United States Patent Office 2,938,813
Patented May 31, 1960

2,938,813

INSULATED COATING FOR SILICON STEEL SHEET

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No Drawing. Filed Oct. 31, 1956, Ser. No. 619,411

Claims priority, application Japan Nov. 2, 1955

6 Claims. (Cl. 117—127)

The present invention relates to the method of producing an interlamellar insulated coating on silicon steel sheet or strip.

With the recent development of the quality of silicon steel sheet or strip, it is very frequent to anneal it in a hydrogen atmosphere at the temperature of 800° C. for the purpose of removing strain after the working steps, such as, shearing, punching, and stamping. In such cases, insulated films coated on silicon steel sheet or strip of the prior art, e.g., varnish-coated films, and iron oxide coated films have been flaked off, carburized, and deteriorated, so that the effect of insulation has been reduced.

Recently the adoption of phosphate coating has been introduced to provide insulation, but resulted in a considerable reduction of insulation after an anneal in an atmosphere containing a substantial amount of hydrogen.

It is one object of my invention to provide a firmly adherent coating of insulation on silicon steel sheet or strip.

It is another object of the invention to provide a new and novel method of producing a strong adherent insulated coating on silicon steel sheet or strip.

It is another object of the invention to provide a firmly adherent insulated coating on silicon steel sheet or strip with a superior property for interlamellar resistance and space factor.

It is another object of the invention to provide an excellent insulated coating on silicon steel sheet or strip which is never attacked by the transformer oil, nor affects the transformer oil badly.

It is an additional object of the invention to provide a superior insulated coating on silicon steel sheet or strip with an excellent resistance to corrosion and scratch or multilation.

With the above and other objects in view that will hereinafter appear, the nature of the invention will be more fully understood by following the detailed description and the appended claims.

The insulated film of my invention is produced by coating an aqueous solution containing 10–60 weight percent of zinc bichromate on the surface of silicon steel sheet or strip with a thin and uniform coating thereon, and heating the thus coated silicon steel sheet or strip at a temperature between 500° and 700° C. for a period of ten to forty seconds. The insulated film of my invention is also formed by heating silicon steel sheet or strip coated with an aqueous solution of the same composition added with 1–4% of glycerine at a temperature of 200–500° C. Moreover, 2–5% of boric acid may be added to the aqueous solution with a view to making the insulated film glossy and scratch-proof.

The insulated film may be produced in any other range than the above-mentioned concentration of zinc bichromate. However, in the concentration below 10% of zinc bichromate, the coated film becomes very thin, which results in a poor insulation property, and the film is produced in excessive thickness if the aqueous solution

contains more than 60% of zinc bichromate. Accordingly, I limit the concentration range of 10–60% of zinc-bichromate in my invention.

It is necessary to heat silicon steel sheet or strip coated with the solution of the invention above the temperature of 500° C. when the solution does not contain glycerine. Under the temperature of 500° C., the incomplete decomposition of zinc bichromate and the subsequent insufficient reaction on the surface of silicon steel sheet or strip will result in a hydrous film, consequently the film absorbs moisture gradually in the course of a prolonged exposure in the air after the formation of the film, which causes a considerably reduced insulation. Accordingly, it is required to heat silicon steel sheet or strip coated with the aqueous solution above the temperature of 500° C., preferably above the temperature of 600° C. in order to develop the desired results.

With the coating solution added with 1–5% of glycerine, the heating temperature of the base material at a temperature of 200–500° C. is sufficient, because the solution adheres tightly to the base sheet or strip with the reaction of zinc bichromate and glycerine at a lower tempertaure and with the subsequent solidification of the thus reacted product. However, it does not matter to heat above the temperature of 500° C. if it is required to do so. As the film produced by coating an aqueous solution of zinc bichromate with or without an addition of glycerine is rough and dull in appearance, and easily mutilated, boric acid may be added in the range of 2–5% in order to develop a glossy and smooth surface on the silicon steel sheet or strip.

An embodiment of the invention is described hereinafter. A mixture of 8.14 kg of zinc oxide and 20 kg of anhydrous chromate is dissolved in water, stirred, and reacted together. The reaction is as follows:

$$ZnO+2CrO_3=ZnCr_2O_7$$

In this reaction, the equivalents of zinc oxide and anhydrous chromate, respectively, must be added. If the amount of CrO_3 is in excess, the film tends to be hydrous, on the contrary, the film tends to be thick due to the remains of ZnO if a litttle amount of CrO_3 is present.

The aqueous solution thus produced may be employed as it is, and besides, as described hereinbefore, the addition of glycerine and boric acid is effected as follows: 4 kg. of boric acid is dissolved and stirred in water, then 100 litres of an aqueous solution is produced by adding more water thereto, and the solution is cooled to the room temperature, finally 2 kg. of glycerine is added thereto.

The aqueous solution thus produced is uniformly coated on the surface of silicon steel sheet or strip by a conventional manner. Removal of oxides present on the surface of silicon steel sheet or strip is not required by means of pickling before the base sheet or strip is coated with the solution of my invention.

In the course of the production of silicon steel sheet or strip, various oxides and silicates, e.g., silica, iron oxide, calcium silicate, and magnesium oxide, are formed on the surface of silicon steel sheet or strip. The complete elimination of such oxides and silicates is not required for the formation of the insulated film in accordance with the invention. As the higher insulation efficiency is acquired in case of silicon steel sheet or strip with oxides present on the surface thereof than in the base sheet or strip without oxides, the concentration of the aqueous solution and the amount of coating may be determined by taking the condition of the surface of silicon steel sheet or strip into consideration.

The silicon steel sheet or strip thus coated with the aqueous solution with no glycerine is heated at a tem-

perature of 500–700° C. for a period of 10–40 seconds. At higher temperatures, a heating process is finished in a shorter period of time. The heating time depends on the amount of coating. It is preferable to heat silicon steel sheet or strip coated with the aqueous solution of 30% zinc bichromate with the amount of 25 cc. per square meter at the temperature of 600° C. for a period of about twenty seconds.

With the coating solution added with glycerine, care must be taken to the heating speed. Gradual heating is necessary, because the film will be peeled off owing to an abrupt heating. The heating speed must be determined according to the concentration of the coating solution and the amount of coating to be applied, but an appropriate speed of heating can be readily found by those skilled in the art.

The insulated film thus produced is regarded as the coated film comprising complicated chromates consisting of chromium oxide, iron, and zinc, and in some cases, silicates.

The film will not be flaked off by being bent at an angle of 180° with the radius of 25 millimeters. An anneal in the hydrogen at the temperature of 800° C. after the formation of the film results in a negligible reduction of insulation resistance, thereby nothing is affected to the practical application.

The following table represents the comparative results.

Interlamellar resistance of film

[Unit: KΩcm.²/sheet.]

Kind of Film	Heat Treatment after Film Formation	Interlamellar Resistance			
		Press., 50 p.s.i.	Press., 100 p.s.i.	Press., 200 p.s.i.	Press., 500 p.s.i.
Phosphate Film of Prior Art.	Not heat treated	479	468	459	432
	Anneal in H at 800° C. for two hours.	0.226	0.215	0.212	0.200
Film of My Invention.	Not heat treated	360	337	294	258
	Anneal in H at 800° C. for two hours.	67.5	59.7	49.7	25.4

As described hereinbefore, corrosion of silicon steel sheet or strip is prevented effectively by the coated film of my invention. The transformer oil will not attack the film, and besides, the film will not deteriorate the transformer oil. Moreover, the formation of the film does not destroy the magnetic property of silicon steel sheet or strip.

From the foregoing description, it is thought that the novel details of insulated coating, the manner of coating, and the advantages of the invention, will be apparent to those skilled in the art to which it relates.

It is of course to be understood that the details of coating composition and method may be variously changed and modified without departing from the spirit and scope of my invention as set forth in the appended claims.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent, is:

1. A method of producing an insulated coating on the surface of silicon steel sheet or strip which comprises coating an aqueous solution of 10–60 weight percent of zinc bichromate in the form of a thin and uniform film on the surface of the silicon steel, and heating the thus coated silicon steel at a temperature of 500°–700° C. for a period of 10–40 seconds, thereby a firmly adherent film of insulation is produced on said silicon steel sheet or strip.

2. A method of producing an insulating coating on the surface of silicon steel which comprises coating said surface with a thin and uniform film of an aqueous solution consisting essentially of from 10 to 60 percent by weight of zinc bichromate, from 0 to 5 percent by weight of boric acid and from 1 to 5 percent by weight of glycerine, and heating the thus coated silicon steel at a temperature of from 200° to 500° C. for a period of from 10 to 40 seconds, thereby forming a firmly adherent film of insulation on the silicon steel.

3. A method of producing an insulating coating on the surface of silicon steel which comprises coating said surface with a thin and uniform film of an aqueous solution consisting essentially of from 10 to 60 percent by weight of zinc bichromate and from 2 to 5 percent by weight of boric acid and heating the thus coated silicon steel at a temperature of from 500 to 700° C. for a period of from 10 to 40 seconds, thereby forming a firmly adherent film of insulation on the silicon steel.

4. A method of producing an insulating coating on the surface of silicon steel which comprises coating said surface with a thin and uniform film of an aqueous solution consisting essentially of from 10 to 60 percent by weight of zinc bichromate and from 1 to 5 percent by weight of glycerine and heating the thus coated silicon steel at a temperature of from 200 to 500° C. for a period of from 10 to 40 seconds, thereby forming a firmly adherent film of insulation on the silicon steel.

5. A method of producing an insulating coating on the surface of silicon steel which comprises coating said surface with a thin and uniform film of an aqueous solution consisting essentially of from 10 to 60 percent by weight of zinc bichromate, from 2 to 5 percent by weight of boric acid and from 1 to 5 percent by weight of glycerin, and heating the thus coated silicon steel at a temperature of from 200° to 500° C. for a period of from 10 to 40 seconds, thereby forming a firmly adherent film of insulation on the silicon steel.

6. A method of producing an insulating coating on the surface of silicon steel which comprises coating said surface with a thin and uniform film of an aqueous solution consisting essentially of from 10 to 60 percent by weight of zinc bichromate, from 0 to 5 percent by weight of boric acid and from 0 to 5 percent by weight of glycerine, and heating the thus coated silicon steel at a temperature of from 500° to 700° C. for a period of from 10 to 40 seconds, thereby forming a firmly adherent film of insulation on the silicon steel.

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