

Specification

Linear Motor Coils Assembly And Manufacturing Method Thereof

Technical Field

5 The present invention relates to a linear motor for generating linear movement, and particularly relates to a linear motor coil assembly having a plurality of coils arranged in a line in the direction of linear motion.

Related Art

Machine tools that use a linear motor to cause a table to move linearly at
10 high speed and position the table with high precision are known. Recently, linear motors have become widely used as they do not require conveying means such as a feed screw. A linear motor for a machine tool is required to generate a large thrust, and to be more compact. Because of this, linear motors more easily generate heat than rotating motors. Temperature rise of a linear motor limits its rated thrust, and
15 lowers mechanical positioning accuracy. In many cases, the linear motor is encapsulated in a cover for preventing magnetic dust infiltrating into the linear motor generating powerful magnetic force. Because of this, natural cooling of the linear motor is not carried out sufficiently, and effective cooling of the linear motor is a very important consideration.

20 Japanese Laid-open Patent 63-18956 discloses a cooling apparatus for a linear motor equipped with a cooling tube at the bottom of a groove formed between adjoining pole teeth. This linear motor cooling tube will be described in detail below with reference to Fig. 9, Fig. 10 and Fig. 11. A plurality of permanent magnets 3 having alternating magnetic poles are fixed in a line on the lower surface of a carrier
25 2 in the direction of movement. A fixed armature is made up of a plurality of T-

shaped pole teeth 4, a base 5 connecting the pole teeth, and a coil 7 wound around the teeth 4. As is clearly shown in Fig. 9, cooling tubes 8 are provided one each at the bottom of grooves 6 formed by adjoining pole teeth 4. The cooling tubes 8 are, for example, a tube 8A meandering around the grooves 6, as shown in Fig. 10. A
5 coolant in gas or liquid form circulates in the pipe 8A. The cooling tubes 8, as shown in Fig. 11, can be stair-shaped pipes 8B. The pipes 8B are equipped with headers 8a and 8b extending parallel to a moving direction opposite with respect to the base 5, and a bridging section 8c bridging the headers 8a and 8b. The coolant is introduced from one end of the header 8a, passes through the bridging section 8c and is
10 discharged from one end of the header 8b.

Summary Of The Invention

An object of the present invention is to provide a linear motor coil assembly that efficiently cools heat generated in the coil.

Another object of the present invention is to provide a compact linear
15 motor coil assembly.

Still another object of the present invention is to provide a method of simply manufacturing a linear motor coil assembly, having high cooling efficiency.

According to the present invention, a linear motor coil assembly for developing linear motion has a plurality of coils arranged in a line in a direction of
20 movement, and respectively having coil shafts perpendicular to the movement direction, and a flat cooling pipe, having a cross section that is elongated in a direction parallel to the coil shafts and folds into which the coils can be engaged, meandering inside the plurality of coils.

The flat cooling pipe preferably has a plurality of clearance holes for
25 passing coolant, formed in a direction parallel to the coil shafts.

Alternatively, the flat cooling pipe may be formed by aligning and attaching a plurality of round pipes for passing coolant in a direction parallel to the coil shafts.

5 The flat cooling tube preferably has interleaved folds at least equal in number to the number of coils.

The linear motor coil assembly may also include cores, divided for each coil, around which the coils are wound.

According to the present invention, there is also provided a method of manufacturing a linear motor assembly for developing linear motion, comprising the
10 steps of, making cores divided for each magnetic pole, winding coils around the respective cores, making a flat cooling pipe having interleaved folds, at least equal in number to the number of coils, into which the coils can be engaged, fitting the core into the folds, and arranging the cores in a line on a base plate.

Other objects and novel features will become clear upon reference to the
15 following description.

Brief Description Of The Drawings

Fig. 1 is a front elevation showing a linear motor coil assembly of the present invention;

Fig. 2 is a plan view showing the coil assembly of Fig. 1;

20 Fig. 3 is a cross sectional drawing showing a coil and a cooling tube in Fig. 1 in magnified form;

Fig. 4 is a cross sectional drawing showing conveyance of heat generated in the coils to the cooling tube;

Fig. 5 is a perspective view showing another example of the cooling tube
25 in Fig. 1;

Fig. 6A, Fig. 6B, Fig. 6C and Fig. 6D are plan drawings showing a method of manufacturing a linear motor coil assembly;

Fig. 7 is a perspective view of a coil assembly viewed in the direction of arrow B in Fig. 6;

5 Fig. 8 is a perspective view showing the coil assembly of Fig. 1 covered by an insulating resin;

Fig. 9 is a plan view of a linear motor of the related art;

Fig. 10 is a cross sectional view of one example of a cooling tube taken along line A - A in Fig. 9; and

10 Fig. 11 is a cross sectional view of another example of a cooling tube taken along line A - A in Fig. 9.

Preferred Mode Of Embodying The Invention

A linear motor coil assembly of the present invention will now be described in the following with reference to Fig. 1, Fig. 2, Fig. 3 and Fig. 4.

15 A linear motor coil assembly 12 for developing motion in the direction of a horizontal linear axis X having a base plate 11, and cores 13 having coils 14 mounted thereon. The coil assembly 12 constitutes one of either a mover or a stator. Reference numeral G1 in Fig. 1 represents a gap formed between a stator and a mover. The base plate 11 has a horizontal upper surface. Cores 13 divided for each magnetic pole are attached to the upper surface of the base plate 11 using screws 19 in a line in the direction of the linear axis X. A plurality of holes 18 for the screws 19 are formed in the base plate. The cores 13 are formed by laminating silicon-steel plates and welding or gluing them together. As is clear from Fig. 2, the cores 13 extend parallel to each other in a horizontal direction Y perpendicular to the linear axis X. As is clear from Fig. 3, in order to make a gap G2 formed between pole faces

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13a of adjoining cores 13 as small as possible, the pole faces 13a of the cores 13 protrude in the direction of the linear axis X. The size of the gap G2 is maintained at a value about double the gap G1. A small gap G2 reduces undesirable torque ripple. A yoke section 13b is formed connecting adjoining cores 13, and holes 13c for

5 screws 19 are formed in the yoke section 13b. One set of insulators 15 for insulating the coils 14 are inserted into the cores 13. The coils 14 are wound around respective cores 13 via insulators 15, without overlapping. Coil axes Z are parallel to each other, and perpendicular to the linear axis X. The insulators 15 are, for example, compact liquid crystal polymer resin capable of being thinly formed having high thermal

10 conductivity. As is clear from Fig. 2, the insulators 15 have a U-shaped horizontal cross section, and one set of insulators are fitted into a core 13 at one location. Tapered insulators 16 for preventing damage to enamel paint of the coils 14 are wrapped around the outside of the coils 14. A flat cooling tube 20 is arranged so as to meander around the inside of the coils 14 arranged in the direction of the linear

15 axis X. The cooling tube 20 is made by extruding aluminum. The cooling tube 20 is glued to the coils 14, and the insulators 16 improve adherence between the coils 14 and the cooling tube 20. As is clear from Fig. 3, the cooling tube 20 has a cross section elongated parallel to the coil axes Z, and is arranged higher up than a height H1 of the yoke section 13b. The length of the elongated cross section is the same as,

20 or slightly larger than, the length L of the coils 14 in the axial direction. As a result, the cooling tube 20 is glued to almost the entire outer surface of the coils 14, being a source of heat. A plurality of holes 25 through which coolant flows are formed in the cooling tube 20 in a direction parallel to the coil axes. The cooling tube 20 does not have any branches, which means that no stagnation occurs in the flow of coolant. As

25 shown by the arrows in Fig. 4, heat generated in the coils 14 and conducted to an

outer side is directly cooled by coolant inside the cooling tube 20. Heat conducted from the coils 14 to the cores 13 is transferred through pole surfaces 13a close to the cooling tube 20 and the yoke section 13b to the cooling tube 20. Fig. 5 shows another example of the cooling tube 20. The cooling tube 20 of Fig. 5 has a plurality of round copper pipes lined up parallel to the coil axes Z. Adjoining copper pipes 26 are joined by brazing. The two ends 20a and 20b of the cooling tube 20 are connected to respective manifolds 21 and 22 by welding.

A method of manufacturing a coil assembly of the present invention will now be described in detail below with reference to Fig. 6A, Fig. 6B, Fig. 6C, Fig. 6D.

As shown in Fig. 6A, cores at two places corresponding to the head and tail of a row of cores are temporarily attached to an upper surface of a base plate 11 using screws 19. With the illustrated embodiment, the row of cores is made up of nine cores 13. Coils 14 are wound around the cores 13 using a coil winding machine. Since the cores are divided for each coil 14, winding of the coils 14 is simple. As shown in Fig. 6B, a flat cooling tube 20 having interleaved folds at least equal in number to the number of coils 14 is manufactured. Here, a flat cooling tube 20 having nine interleaved folds is manufactured. The folds of the cooling tube 20 are formed corresponding to the size of the outline of the coils 14, so that the coils 14 can fit into the folds. The two ends of the cooling tube 20 are fixed by welding to elongated holes formed in manifolds 21 and 22. The cooling tube 20 is moved horizontally, and folds of the cooling tube 20 fit into two coils 14 on the base plate 11. Three cores 13 are then moved horizontally, and inserted into folds of the cooling tube 20. Then, as shown in Fig. 6C, an odd number of, namely five, cores of the row of cores are arranged on the upper plane of the base plate. Since the cores

are inserted in the direction in which the coils are wound, it is difficult to damage the coils. An even number of cores of the core row, namely four cores, are now moved horizontally, and inserted into folds of the cooling tube 20. One of the manifolds 21 is fixed to one end of the base plate 11. All of the cores 13 are then fixed to the base
5 plate 11 using screws 19. As shown in Fig. 6D and Fig. 7, a cylindrical member 23 is vertically attached to the other end of the base plate 11. The cooling tube 20 remaining at the other end of the base plate 11 is bent around the center of the cylindrical member 23. Then, the other manifold 22 is fixed to one end of the base plate 11.

10 After lead wires of the coils 14 have been located on the outer side of the base plate, the coil assembly 12 is covered with a box-shaped frame. Insulating resin is filled into the frame until the pole faces 13a of the cores 13 are covered. A fixed resin compact is finished to the specified dimensions so as to expose the pole faces 13a. Fig. 8 shows the coil assembly covered with the insulating resin in this way. In
15 the case where the insulating resin sufficiently permeates into the coil assembly 12, there is no need for the insulators 16.

The illustrated embodiment has been selected simply to describe the gist and practical application of the present invention, and the scope of the present invention is defined by the appended claims.

What is claimed is:

1. A linear motor coil assembly for developing linear motion, comprising:
a plurality of coils arranged in a line in a direction of movement, and
respectively having coil shafts perpendicular to the movement direction;
5 and a flat cooling pipe, having a cross section elongated in a direction
parallel to the coil shafts and folds for the coil to engage into, meandering inside the
plurality of coils.
2. The linear motor coil assembly of claim 1, wherein the flat cooling pipe
has a plurality of clearance holes for passing coolant, formed in a direction parallel
10 to the coil shafts
3. The linear motor coil assembly of claim 1, wherein the flat cooling pipe
has a plurality of round pipes for passing coolant aligned and attached in a direction
parallel to the coil shafts.
4. The linear motor coil assembly of claim 1, wherein the flat cooling tube
15 has interleaved folds at least equal in number to the number of coils.
5. The linear motor coil assembly of claim 1, wherein the elongated cross
section of the flat cooling pipe is the same as, or slightly larger than, the length of
the coils in an axial direction.
6. The linear motor coil assembly of claim 1, further comprising cores,
20 divided for each coil, around which the coils are wound.
7. The linear motor coil assembly of claim 6, further comprising a base plate,
to which the cores are fixed in a line in the direction of motion.
8. A method of manufacturing a linear motor assembly for developing linear
motion, comprising the steps of:
25 making cores divided for each magnetic pole;



winding coils around the respective cores;

making a flat cooling pipe having interleaved folds, at least equal in number to the number of coils, into which the coils can be engaged;

fitting the core into the folds; and

5 arranging the cores in a line on a base plate.

