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Nakatsuka

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[54] **STATOR WITH MOLDED ENCASEMENT FOR SMALL MOTORS AND MANUFACTURING PROCESS THEREFOR**

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Related U.S. Application Data

[62] Division of application No. 08/848,371, Apr. 30, 1997.

[51] **Int. Cl.**[7] **H02K 1/00**

[52] **U.S. Cl.** **310/216**; 310/43; 310/179; 310/258; 310/259; 29/596; 29/598

[58] **Field of Search** 310/216, 43, 179, 310/258, 259; 29/596, 598

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[57] **ABSTRACT**

A stator has a lamination stack with a first electrically insulating layer and coil guides formed of high flow thermoplastic synthetic resin simultaneously insert-molded thereon. A coil is wound onto the stack and over the electrically insulating layer and the coil guides, and a second electrically insulating layer is molded over the coil to encase the coil. The second electrically insulating layer is formed of the high flow thermoplastic synthetic resin by injection molding. The method for producing the stator includes inserting the lamination stack into a first molding tool installed on an injection molding machine and injection molding onto the lamination stack the first insulation layer and the coil winding guides wherein the first insulation layer coats at least top and bottom surfaces and surfaces of slots of the lamination stack with thin resin skin insulation. The coil is then wound using insulated thin copper wire. The lamination stack is inserted into a second molding tool, having a gate disposed at a location where injected resin will not directly hit the coil, and the second insulator layer is then injection molded on the coil using the high flow thermoplastic synthetic resin injected at a filling pressure about 20 to 60% lower than a standard value for the high flow thermoplastic synthetic resin and at an injection speed more than twice as high as a standard injection speed for the high flow thermoplastic synthetic resin.

21 Claims, 2 Drawing Sheets

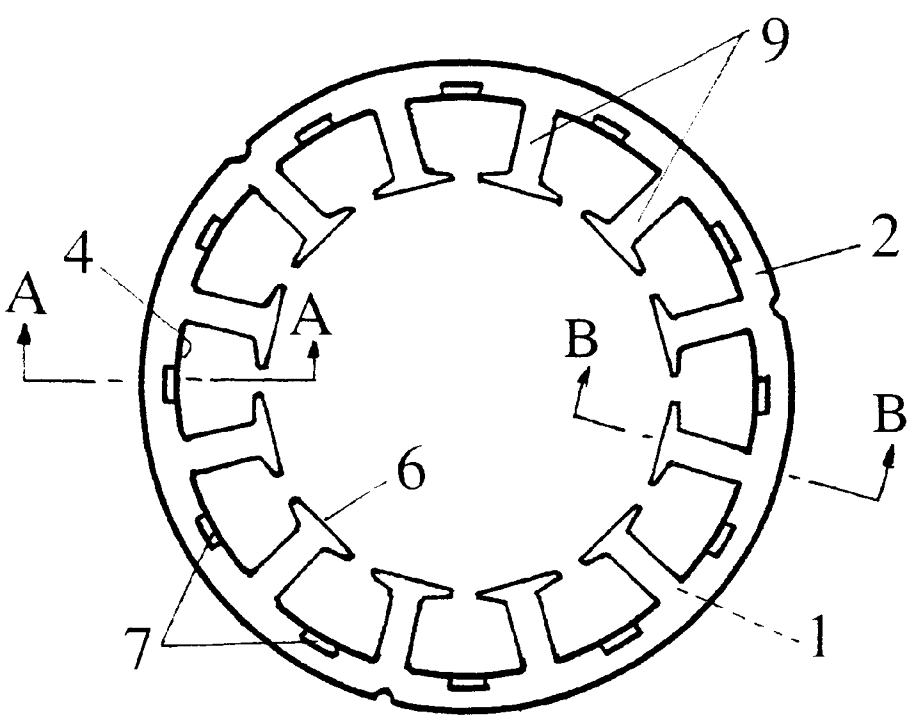


FIG. 1

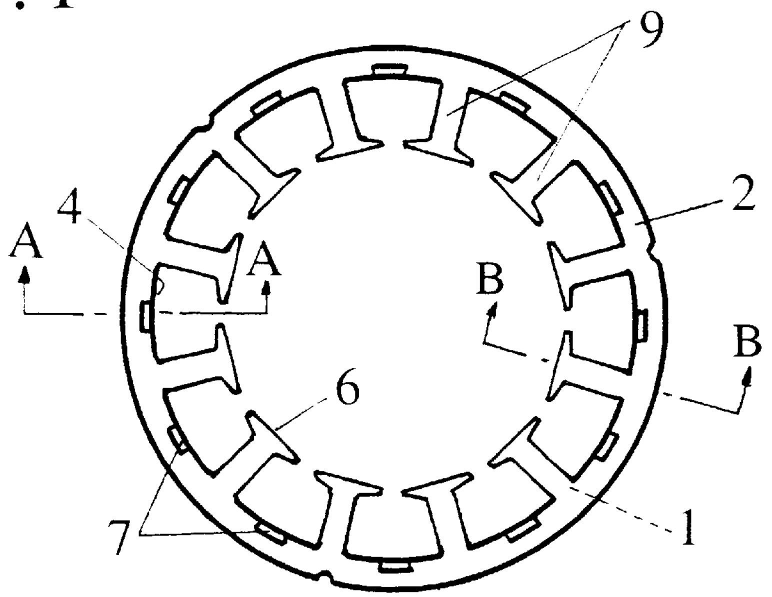


FIG. 2

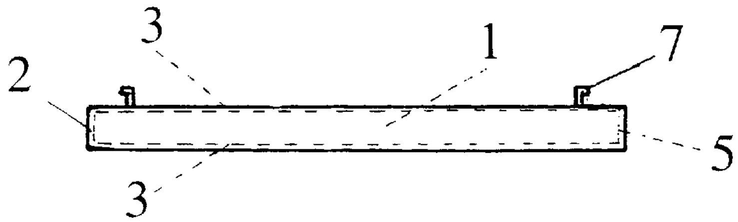


FIG. 3

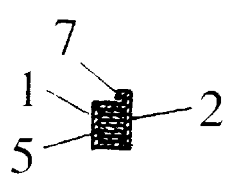


FIG. 4

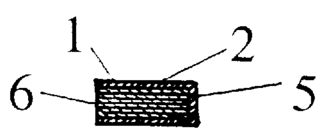


FIG. 5

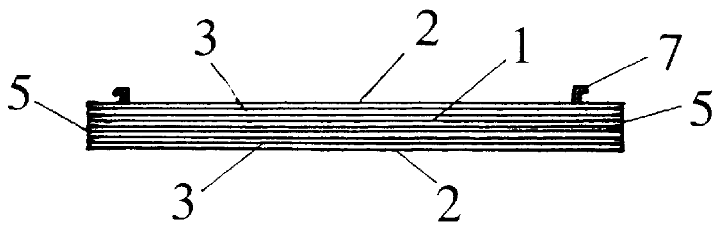


FIG. 6

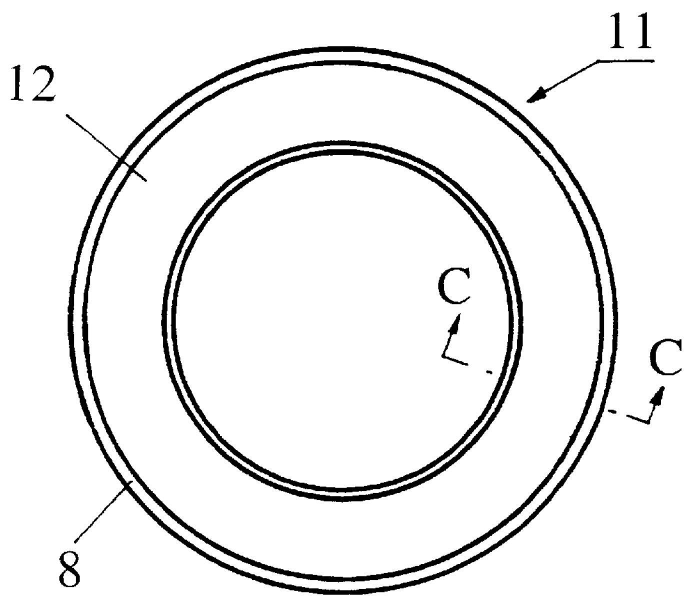
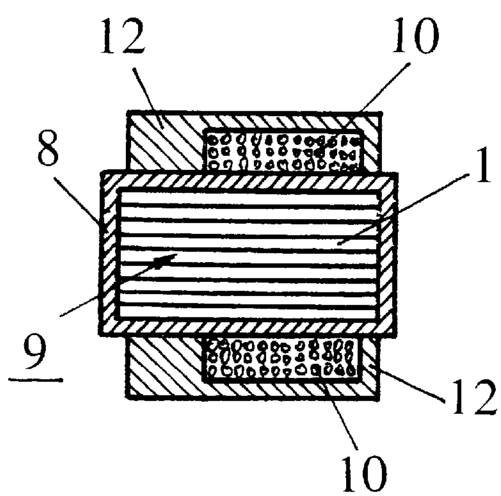


FIG. 7



STATOR WITH MOLDED ENCASEMENT FOR SMALL MOTORS AND MANUFACTURING PROCESS THEREFOR

This is a division, of application Ser. No. 08/848,371, filed Apr. 30, 1997.

BACKGROUND OF THE INVENTION

The present invention relates to a stator having a molded casing and, more particularly, to a stator for small motors having a first molded layer on a stack and a second molded layer enclosing a coil and portions of the first molded layer. The stator has applications in small motors such as spindle motors or servo motors, which are used in hard disk drives, wherein thin insulation is required.

The ever increasing demand for hard disk drives with greater storage capacity has resulted in increasingly strict requirements for cleanliness of the driving unit. Motors have been found to be a source of particles, gas, organic substances, and ionic substances. Thus, spindle motors used in hard disk drives must not produce contaminants during operation. It has been found that particles are generated from the stator or the wound windings of the rotor coil due to abrasion. Improvement in the functioning of hard disk drives is achieved by enclosures for containing particles and gases generated by the coil and stack of the motor stator of the hard disk driving unit. Even trace foreign particles can adhere onto the magnetic head or hard disk and cause noise or a head crash. Therefore, it is necessary to prevent particles or gasses from being generated by the-motor.

Various kinds of small or thin motors are applied in various fields, and the demand for further reduction in size is increasing. At the same time, simplification of the manufacturing process for such motors and improvements in reliability are required. Motor characteristics such as starting torque and power are improved when an insulator on the stack of the stator is thinner because more coil can be wound on the stator. Furthermore, a thinner insulation results in better thermal transfer characteristics allowing improved dissipation of heat generated by the motor. Finally, it is also necessary to protect against vibration, noise caused by electric current pulses and to increase durability of the hard disk unit.

In the conventional methods used to manufacture stators, multiple plates of punched thin thickness steel are interlocked to produce a lamination stack. The stack is then coated with insulation after an anti-corrosion treatment. Following the coating, a coil is wound after a winding guide is affixed. However, due to laminating the punched thin steel, the outer surface and slot being exposed is not be completely planar, thus resulting in recesses and projections.

A major issue for using an insertmolding process is the variation in the thickness of the laminated stack. Therefore, in order to perform insertmolding, screening of the thickness and adjustment of the core in the molding tool is required. The adjustment of the core in the molding tool further causes the formation of flash which requires deburring. Thus, the screening, the adjustment and the deburring add further costs to the production process.

A coating of 50–80 micron thickness is necessary to provide insulation on such rough surface. Prior to coating, costs are further increased by the requirement for a pretreatment of shotblasting or tumbling to effect deburring. Despite such steps, the coating is often left with pinholes which deteriorate the insulation or edges are left uncovered by the coating which results in low yields.

The manufacturing process is also complicated because the winding guide is affixed after the coating is applied. There is a method disclosed by published Japanese patents #63-3636 and #63-3637 which uses a steel lamination with thermoplastic synthetic resin pre-adhered on outer face surfaces of the two outer most steal plate laminations. After lamination of the steel plates, the synthetic resin is heated to deform and flow to coat edges of the laminations to provide insulation. However, a sufficient amount of synthetic resin on the steel plate laminations must be provided to permit the requisite amount of deformation and coating using such a method. Accordingly, the resin coating must be relatively thick to permit a sufficient flow to the center of the laminations for complete coverage with synthetic resin. Furthermore, it is rather difficult to coat the whole stack with uniform thickness.

Methods to enclose wound wire with synthetic resin have been suggested. When enclosing windings with synthetic resin, it is important not to damage the insulation of the wire by heat or pressure, and not to disturb the wound coil. In general, enclosing with synthetic resin is performed with thermosetting resin under low temperature (less than 120° C.) and low pressure. Bulk molding compound (BMC) is mainly used as resin material. The resin temperature is low, but the manufacturing cycle takes several minutes using such a method.

Some methods using injection molding have also been suggested for enclosing wound wire with synthetic resin. Published Japanese patent #61-10949 discloses inserting coiled wire into a molding tool for injection molding, setting the tooling temperature at a 120–150° C., using polyphenylenesulfide (PPS) resin with 20–40 wt % inorganic filler, and setting the resin temperature at 300–350° C. and injection pressure at 800–1000 kg/cm^2 in the process of coating the wound wire. This enables molding with relatively short cycle by using thermoplastic resin for enclosing wound wire since conventionally used thermosetting epoxy resin requires a longer molding cycle which results in low productivity. Since this method applies high pressure to inject molten resin at high temperature, it may be acceptable for applications where the diameter of wire is large enough and insulating coating of coil is thick enough to withstand the process. In applications involving coil wire of smaller diameter and a thin insulating coating of the coil wire, the wound coil is susceptible to being disturbed and the insulation coating of wire is prone to damaged. Thus, this method is not practical in such applications.

Published Japanese patent #3-70441 discloses a stack having multiple slots to be wound. The stack of the rotor with a rectifier and an outer surface of wound wire are enclosed by injection molding with insulating encapsulating material (polyacetal with glass fiber). The resin injecting position is located at an opposite surface of the rectifier and parallel with the axis of the rotor. Injection is performed in two stages. In the first stage an injection pressure of is 220 kg/cm^2 is used and in the second stage a pressure of 50 kg/cm^2 is used. However, the method relates to the rotor, not the stator, and differs from the object of the present invention. The technical point of the published patent is to specify the direction of resin injection to prevent disturbance of wound wire and minimize molding defects such as wrinkles and sink marks. The resin injection time is reduced to 2.5 seconds. Even with this shortened time, as the insulation coating of the winding of the stator for the small-sized precision motor is so thin, the wire is prone to damaged by the high temperature of molten resin. Also, as the initial injection pressure of 220 kg/cm2 is high, the wound coil is prone to being disturbed by the effect of injected resin.

Finally, published Japanese patent #6-327208 discloses an assembly of a stator block of an axial gap type DC brushless motor provided with multiple stator blocks having stacks of columnar soft magnetic material with coils wound between a set of permanent magnets affixed to the rotor. The coils are fixed by a resin having a major filler with a heat conductivity of more than 10 (w/m·k). The resin to be used is either thermoplastic and thermosetting resin, but the thermosetting resin is mainly described. Molding methods discussed include injection molding, which is not disclosed in detail, a potting method for liquid thermosetting resin, a transfer molding method for powder thermosetting resin, and a casting method, the particular method depending on the configuration. An epoxy resin containing a filler of improved heat conductivity, such as aluminum oxide or aluminum nitride, is also discussed but no reference to the flow character of such a resin is made.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a stator with a molded encasement and a method for production thereof which overcomes the drawbacks of the prior art.

Accordingly, it is an object of the present invention to provide a stack produced with insulation for encasing the stack applied using a simplified manufacturing process which reduces defects and wherein the insulator and winding guides are simultaneously formed, and resistance and inductance is improved. Wound wire is enclosed with synthetic resin to prevent contaminants from spreading from the stator or abrasion of the wound wire of the rotor, and reduce vibration and noise generated by electric current pulses.

Briefly stated, the present invention provides a stator having a lamination stack with a first electrically insulating layer and coil guides both formed of high flow thermoplastic synthetic resin simultaneously insert-molded thereon. A coil is wound onto the stack and over the electrically insulating layer and the coil guides, and a second electrically insulating layer is molded over the coil to encase the coil. The second electrically insulating layer is formed of the high flow thermoplastic synthetic resin by injection molding. The method for producing the stator includes inserting the lamination stack into a first molding tool installed on an injection molding machine and injection molding onto the lamination stack the first insulation layer and the coil winding guides wherein the first insulation layer coats at least top and bottom surfaces and surfaces of slots of the lamination stack with thin resin skin insulation. The coil is then wound using insulated thin copper wire. The lamination stack is then inserted into a second molding tool, having a gate disposed at a location where injected resin will not directly hit the coil, and the second insulator layer is injection molded on the coil using the high flow thermoplastic synthetic resin injected at a filling pressure about 20 to 60% lower than a standard value for the high flow thermoplastic synthetic resin and at an injection speed more than twice as high as a standard injection speed for the high flow thermoplastic synthetic resin.

In accordance with these and other objects of the invention, there is provided an overmolded stator for small-sized motor having a stack which is insert-molded to form a first insulator layer of insulating high flow thermoplastic resin on the stack, coil windings wound on the stack over the first insulating layer, and a second insulating layer overmolded on the coil windings by injection molding using the same type of thermoplastic resin used for the first insulating layer.

The present invention also provides a manufacturing method comprising the steps of punching steel plate into a desired shape to form a requisite number of laminations for a lamination stack, interlocking the laminations together to form the lamination stack, inserting the lamination stack into a molding tool installed on an injection molding machine, undermolding the lamination stack with a high flow thermoplastic synthetic resin having desired insulation characteristics to coat at least top and bottom surfaces and slots of the lamination stack with a thin resin skin for insulation while simultaneously forming with the resin a hook member as a coil winding guide on a top surface of the stack, winding a coil of insulated thin copper wire using the hook member as a guide, overmolding the stator with the coil wound upon it by injection molding using the high flow thermoplastic synthetic resin used for undermolding at a filling pressure 20–60% lower than a standard value of the injection machine to be used and an injection speed at least twice as high as a standard injection speed using a molding tool having a gate disposed at a position where injected resin will not hit directly the wound coil of the stator.

According to a feature of the invention, there is further provided method for producing a stator with a lamination stack comprising: inserting the lamination stack into a first molding tool installed on an injection molding machine; injection molding onto the lamination stack a first insulation layer and coil winding guides formed of a high flow thermoplastic synthetic resin which is an electrical insulator, the first insulation layer coating at least top and bottom surfaces and surfaces of slots of the lamination stack with thin resin skin insulation and the coil winding guides being simultaneously formed integral with the first insulation layer on the top surface of the lamination stack; winding a coil of insulated thin copper wire over the first insulation layer and the winding guides; inserting the lamination stack with the coil into a second molding tool having a gate disposed at a location where injected resin will not directly hit the coil; and injection molding a second insulator layer on the coil using the high flow thermoplastic synthetic resin injected at a filling pressure about 20 to 60% lower than a standard value for the high flow thermoplastic synthetic resin and at an injection speed more than twice as high as a standard injection speed for the high flow thermoplastic synthetic resin.

The present invention further includes the second molding tool including a pressure adjusting means for maintaining injection pressure within the range of the filling pressure. The pressure adjusting means in one embodiment of the invention comprises spring biased pins communicating with an interior of the second molding tool which are displaced by the filling pressure to maintain the filling pressure within a desired range.

The above, and other objects, features and advantages of the present invention will become apparent from the following description read in conjunction with the accompanying drawings, in which like reference numerals designate the same elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a plane view of an embodiment of the present invention having a lamination stack with an insulator insertmolded;

FIG. **2** shows the front view of the lamination stack with the insulator insertmolded of FIG. **1** with a winding guide is partially omitted;

FIG. **3** shows the cross section along line A—A of FIG. **1**;

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