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HEAT TRANSFER ARRANGEMENT FOR MAGNETIC POLES IN ELECTROMAGNETIC DEVICES

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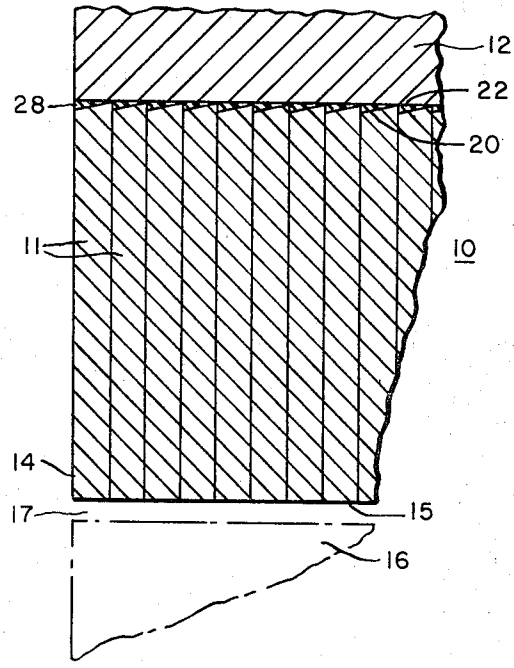


FIG. 1.

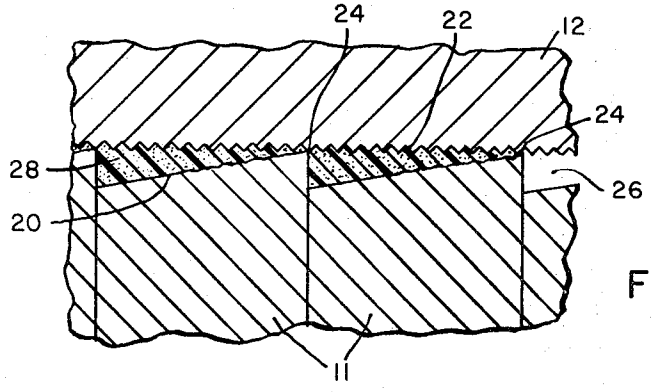


FIG. 2.

WITNESSES

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HEAT TRANSFER ARRANGEMENT FOR MAGNETIC POLES IN ELECTROMAGNETIC DEVICES

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ABSTRACT OF THE DISCLOSURE

A filler or layer of material disposed between the frame of a dynamoelectric machine and the frame engaging face or surface of a pole piece, the layer of material filling spaces between the frame and pole piece, the layer of material reducing substantially the temperature drop and the ampere turns loss across the interface between the frame and pole piece.

BACKGROUND OF THE INVENTION

The invention relates generally to dynamoelectric machines, and particularly to a means for effecting highly improved heat flow from the field poles of the machine to the frame of the machine, and magnetic flux flow between the frame and poles of the machine.

The attainment of acceptable hot spot temperatures in electric machines requires improved heat transfer or reduced temperature drop from the interior elements of the machine to the ambient air. Hot spot temperatures are those temperatures found to be the highest in an operating machine, i.e., higher than average temperatures. The hot spot temperature and the temperature drop problems become more acute with reduction in the size of the machine which results in a higher loss density, the heat generated in an electrical conductor being proportional to the square of the current flow in the conductor.

In test conducted with standard, presently used direct current machines, the temperature drop from pole pieces to frame were found to be substantial. This temperature drop is caused by the relatively small proportion of actual metallic contact and open spaces (or air gaps) between the pole pieces and frame, the limited amount of metallic contact creating a thermal high impedance or resistance to the flow of heat from the pole piece to frame.

Generally, pole pieces are formed by a large number of laminations which are usually produced by a simple punching operation and then secured together. The edges of the laminations forming the rear face or frame engaging surface of each pole piece are uneven, and thus do not seat evenly against the inner surface of the frame to form maximum metal-to-metal contact with the frame.

In a similar manner, the frame may be laminated, or, if cast or machined may have mold or tool marks which form a rough frame surface which limits the metal-to-metal contact of the frame and pole piece.

A further problem caused by the limited metallic contact and open spaces between the pole pieces and frame is the loss of ampere turns in forcing the magnetic flux between the poles and frame, the metal saturating when subjected to magnetic flux. The saturation of the metal, providing the limited contact, produces the effect of a larger air gap using more magnetizing force to attain the necessary total flux for machine operation.

BRIEF SUMMARY OF THE INVENTION

The tests conducted with standard, typical machines as explained above, showed the temperature drops from

pole piece to frame to be substantial. The present invention is directed to reducing this temperature drop to obtain acceptable hot spot temperatures within the machines. This is accomplished by disposing a layer or filler of heat conductive material between the mutually engaging surfaces of the frame and pole pieces which conforms to the rough, uneven surfaces thereof thereby filling the open spaces and voids created by the rough surfaces. If the heat conductive layer is also a magnetic flux conducting material, the double problem of high thermal resistance and the air gap is solved. Such a material would include an iron filled resin for example, which may be simply applied in the form of a paste to the back, i.e., to the frame engaging or mounting surface of each pole, though the invention is not limited thereto. If a paste is used, a serrated or sawtooth applicator may be employed to provide a suitable quantity of material for a proper layer thickness when the pole and frame are placed together, i.e., a thickness adequate to fill the voids without increasing the air gap between the mutually engaging surfaces.

THE DRAWING

The invention, with its advantages and objectives, will best be understood by reading the following detailed description in connection with the accompanying drawing in which:

FIG. 1 shows a side elevation view of a typical laminated field pole attached to a frame (in section), and a heat conducting layer disposed between the pole and frame in accordance with principles of the invention; and

FIG. 2 is a view showing an enlarged portion of structure shown in FIG. 1.

PREFERRED EMBODIMENT

Specifically, the figures show a field pole piece **10** made of laminated plates or punchings **11** suitably secured together and attached to the frame **12** (in section) of a dynamoelectric machine. The pole piece includes a pole shoe **14** (FIG. 1) having a radially located inner face **15** disposed adjacent a rotatable armature **16** (shown only in outline) to form an air gap **17** therewith.

The pole piece **10** has a rear face or surface **20** formed by the edges of the laminated plates which engages the inner surface **22** of the frame **12**. In FIG. 2, both of the surfaces are enlarged so that the texture of the frame surface **22** can be better illustrated as well as the uneven surface **20** presented by the ends of the laminations **11**.

In FIG. 2, the texture of the surface **22** is that of a machined surface greatly exaggerated. Such a surface has generally an even, almost sawtooth configuration.

The configuration of the surface **20** of the laminated pole piece **10** is uneven and has a somewhat sawtooth shape formed by slanted or angled edge portions of the laminations **11** which are shown somewhat exaggerated in FIG. 2 for purposes of illustration. The edge of each lamination is generally rough and has a burr formed on one side thereof by the die in the punching process. The die actually cuts about halfway through the thickness dimension of the lamination. The other half of the metal thickness is broken or torn, the die dragging a burr after it and beyond the edge of the metal. When the laminations are stacked and pressed for riveting or otherwise securing together to form the pole piece, the pressure of the compacted laminations forces the burrs outwardly from the stack which produces the somewhat bevelled surface as shown in the drawing.

In FIG. 2 the metal of the surfaces **20** and **22** are thus shown having limited contact, the metal of each surface contacting each other at locations indicated by numerals

24 to leave air gaps or void areas 26 (FIG. 2) between the surfaces and contacting locations.

As explained earlier, the voids 26 present thermal resistance to the conduction of heat, as well as air gaps to the magnetic flux, between the pole piece 10 and frame 12, and the metal contacting location 24 tend to saturate when subject to the magnetic flux thereby increasing the effective air gap between the pole piece and frame.

In accordance with the invention, a layer 28 of heat conducting material is disposed between he pole piece 10 and frame 12 to fill the voids 26 and conform to the uneven surfaces 20 and 22, thereby providing a solid mass of material between the pole and frame to serve as a broad continuous heat conducting path. In this manner, the heat generated within the machine and transferred therefrom to the frame 12 for transfer from the frame to the atmosphere around the frame.

The layer 28 may comprise a thermally stable resin filled with heat conducting particles, for example a metal in powdered form, though the invention is not limited thereto.

The layer 28 may be formed by simply applying the resin in the form of a paste to the rear face 20 of the pole pieces 10 so that the resin can readily fill the voids 26 and otherwise conform to the rough surfaces of the pole pieces and frame when the pole piece is attached to the frame. The resin is then cured to form the above-described solid mass of material between pole pieces and frame.

To solve the double problem of resistance to the flow of heat and magnetic flux created by the rough, engaging surfaces 20 and 22 of the pole piece 10 and frame 12, an iron filled resin or epoxy compound may be employed to fill the voids 26. In this manner, the iron in the epoxy essentially eliminates the air gap created between the pole piece and frame by providing a magnetic material between the locations 24 of metal contact, as well as assisting the epoxy in conducting heat from the pole to the frame.

The resin or epoxy paste should be applied in a controlled manner in forming the layer 28 in order to avoid further separation of the pole piece 10 and frame 12. This may be accomplished by using a serrated applicator with properly dimensioned teeth.

Numerous tests were conducted in order to determine the effectiveness of the layer 28 as thus far described. Pole pieces of standard, typical machines were tested to measure the temperature drop across the interface between the engaging surfaces of pole pieces and a machined plate adapted to simulate a matching surface of a motor or generator frame. Thermo couples were located about the interface, and their outputs measured to determine resulting temperature rise with power input to typical field coils disposed on the pole pieces. Similarly, the temperature rise by resistance measurement was taken as an indication of average temperature readings in contradistinction to the localized or hot spot indications provided by strategically located thermocouples.

With laminated poles bolted to the machined plate without a heat conducting filler or layer, typical temperature drops from pole to plate ranged from 0.05 to 0.085 degree centigrade per watts of input power to the field coil. Three identical poles, for example, showed 0.061, 0.075 and 0.084. Hereinafter, temperature drop figures will be in unit degrees centigrade without further reference thereto.

When the pole giving the lowest, i.e., the 0.061 reading, was reassembled with five sheets of 0.002 inch aluminum foil disposed in the interface, the temperature drop was reduced to 0.024, the foil providing wider areas of contact between the edges of the laminated plates and frame surface.

Further tests were conducted with an epoxy compound filled with aluminum powder. The measured temperature drops reached the low of 0.003. However, with the possibility of a low permeability gap forming between the pole piece and shoe as explained above, an iron filled epoxy layer was employed and tested. This resulted in a slightly higher temperature drop.

From the foregoing data, it is readily apparent that the heat conducting layer 28 is highly effective in transferring heat from a pole to a machine frame. More particularly, the decrease in temperature drop with the layer 28 over that of a pole and frame without the layer is by a factor of at least ten, i.e., the layer 28 is ten times more effective in reducing the temperature drop from pole to the frame where it can be radiated or otherwise conducted to the ambient atmosphere outside the machine.

Many other tests were conducted using a variety of materials to ascertain suitable materials for the layer 28. As mentioned earlier, the resin or epoxy compounds need not necessarily be filled with metal materials to provide good heat conductivity. Beryllium oxide, for example, is a non-metall which exhibits good heat conducting characteristics, and thus could be contained within a resin or epoxy compound for use as the heat conducting layer 28. Other non-metals would include powdered fused magnesium, fused silica and others.

The heat conducting layer 28 of the present invention has uses in a variety of machine types. For example in permanent magnet machines, the heat conductive layer 28 may also have an adhesive characteristc. The magnetic pole pieces of the machine are first demagnetized and then positioned in a frame with the adhesive, heat conductive layer applied to the frame engaging faces of the poles. When the poles are remagnetized on the frame, the attracting force of the magnetic field and the adhesive property of the layers 28 secure the pole pieces to the frame. In case of accidential demagnetization, the adhesive layers secure the pole pieces from detachment. The adhesive layer 28, however, is permanent, so that in machines where it is desired to remove the pole pieces at a future occasion or occasions, a non-adhesive layer 28 should be used.

In some applications, for example in machines designed for rapid response to changes in load, the heat conductive layer 28 would comprise a low electrical conductivity material. Such machines usually employ laminated poles and/or frames designed to provide an electrical ty material. Such machines usually employ laminated to prevent eddy current flow which oppose changes in machine current flow. A low electrical conductivity layer 28 provides the necessary heat conducting path between a pole and frame without electrically shorting the laminations.

In a similar manner, the heat conducting layer 28 of the present invention may be applied and utilized in electromagnetic devices other than dynamoelectric machines, in solenoids, for example, or in electromagnetic braking devices. The latter devices generally employ two iron plates on which are supported magnetic pole pieces with field coils. When the coils, are energized with an electric current, a magnetic circuit is completed through the pole pieces and the supporting plates which brings the plates, with their respective poles, together to apply a brake to the shaft of an electric motor, for example. Between the supporting plates and the plate engaging faces of the pole, the layer 28 may be disposed to substantially reduce the temperature drop between the poles and plates, and to reduce the loss of ampere turns required to force the magnetic flux across any air gap existing between the plates and poles.

It should now be apparent from the foregoing description that a new and useful filler or layer of material 28 has been disclosed, the layer producing unobvious results, namely, a substantial increase in the conductance of heat from the pole pieces to the frame of an associated machine over that of poles and frames without such a layer. In a similar manner, the invention essentially eliminates the air gap which develops between the pole and

frame by using a magnetic flux conducting material between the pole and frame.

Though the invention has been described with a certain degree of particularity, changes may be made therein without departing from the spirit and scope thereof. For example, in the figure and specification, a laminated main field pole is shown and described. The invention, however, is applicable to commutating poles and to non-laminated poles.

What is claimed is:

1. In a dynamoelectric machine having a stator frame and mangetic pole pieces attached thereto, each of said pole pieces having a frame engaging face, said frame and the engaging faces of said pole pieces having relatively rough surfaces, with limited areas of contact therebetween, so that a heat and a magnetic flux flow resistant interface exists between said pole pieces and frame,

a layer of heat conducting material disposed in said interface in locations of no contact between said surfaces, said layer conforming to said surfaces without substantially increasing distance between said surfaces,

said layer providing a heat conductive path between said pole pieces and frame so that a minimum temperature drop exists across said interface.

2. The structure described in claim 1 in which the layer of heat conducting material is a thermally stable material containing heat conducting particles.

3. The structure described in claim 1 in which the heat conducting layer is a metal filled resin material.

4. The structure described in claim 1 in which the heat conducting layer is an epoxy compound containing a magnetic permeable material.

5. The structure described in claim 2 in which the heat conducting particles are non-metallic particles.

6. An electromagnetic device having a supporting member and at least one pole piece attached thereto, said member and pole piece having mutually engaging surfaces which are relatively rough with locations of limited contact interspersed with locations of no contact therebetween, said surfaces creating a heat and a magnetic flux flow resistant interface between said member and pole piece,

a layer of heat conducting material disposed in said interface substantially only in said location of no contact, and conforming to the rough surfaces of said member and pole piece without substantially increasing distance between said surfaces from what occurs due to the roughness thereof,

said layer providing a heat conductive path between said pole piece and supporting member so that a minimum temperature drop exists across said interface.

7. The structure described in claim 6 in which the layer of heat conducting material is a thermally stable material containing heat conducting particles.

8. The structure described in claim 6 in which the heat conducting layer is a metal filled resin material.

9. The structure described in claim 6 in which the heat conducting layer is an epoxy compound containing a magnetic permeable material.

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