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SPECIFICATION

TITLE OF INVENTION

ELECTROMAGNETIC STEEL PLATE FOR IRON CORE FOR STATOR, IRON CORE FOR STATOR USING THE SAME, AND METHOD OF MANUFACTURING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of manufacturing an electromagnetic steel plate for an iron core for a stator and an iron for a stator using the same, an electromagnetic steel plate for an iron core for a stator and an iron core for a stator using the same. More particularly, the present invention relates to a method of manufacturing an electromagnetic steel plate for an iron core for a stator by continuously and efficiently punching a steel strip and by laminating a plurality of the electromagnetic steel plates for the stator by a required number, and to an electromagnetic steel plate for an iron core for a stator manufactured by the foregoing and an iron core for a stator.

2. Background Art

The cross section of a conventional hermetically

sealed type compressor is shown in Fig. 8.

Reference numeral 50 represents an hermetically sealed container having an oil reservoir 51 in which oil is accumulated. The hermetically sealed container 50 accommodates an electromotive element 52 in the upper portion thereof and a rotary compression element 53 in the lower portion thereof. The electromotive element 52 comprises a rotor core 55 attached to a rotational shaft 54, a stator core 57 having, on the outer circumference thereof, an oil return hole 56 and so forth. Reference numeral 58 represents an air gap formed by the outer circumference of the rotor core 55 and the inner surface of the stator core 57. Reference numeral 59 represents a coil end of a coil included in the stator core 57. The rotary compression element 53 comprises a cylinder 60, a roller 62 which is rotated in the cylinder by an eccentric portion 61 of the rotational shaft 54, a vane 63 which is in contact with the roller 62 and which sections the inside portion of the cylinder 60, upper and lower bearings 64 and 65 for sealing openings of the cylinder 60, a discharge valve 66 attached to the upper bearing 64 and a cup muffler 67 for covering the discharge valve 66. Reference numeral 68 represents a discharge port formed in the cup muffler 67. Reference numeral 69 represents a refrigerant discharge pipe formed to penetrate the central portion of the upper portion of the hermetically

sealed container 50 having an upper portion hermetically sealed by an end cap 70 connected thereto. Reference numeral 71 represents an accumulator. Arms shown in Fig. 8 indicate flow of the refrigerant.

In the hermetically sealed type compressor having the above-mentioned structure, the refrigerant compressed by the rotary compression element 53 is allowed to pass through the air gap 58 of the electromotive element 52 so as to be moved to the upper portion of the electromotive element 52. Oil contained in the refrigerant moved to the upper portion of the electromotive element 52 is, by centrifugal force generated when the rotor core 55 has been rotated, blown off to the stator core 57. Then, the refrigerant gas is discharged from the refrigerant discharge pipe 69 to the outside of the hermetically sealed container 50. Separated oil is returned to the oil reservoir 51 in the hermetically sealed container 50 through the oil return hole 56 formed in the outer circumference of the stator core 57.

Fig. 9 is a diagram showing a punching machine for manufacturing a conventional rotor core and a stator core.

Referring to Fig. 9, reference numeral 79 represents a punching machine for manufacturing a rotor core and a stator core. The punching machine 79 has, in the upper portion thereof, a plurality of male punching dies consisting of first line dies 80(1) to 84(1) and second line dies 80(2)

to 84(2) for manufacturing electromagnetic steel plates for rotor cores and a plurality of male punching dies consisting of first line dies 86(1) to 88(1) and second line dies 86(2) to 88(2) for manufacturing electromagnetic steel plates for stator cores. The punching machine 79 has, in the lower portion thereof, a plurality of female punching dies corresponding to the male dies. A steel strip S is continuously supplied between the male dies and the female dies. Then, the male dies are vertically moved so that the steel strip S is sequentially punched at required zigzag positions on two lines running parallel to the lengthwise direction of the steel strip S and extending in the lengthwise direction of the same. Thus, electromagnetic steel plates for rotor cores each having a plurality of caulking portions are manufactured. Reference numerals 85(1) and 85(2) represent female dies for pressing and laminating the electromagnetic steel plates for rotor cores, and 89(1) and 89(2) represent ports for taking out the rotor cores.

Then, the outer circumference of the steel strip S, from which the electromagnetic steel plates for rotor cores have been obtained by punching, is sequentially punched at required portions so that electromagnetic steel plates for stator cores each having a plurality of caulking portions are manufactured. The electromagnetic steel plates for stator cores are laminated by a required number so that stator cores

are manufactured. Reference numerals 91(1) and 91(2) represent female dies for manufacturing stator cores by pressurizing and laminating the electromagnetic steel plates for stator cores, 90(1) and 90(2) represent outlet ports for taking out the stator cores, and symbol a represents a blank portion which is not punched.

Fig. 10 is a plan view showing a state where the steel strip S has been punched by using the punching machine 79. Referring to Fig. 10, reference numerals 80(1) to 84(1) and 80(2) to 84(2) represent electromagnetic steel plates for rotor cores in which required portions have been removed by punching with corresponding male punching dies, 86(1) to 88(1) and 86(2) to 88(2) represent electromagnetic steel plates for stator cores obtained at required portions by corresponding male dies. The same reference numerals as those shown in Fig. 9 represent the same elements. Symbols K1 and K2 represent caulking portions provided for the electromagnetic steel plates for rotor cores, and K3 and K4 represent caulking portions provided for the electromagnetic steel plates for stator cores. Portions having no corresponding reference numerals represent marks left after the steel strip S has been punched. Reference numerals 92 and 93 represent guide holes for moving the steel strip S for a predetermined distance.

Figs. 11(a) to 11(d) are diagrams showing the

electromagnetic steel plates for rotor cores in which required portions have been removed by punching with the male dies 80(1) to 83(1) and 80(2) to 83(2) of the punching machine 79. Reference numeral 92 shown in Fig. 11 (a) represents guide holes for moving the steel strip S for a predetermined distance. Symbols K1 and K2 shown in Fig. 11(c) represent caulking portions provided for the electromagnetic steel plates for rotor cores.

Fig. 12(a) is a diagram showing the blank portion on the second line which is not punched, and the first line, on which the electromagnetic steel plate for the rotor core having an outer circumference punched by the male die 84(1), the female die 85(1) for pressurizing and laminating the electromagnetic steel plates for rotor cores and the port 89(1) for taking out the rotor cores are arranged. Fig. 12(b) is a diagram showing the first line on which the mark is left after the electromagnetic steel plate for the rotor core has been punched and the second line on which the electromagnetic steel plate for the rotor core having an outer circumference punched by the male die 84(2), the female die 85(2) for pressurizing and laminating a predetermined number of the electromagnetic steel plates for rotor cores and the port 89(2) for taking out the rotor cores are arranged. Fig. 12(c) is a diagram showing the mark left after the steel strip S has been punched. Fig. 12(d) is a

diagram showing the electromagnetic steel plates for stator cores respectively having four caulking portions K3 and four caulking portions K4 punched by the male dies 86(1) and 86(2) on the first and second lines. Reference numeral 93 shown in Fig. 12(c) represent the guide holes again formed for moving the steel strip S for a predetermined distance.

Fig. 13(a) is a diagram showing the electromagnetic steel plates for the stator cores from which required portions have been punched by the male dies 87(1) and 87(2) on the first and second lines. Fig. 13(b) is a diagram showing the second line on which the blank portion which has not been punched and the first line on which the electromagnetic steel plate for the stator core having the outer circumference which has been punched by the male die 88(1), the female die 91(1) for pressurizing and laminating the electromagnetic steel plates for stator cores and the port 90(1) for taking out the stator cores are arranged.

Fig. 13(c) is a diagram showing the first line on which the marks is formed after the steel strip S has been punched and the second line on which the female die 91(2) for pressurizing and laminating the required number of the electromagnetic steel plates for stator cores and the port 90(2) from which the stator core is taken out are arranged.

Fig. 14 is a diagram showing the electromagnetic steel plates for stator cores from which required portions

have been punched by the male dies 87(1) and 88(1) on the first line and the electromagnetic steel plates for stator cores from which required portions have been punched by the male dies 86(2) and 87(2) on the second line.

Fig. 15(a) is a diagram showing an example of the caulking portion, and 15(b) is a diagram showing another example of the caulking portion.

Fig. 16(a) is a diagram showing an example of the electromagnetic steel plate for the rotor core manufactured by the above-mentioned method, and 16(b) is a diagram showing the rotor core formed by pressurizing and laminating the electromagnetic steel plates for the rotor cores by a required number.

Fig. 17(a) is a diagram showing an example of the electromagnetic steel plate for the stator core manufactured by the above-mentioned method, and Fig. 17(b) is a diagram showing the stator core formed by pressurizing and laminating the electromagnetic steel plates for the stator cores by a required number. Referring to Fig. 17(a), symbols K represent caulking portions.

However, as shown in Fig. 14, the circular arcs of the outer ends of the electromagnetic steel plates 86(2) and 87(1) for the stator cores (1), those of the electromagnetic steel plates 87(2) and 87(1) for the stator cores and those of the electromagnetic steel plates 87(2) and 88(1) for the

stator cores each having radius r and formed on the first and second lines are in contact with each other such that the cutting margins are left. Therefore, a wide steel strip must be used to manufacture the electromagnetic steel plates for the stator cores and thus there arises a problem in that a great loss of the steel strip cannot be prevented.

As shown in Fig. 14, the outer circumferences of the electromagnetic steel plates for the stator cores corresponding to the portions in which the four caulking portions (for example, the four caulking portions K3 of the electromagnetic steel plate for the stator core 87(1)) are, by punching, formed into circular arcs each having the radius r. Therefore, the outer circumference of the electromagnetic steel plate for the stator core corresponding to the portion in which the caulking portion is formed is unintentionally expanded and thus the stator core is deformed because the internal stress or the distortion is caused from the operation for punching the caulking portion when the stator core, which has been manufactured by pressurizing and laminating the electromagnetic steel plates for the stator cores by a required number, is used as an electromotive element.

Figs. 18(a) to 18(c) are diagrams showing expansion of the outer circumference of the electromagnetic steel plate for the stator core corresponding to the portion in which the

caulking portion is formed. Fig. 18(a) is a diagram showing a portion of the outer circumference of the electromagnetic steel plate for the stator core, Fig. 18(b) is a diagram showing a caulking portion formed at a predetermined position near the outer circumference of the electromagnetic steel plate for the stator core, and Fig. 18(c) is a diagram showing generation of a deformed portion in the outer periphery of the electromagnetic steel plate for the stator core corresponding to the portion in which the caulking portion is formed attributable to the internal stress or distortion caused from the operation for punching the caulking portion in a state where the stator core manufactured by using the above-mentioned electromagnetic steel plates for the stator cores is used as the electromotive element.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method of manufacturing an electromagnetic steel plate for the stator core and a stator core using the electromagnetic steel plate for the stator core which is capable of using a steel strip having a small width and reducing loss of the steel strip, and preventing a problem in that the outer circumference of the electromagnetic steel plate for the stator core corresponding to the portions in which caulking

portions are formed is expanded and that the stator core is deformed. Another object of the present invention is to provide the electromagnetic steel plate for the stator core manufactured by the above-mentioned method and the stator core using the electromagnetic steel plate for the stator core.

Inventors of the present invention has researched and developed the above-mentioned problems, thus resulting in that a fact being found that the foregoing problem can be solved by a structure formed such that the caulking portions are disposed at specific position of the electromagnetic steel plate for the stator core, and the caulking portions are previously punched and then the outer circumference is punched, followed by providing cut portions in the outside of the electromagnetic steel plate for the stator core corresponding to the portions in which the caulking portions are formed.

According to one aspect of the present invention, there is provided a method of manufacturing an electromagnetic steel plate for the stator core and a stator core using the electromagnetic steel plate for the stator core such that when a steel strip is continuously supplied between a male die and a female die of a punching machine having a plurality of male punching dies in the upper portion thereof and a plurality of female punching dies in the lower

portion thereof and structured to vertically move the male die to manufacture a rotor core and a stator core so as to manufacture the rotor core by laminating a required number of the electromagnetic steel plates for the rotor cores formed at zigzag positions on two lines running parallel to the lengthwise direction of the steel strip and formed by sequentially punching required portions in the lengthwise direction of the steel strip and each having a plurality of caulking portions and then manufacture an electromagnetic steel plate for the stator core having a plurality of caulking portions by sequentially punching required portions in the outer circumference left after the electromagnetic steel plates for the rotor cores have been punched, a required portion including the plural caulking portions is initially punched and then the outer circumference is punched to manufacture the electromagnetic steel plate for the stator core, followed by laminating the required number of the electromagnetic steel plates for the stator cores to manufacture the stator core, the method of manufacturing an electromagnetic steel plate for the stator core and a stator core using the electromagnetic steel plate for the stator core comprising the steps of: making the outer circumferences of the electromagnetic steel plates for the stator cores on the first and second lines to be in contact with each other such that cutting margins are left; making the outer

15 APR 2003

circumferences to be in contact with the widthwise ends of the steel strip such that cutting margins are left; forming cut portions at positions at which a center line connecting the center of the electromagnetic steel plate for the stator core on the first line and a center of the electromagnetic steel plate for the stator core on the second line which is in contact with the electromagnetic steel plate for the stator core such that a cutting margin is left intersects the outer circumference of the electromagnetic steel plate for the stator core, the cut portion being formed perpendicularly to the center line; and forming the caulking portions on the outer periphery of the electromagnetic steel plate for the stator core corresponding to the cut portions, the caulking portions being formed perpendicularly to the center line.

The manufacturing method according to the first aspect of the present invention may have a structure such that the number of the caulking portions is four, and the electromagnetic steel plate for the stator core having four caulking portions is manufactured such that at least one of four caulking portions is formed in a next or a later step.

The manufacturing method according to the first or second aspect of the present invention may have a structure such that four oil returning cut portions are formed at positions at which a line drawn from the center of the electromagnetic steel plate for the stator core which has

been punched at required portions to be perpendicular to the lengthwise direction of the steel strip intersects the outer circumference of the electromagnetic steel plate for the stator core and positions at which a line drawn from the center of the electromagnetic steel plate for the stator core to run parallel to the lengthwise direction of the steel strip intersects the outer circumference of the electromagnetic steel plate for the stator core, the four oil returning cut portions being formed perpendicular to the lines.

According to another aspect of the present invention, there is provided an electromagnetic steel plate for the stator core manufactured by the manufacturing method according to any one of first to third aspects of the present invention.

According to another aspect of the present invention, there is provided a stator core manufactured by the manufacturing method according to any one of the first to third aspects of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing a punching machine for manufacturing a rotor core and a stator core according to the present invention;

Fig. 2 is a plan view showing a state where a steel

strip has been sequentially punched by using the punching machine shown in Fig. 1;

Figs. 3(a) to 3(c) are diagrams showing electromagnetic steel plates for the rotor cores punched at required portions;

Fig. 3(d) is a diagram showing a second line on which a blank portion is formed in which no punching is performed and a first line on which an electromagnetic steel plate for the rotor core having an outer circumference punched by the male die 4(1), a female die 5(1) for pressurizing and laminating the electromagnetic steel plates for the rotor cores and a port 6(1) for taking out the rotor core are formed;

Fig. 4(a) is a diagram showing the first line on which a mark is formed after the electromagnetic steel plate has been punched and the second line on which the electromagnetic steel plate for the rotor core having an outer circumference punched by a male die 4(2), a female die 5(2) for pressurizing and laminating the electromagnetic steel plate for the rotor core and a port 6(2) for taking out the rotor core are formed;

Fig. 4(b) is a diagram showing a mark formed after punching has been performed;

Figs. 4(c) to 4(d) are diagrams showing the electromagnetic steel plates for the stator cores punched at

required portions;

Fig. 5(a) is a diagram showing the second line on which a blank portion in which no punching is performed is formed and a first line on which the electromagnetic steel plate for the stator core having the outer circumference punched by the male die 9(1) and a female die 10(1) for pressurizing and laminating the electromagnetic steel plates for the stator cores are formed;

Fig. 5(b) is a diagram showing the second line on which the electromagnetic steel plate for the stator core having the outer circumference punched by the male die 9(2), a female die 10(2) for pressurizing and laminating the electromagnetic steel plates for the stator cores by a required number and a port 11(2) for taking out the stator core are formed and a first line on which a mark is formed after punching has been performed;

Fig. 6 is a diagram showing electromagnetic steel plates for the stator cores 8(1) and 9(1) formed on the first line and punched at required portions and electromagnetic steel plates for the stator cores 7(2) and 8(2) formed on the second line and punched at required portions;

Fig. 7(a) is a diagram showing an example of the electromagnetic steel plate for the stator core according to the present invention;

Fig. 7(b) is a diagram showing an example of the

stator core according to the present invention and manufactured by pressurizing and laminating the electromagnetic steel plates for the stator cores according to the present invention by a required number;

Fig. 8 is a cross sectional view showing a conventional hermetically sealed type compressor;

Fig. 9 is a diagram showing a punching machine for manufacturing a conventional rotor core and a stator core;

Fig. 10 is a plan view showing a state where a steel strip has been punched by using the conventional punching machine;

Figs. 11(a) to 11(d) are diagrams showing electromagnetic steel plates for the rotor cores punched at required portions by the conventional punching machine;

Fig. 12(a) is a diagram showing the second line on which the blank portion in which no punching is performed is formed and the first line on which the electromagnetic steel plate for the rotor core having the outer circumference punched by the male die 84(1), a female die 85(1) for pressurizing and laminating the electromagnetic steel plates for the rotor cores and a port 89(1) for taking out the rotor core are formed;

Fig. 12(b) is a diagram showing the second line on which the electromagnetic steel plate for the rotor core having the outer circumference punched by a male die 84(2), a

female die 85(2) for pressurizing and laminating the electromagnetic steel plates for the rotor cores by a required number and a port 89(2) for taking out the rotor core are formed;

Fig. 12(c) is a diagram showing a mark formed after punching has been performed;

Fig. 12(d) is a diagram showing the electromagnetic steel plate for the stator core having four caulking portions K3 and K4 and punched at required portions;

Fig. 13(a) is a diagram showing the electromagnetic steel plate for the stator core punched at required portions;

Fig. 13(b) is a diagram showing the second line on which the blank portion in which no punching is performed is formed and the first line on which the electromagnetic steel plate for the stator core having the outer circumference punched by a male die 88(1), a female die 91(1) for pressurizing and laminating the electromagnetic steel plates for the stator cores and a port 90(1) for taking out the stator core are formed;

Fig. 13(c) is a diagram showing the first line on which the mark left after punching has been performed is formed and a second line on which the electromagnetic steel plate for the stator core having the outer circumference punched by a male die 88(2), a female die 91(2) for pressurizing and laminating the electromagnetic steel plates

for the stator cores by a required number and a port 90(2) for taking out the stator core are formed;

Fig. 14 is a diagram showing electromagnetic steel plates for the stator cores 87(1) and 88(1) formed on the first line and punched at required portions and electromagnetic steel plates for the stator cores 86(2) and 87(2) formed on the second line and punched at required portions;

Fig. 15(a) is a diagram showing an example of the caulking portion;

Fig. 15(b) is a diagram showing another example of the caulking portion;

Fig. 16(a) is a diagram showing an example of a conventional electromagnetic steel plate for the rotor core;

Fig. 16(b) is a diagram showing a rotor core formed by pressurizing and laminating the conventional electromagnetic steel plates for the rotor cores by a required number;

Fig. 17(a) is a diagram showing an example of the conventional electromagnetic steel plate for the stator core;

Fig. 17(b) is a diagram showing the conventional stator core formed by pressurizing and laminating the conventional electromagnetic steel plates for the stator cores by a required number; and

Figs. 18(a) to 18(c) are diagrams showing expansion

of the outer circumference of the electromagnetic steel plate for the stator core corresponding to the portions in which the caulking portions are formed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a diagram showing a punching machine for manufacturing rotor cores and stator cores according to the present invention.

Referring to Fig. 1, reference numeral 1 represents a punching machine for manufacturing the rotor cores and stator cores. The punching machine 1 has, in the upper portion thereof, a plurality of male punching dies 1(1) to 4(1) on the first line and those 1(2) to 4(2) on the second line for manufacturing the electromagnetic steel plates for the rotor cores, and a plurality of male punching dies 7(1) to 9(1) on the first line and those 7(2) to 9(2) on the second line for manufacturing the electromagnetic steel plates for the stator cores. Moreover, the punching machine 1 has a plurality of female punching dies corresponding to the above-mentioned male punching dies. A steel strip Sa is continuously supplied between the male dies and the female dies and the male dies are vertically moved so as to punch required portions on the two lines which are formed parallel to the lengthwise direction of the steel strip Sa and which extend in the lengthwise direction of the steel strip Sa so

that electromagnetic steel plates for the rotor core having a plurality of caulking portions is manufactured. Reference numerals 5(1) and 5(2) represent female dies for pressurizing and laminating a required number of electromagnetic steel plates for the rotor cores to manufacture rotor cores, and 6(1) and 6(2) represent ports for taking out the rotor cores. Then, the portion left after the electromagnetic steel plate for the rotor core has been punched is punched at required portions so that an electromagnetic steel plate for the stator core is manufactured. Then, a required number of the electromagnetic steel plates for the stator core are laminated so that a stator core is manufactured. Reference numerals 10(1) and 10(2) represent female dies for manufacturing the stator core by pressurizing and laminating a required number of the electromagnetic steel plates for the stator core, 11(1) and 11(2) represent ports for taking out the stator cores and symbol a represents a blank portion.

Fig. 2 is a plan view showing a state where the steel strip Sa has been sequentially punched by using the punching machine 1. Referring to Fig. 2, reference numeral 1(1) to 4(1) and 1(2) to 4(2) represent electromagnetic steel plates for the rotor cores which have been punched at required portions by the corresponding male dies, and 7(1) to 9(1) and 7(2) to 9(2) represent electromagnetic steel plates for the stator cores which have been punched at required

portions by the male dies. Symbol k represents a caulking portion. Referring to Fig. 2, the same reference numerals as those shown in Fig. 1 represent the same elements. Portions having no reference numerals represent marks left after the electromagnetic steel plates have been punched. Reference numerals 12 and 13 represent guide holes for supplying the steel strip Sa for a predetermined distance.

Figs. 3(a) to 3(c) are diagrams showing the electromagnetic steel plates for the rotor core punched at required portions by the male dies 1(1) to 3(1) and 1(2) to 3(2) of the punching machine 1. Referring to Fig. 3(a), reference numeral 12 represents a guide hole for supplying the steel strip Sa for a predetermined distance. In the step shown in Fig. 3(c), five caulking portions k are formed. Fig. 3(d) is a diagram showing the second line on which the blank portion is formed after the electromagnetic steel plate has been punched and the first line on which the electromagnetic steel plate for the rotor core having the outer circumference punched by the male die 4(1) of the punching machine 1, the female die 5(1) for pressurizing and laminating the electromagnetic steel plate for the rotor core and the port 6(1) for taking out the rotor core are formed.

Fig. 4(a) is a diagram showing the first line on which the mark formed after the electromagnetic steel plate has been punched (or a blank portion which has not been

punched) and the second line on which the electromagnetic steel plate for the rotor core having the outer circumference punched by the male die 4(2) of the punching machine 1, the female die 5(2) for pressurizing and laminating the electromagnetic steel plate for the rotor core and the port 6(2) for taking out the rotor core are arranged. Fig. 4(b) is a diagram showing the marks from which electromagnetic steel plates have been punched (or the blank portions which have not been punched). Fig. 4(c) is a diagram showing the first line on which the electromagnetic steel plate for the stator core punched by the male die 7(1) is formed and the second line on which the electromagnetic steel plate for the stator core punched by the male die 7(2) is formed. In comparison to the electromagnetic steel plate for the stator core 7(1) on the first line which has four caulking portions k, the electromagnetic steel plate for the stator core 7(2) on the second line having no marginal space for attaching the male die for punching the caulking portion has three caulking portions k. Fig. 4(c) is a diagram showing the first line on which the electromagnetic steel plate for the stator core punched by the male die 8(1) is formed and a second line on which the electromagnetic steel plate for the stator core punched by the male die 8(2) is formed. One residual caulking portion k is formed on the second line. Reference numeral 13 shown in Fig. 4(b) represents guide holes again

punched for supplying the steel strip Sa for a predetermined distance.

Fig. 5(a) is a diagram showing the second line on which the blank portion which has not been punched is formed and the first line on which the electromagnetic steel plate for the stator core having the outer circumference punched by the male die 9(1), the female die 10(1) for pressurizing and laminating the electromagnetic steel plate for the stator core and the port 11(1) for taking out the stator core is taken out are arranged.

Fig. 5(b) is a diagram showing the second line on which the electromagnetic steel plate for the stator core having the outer circumference punched by the male die 9(2), the female die 10(2) for pressurizing and laminating the electromagnetic steel plates for the stator cores by a required numbers and the port 11(2) for taking out the stator core are arranged. A mark left after the electromagnetic steel plate has been punched is formed on the first line.

Fig. 6 is a diagram showing the electromagnetic steel plate for the stator core punched at required portions by the male dies 8(1) and 9(1) on the first line and the electromagnetic steel plate for the stator core punched at required portions by the male dies 7(2) and 8(2) on the second line.

Referring to Fig. 6, line a connecting the centers

of the electromagnetic steel plates for the stator cores 8(1) and 9(1) on the first line and line b connecting the centers of the electromagnetic steel plates for the stators 7(2) and 8(2) formed on the second line and punched at required portions run parallel to each other with respect to the lengthwise direction of the steel strip Sa (having a width of about 226.0 mm).

The outer circumferences of the electromagnetic steel plates for the stator cores 8(1), 9(1), 7(2) and 8(2) on the first and second lines are in contact with each other such that cutting margins (about 0.95 mm to 1.0 mm) are left and cutting margins (about 0.95 mm to 1.0 mm) are left in the widthwise end portions of the steel strip Sa.

Moreover, cut portions e and g are formed at portions at which the center lines c and d for connecting the center of the electromagnetic steel plate for the stator core 8(1) on the first line and the centers of the electromagnetic steel plates for the stator cores 7(2) and 8(2) on the second line which are in contact with the electromagnetic steel plate for the stator core 8(1) intersect the outer circumference of the electromagnetic steel plate for the stator core 8(1), the cut portions e and g being formed perpendicularly to the center line c. Moreover, cut portions f and h are determined perpendicularly to the center line d. In addition, caulking portions Ke, Kf, Kg and Kh are formed

on the outer periphery of the electromagnetic steel plate for the stator core 8(1) corresponding to the cut portion e, f, g and h to be perpendicular to the center lines c and d. Also four cut portion and four caulking portions K are provided for the other electromagnetic steel plates for the stator cores 9(1), 7(2) and 8(2). The cut portions e, f, g and h form oil return holes in the outer circumference of the stator core.

Moreover, oil returning cut portions Ki and Kj are formed at positions at which line i drawn from the center of the electromagnetic steel plate for the stator core 8(1) in the lengthwise direction of the steel strip Sa intersects the outer circumference of the electromagnetic steel plate for the stator core 8(1), the oil returning cut portions Ki and Kj being formed perpendicular to the line i. In addition, oil returning cut portions Kk and Kl are formed at positions at which line a drawn in parallel to the lengthwise direction of the steel strip Sa from the center of the electromagnetic steel plate for the stator core 8(1) intersects the outer circumference of the electromagnetic steel plate for the stator core 8(1), the oil returning cut portions Kk and Kl being formed perpendicular to the line a. Note that the angle Θ made between the center line d and the line i is 29°18'. The electromagnetic steel plates for the stator cores 9(1), 7(2) and 8(2) are provided with four oil

returning cut portions, similarly to the electromagnetic steel plate for the stator core 8(1). The cut portions Ki, Kj, Kk and Kl form oil returning holes in the outer circumference of the stator core.

Fig. 7(a) is a diagram showing an example of the electromagnetic steel plate for the stator core according to the present invention. Fig. 7(b) is a diagram showing an example of the stator core according to the present invention which is formed by pressurizing and laminating a required number of electromagnetic steel plates for the stator cores according to the present invention.

The present invention is not limited to the number, size and shape of the caulking portions Ke, Kf, Kg and Kh. The conventional caulking portion shown in Fig. 15 may be employed. Although the number of the caulking portions must be two or more, it is preferable that four caulking portions be provided because a long time is required to punch the caulking portions, a great loss takes places and thus the electromagnetic characteristic of the stator core is adversely affected if the number of the caulking portions is too large.

In the present invention, the size and the shape of the cut portions e, f, g and h and the oil returning cut portions Ki, Kj, Kk and Kl are not limited particularly. Although the oil returning characteristic can be improved if

the cut area is enlarged, the electromagnetic characteristic of the stator core is adversely affected. Therefore, the specifications are required to be determined in consideration of the above-mentioned factors.

As described above, the caulking portions Ke, Kf, Kg and Kh are punched at specific positions, and then the overall outer circumference including the cut portions e, f, g and h are punched. Thus, a steel strip even having a small width can be used and, therefore, loss of the steel strip can be reduced. When an electromagnetic steel plate for the stator core having an outer diameter of, for example, 121.7 mm and shown in Fig. 7(a) is manufactured with the conventional structure, a steel strip having a width of 227.5 mm must be used. In this case, a loss ratio of about 40 % to 50 % of the steel strip takes place. However, the present invention requires a steel strip having a small width of about 226 mm to 224 mm to manufacture the electromagnetic steel plate for the stator core having the above-mentioned outer diameter. Moreover, the loss ratio of the steel strip can be reduced by about 40 % as compared with the conventional technology.

Although the electromagnetic steel plate for the stator core and the stator core according to the present invention are somewhat deformed at the cut portions e, f, g and h corresponding to the portions in which the caulking

portions Ke, Kf, Kg and Kh are formed, no critical deformation of the outer circumference of the electromagnetic steel plate for the stator core and the stator core takes place, as is experienced with the conventional technology as shown in Fig. 18.

According to the present invention, there are provided a satisfactory electromagnetic steel plate for the stator core and a stator core using the electromagnetic steel plate for the stator core which enables a steel strip having a small width to be used and the loss of the steel strip to be reduced and capable of preventing expansion of the outer circumference of the electromagnetic steel plate for the stator core at positions corresponding to the portions in which the caulking portions are formed and deformation of the stator core.

WHAT IS CLAIMED IS:

1. A method of manufacturing an electromagnetic steel plate for the stator core and a stator core using said electromagnetic steel plate for the stator core such that when a steel strip is continuously supplied between a male die and a female die of a punching machine having a plurality of male punching dies in the upper portion thereof and a plurality of female punching dies in the lower portion thereof and structured to vertically move the male die to manufacture electromagnetic steel plates for a rotor core and a stator core so as to manufacture the rotor core by laminating a required number of the electromagnetic steel plates for the rotor cores formed at zigzag positions on two lines running parallel to the lengthwise direction of the steel strip and formed by sequentially punching required portions in the lengthwise direction of the steel strip and each having a plurality of caulking portions and then manufacture an electromagnetic steel plate for the stator core having a plurality of caulking portions by sequentially punching required portions in the outer circumference left after the electromagnetic steel plates for the rotor cores have been punched, a required portion including the plural caulking portions is initially punched and then the outer circumference is punched to manufacture the electromagnetic steel plate for the stator core, followed by laminating the

required number of the electromagnetic steel plates for the stator cores to manufacture the stator core, said method of manufacturing an electromagnetic steel plate for the stator core and a stator core using said electromagnetic steel plate for the stator core comprising the steps of:

making the outer circumferences of the electromagnetic steel plates for the stator cores on the first and second lines to be in contact with each other such that cutting margins are left;

making the outer circumferences to be in contact with the widthwise ends of the steel strip such that cutting margins are left;

forming cut portions at positions at which a center line connecting the center of the electromagnetic steel plate for the stator core on the first line and a center of the electromagnetic steel plate for the stator core on the second line which is in contact with the electromagnetic steel plate for the stator core such that a cutting margin is left intersects the outer circumference of the electromagnetic steel plate for the stator core, the cut portion being formed perpendicularly to the center line; and

forming the caulking portions on the outer periphery of the electromagnetic steel plate for the stator core corresponding to the cut portions, said caulking portions being formed perpendicularly to the center line.

2. A manufacturing method according to claim 1, wherein the number of the caulking portions is four, and the electromagnetic steel plate for the stator core having four caulking portions is manufactured such that at least one of four caulking portions is formed in a next or an later step.

3. A manufacturing method according to claim 1 or 2, wherein four oil returning cut portions are formed at positions at which a line drawn from the center of the electromagnetic steel plate for the stator core which has been punched at required portions to be perpendicular to the lengthwise direction of the steel strip intersects the outer circumference of the electromagnetic steel plate for the stator core and positions at which a line drawn from the center of the electromagnetic steel plate for the stator core to run parallel to the lengthwise direction of the steel strip intersects the outer circumference of the electromagnetic steel plate for the stator core, the four oil returning cut portions being formed perpendicular to the lines.

4. An electromagnetic steel plate for the stator core manufactured by the manufacturing method according to any one of claim 1 to 3.

5. A stator core manufactured by the manufacturing method according to any one of claims 1 to 3.