the resulting sheet stock will have an excellent die life; and I therefore recommend a treatment at about 900° F. for sheet stock which will later be punched or sheared.

I have found on the other hand that if I maintain the temperature in the furnace at about 1400° F. I obtain an improved resistance to adhesion to the extent that the adhesion problem is eliminated. At the same time, however, material treated at the more elevated temperature is harder to punch and the die life is not as good as it is when the stock is treated at 900° F. Therefore, if the material is not to be punched, but is to be used for winding, it will be preferable to carry on the heat treatment at about 1400° F.

While the furnace may be carried at a temperature below 700° F. down to about 400° F. as disclosed in said copending application, I have found that for my present purposes the time required to produce satisfactory results is too long, and I therefore prefer to operate at not less than 700° F.

It appears that during the baking step in the furnace where the principal chemical reaction takes place, the mica particles are embedded in the layer which is formed upon the sheet stock.

Sheet stock treated according to my present invention in addition to having a very high surface resistivity (at least equal to that of sheet stock treated according to my said copending application) also has a very much improved abrasion resistance and substantially no tendency toward adhesion with other laminae. While I do not wish to be bound by theory, I believe that this is due, in part at least, to the fact that mica has a crystalline structure of the plate type, so that adjacent mica crystals slide over each other with little resistance. Likewise, the lines of cleavage in such crystals are flat, and the cleft parts slide over each other very easily. This gives to the mica lubricating quality; and since the mica particles are embedded in the surface coating of the sheet stock, adjacent laminae coated as above described will not adhere to each other but will slide over each other easily. I believe also that the lubricating quality of the mica particles is what gives sheet stock treated according to my present invention its greater resistance to abrasion, whereby the high resistivity coating is not damaged during processing of the treated sheet stock.

While my treatments have been described in connection with silicon steel sheet stock, they are applicable to other magnetic materials, including pure iron, nickel iron alloys, with or without silicon, and the like.

In general, material treated by my present process will exhibit all the advantages of the material treated according to my said copending application, with the additional advantageous properties of abrasion resistance and resistance to adhesion.

It will be clear that numerous modifications may be made without departing from the spirit of my invention, and I therefore do not intend to limit myself, except as pointed out in the claims which follow.

Having now fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A process of treating ferrous magnetic materials to give them a high surface resistivity and to prevent adhesion between laminae thereof which comprises treating the clean surfaces of ferrous materials with a solution of phosphoric acid in which substantially between 7% and 50% by weight is the acid, said solution having in mechanical suspension finely divided mica, controlling the quantity of residual solution remaining on the surfaces of the material to a film of substantially uniform thickness, and subjecting the materials to a heat treatment at a temperature of substantially 700° F. to substantially 1400° F.

2. The process of claim 1 in which there is substantially .6 pound of said mica per gallon of said phosphoric acid solution.

3. The process of claim 1 in which there is substantially .6 pound of said mica per gallon of said phosphoric acid solution, and in which said mica

is of such fineness that it will pass through at least a 200 mesh screen.

4. A process of treating ferrous magnetic materials to give them a high surface resistivity and to prevent adhesion between laminae thereof which comprises treating the clean surfaces of ferrous materials with a solution of phosphoric acid containing substantially between 7% and 50% by weight of the acid, said solution containing in mechanical suspension finely divided mica, controlling the quantity of residual solution remaining on the surfaces of the material to a film of substantially uniform thickness, and subjecting the materials to a heat treatment at a temperature of about 900° F.

5. The process of claim 4 in which there is substantially .6 pound of said mica per gallon of said phosphoric acid solution.

6. The process of claim 4 in which there is substantially .6 pound of said mica per gallon of said phosphoric acid solution, and in which said mica is of such fineness that it will pass through at least a 200 mesh screen.

7. A process of treating ferrous magnetic materials to give them a high surface resistivity and to prevent adhesion between laminae thereof which comprises treating the clean surfaces of ferrous materials with a solution of phosphoric acid containing substantially between 7% and 50% by weight of the acid, said solution containing in mechanical suspension finely divided mica, controlling the quantity of residual solution remaining on the surfaces of the material to a film of substantially uniform thickness, and subjecting the materials to a heat treatment at a temperature of about 1400° F.

8. The process of claim 7 in which there is substantially .6 pound of said mica per gallon of said phosphoric acid solution.

9. The process of claim 7 in which there is substantially .6 pound of said mica per gallon of said phosphoric acid solution, and in which said mica is of such fineness that it will pass through at least a 200 mesh screen.

10. Silicon steel sheet stock having on its surface a thin, tightly adherent coating of heat treated phosphate of iron, the iron in said phosphate being derived principally from the iron in said sheet stock, said coating having embedded therein finely divided particles of mica, said coating having the characteristics of a phosphate coating heated to a temperature of between substantially 700° F. and substantially 1400° F.

11. Silicon steel sheet stock according to claim 10, in which the concentration of mica particles is such as would be obtained from a phosphoric acid solution containing substantially .6 pound of mica per gallon.

12. Silicon steel sheet stock according to claim 10, in which the mica particles are of such fineness that they will pass through at least a 200 mesh screen.

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