

Description

BACKGROUND OF THE INVENTION

1) Field of the Invention

The present invention relates to a method and apparatus for manufacturing a wound core of a transformer.

2) Description of the Related Art

As the iron cores of transformers, wound cores in which a strip having excellent magnetic characteristics is wound in a ring shape are now used. For example, a wound core is obtained by winding a strip material on a winding spool to obtain a square, rectangular, stepwise, or circular cross-section. For this wound core, two split cylindrical coil bobbins are pressure welded at pressure welding faces thereof, and windings are wound on the coil bobbins. Also, a cut-core type is known in which a core is cut and separated at the leg portions thereof, and windings are inserted from the leg portions into the core, to complete a wound core.

When manufacturing the above-mentioned wound core, a strip having a predetermined shape is wound on a winding spool, and as a result, when the winding thickness of the winding spool reaches a predetermined thickness, this winding operation is stopped, and a wound core is obtained. In this case, if the winding thickness is too large, when pressure welded coil bobbins are applied to the wound core and rotated, the wound core scratches the inner surface of the coil bobbins, thereby seriously hindering the winding operation of windings. Also, sometimes it is impossible to perform the pressure welding operation because the coil bobbins have split into two pieces and cannot be joined together again. Conversely, if the winding thickness is too small, a large air gap is formed between the coil bobbins and the wound core, and thus the effective cross section is reduced, and accordingly, the amount of magnetic flux is reduced.

In the prior art, the above-mentioned thickness is determined by a predetermined number of rotations of the winding spool. In this case, since the thickness of the strips is not always the same, this predetermined number may be larger than a desired value. Accordingly, when the winding spool has rotated a predetermined number of rotations, the thickness of a strip wound on the winding spool is actually measured, and it is then determined whether the winding operation should be continued or a part of the already wound strip removed. As a result, the efficiency of the winding of the wound cores is lowered and the loss of material is in-

creased, thus increasing the cost of manufacturing the transformers (wound cores).

Similarly, when manufacturing a strip having a predetermined shape from a material having two straight edges, i.e., on both sides thereof, the material is cut by a slitter unit into a plurality of pieces of continuous strip for each core, this strip is wound on a temporary winding frame, and subsequently, the strip is wound on the winding spool, as explained above. Assuming the thickness of the wound core is predetermined by controlling the number of turns of the spool to compensate for variations in the thickness of the strip, the cross-section is nevertheless not predictable as it is dependent on the strip thickness. Thus, it is substantially impossible to obtain an absolutely precise predetermined cross-section, such as a circular cross-section, after the strip is wound on the winding spool. As a result, the effective cross-section of the wound core is unsatisfactory, and therefore the amount of magnetic flux is reduced, thus lowering the performance of the wound core.

Patent Abstracts of Japan, Volume 10 No. 351 (page 520) [2407] November 27th 1986, discloses an apparatus suitable for manufacturing a wound core by winding a continuous strip on a spool in which a thickness gauge is provided to measure the thickness of the strip as it is being wound on to the spool and means are provided for summing the strip thickness at predetermined periods. Although this apparatus could potentially be used to produce wound cores of a desired thickness it does not provide any solution to the problem of obtaining cores with a desired cross-section.

Patent Abstracts of Japan Volume 10, No. 154 (page 463) [2210] 4th June 1986, discloses a method for measuring the thickness of a finish sheet being wound onto a reel in a cold tandem mill. This document is directed towards the provision of a high precision measuring method which could be used to increase the accuracy of the above method. However, this document does not address the problem of obtaining wound cores with a desired cross-section.

Soviet inventions illustrated, Derwent Week WE33 publication 29th September 1982, discloses a further method of determining the thickness of a strip being wound on to a roller in order to increase the accuracy of measuring the length of the strip. However, again this disclosure does not address the problem of producing a wound core of a required cross-section.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to enhance the efficiency of the winding of wound cores on winding spools, and to reduce the loss of

material, thus reducing the cost of manufacturing the transformers (wound cores).

Another object of the present invention is to accurately obtain a predetermined cross section of a wound core after the strip is wound on the winding spool.

According to the present invention there is provided a method for manufacturing a wound core by winding a continuous strip on a winding spool, comprising steps of

- a) preparing a material having two straight edges on sides thereof;
- b) winding said material on a winding spool to obtain a wound core;
- c) periodically measuring a thickness of the said material which is being wound onto said winding spool; and
- d) cutting the material in accordance with the measured thickness; characterised in that the method comprises the further steps of:
 - e) summing said measured thickness of the material at predetermined periods;
 - f) performing a cutting operation using slitter blades upon said material to obtain a strip having a width which varies along the length thereof;
 - g) controlling the cut width of said slitter blades in accordance with said summed thickness of the strip;
 - h) determining whether or not said summed thickness of the said strip has reached a predetermined value;
 - i) stopping the winding operation by said winding spool when said summed thickness of said strip has reached a predetermined value.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more clearly from the description as set forth below with reference to the accompanying drawings, wherein:

Figs. 1 and 2 are schematic views of prior art wound cores;

Figs. 3, 4 and 5 are cross-sectional views of prior art wound cores;

Figs. 6A and 6B are plan views of a continuous strip for the wound core of Fig. 5;

Fig. 7 is a schematic view illustrating a first apparatus for manufacturing a wound core according to the method of the present invention;

Figs. 8 and 9 are flowcharts explaining the operation of the control unit of Fig. 7;

Fig. 10 is a schematic view illustrating a second apparatus for manufacturing a wound core according to the method of the present invention; and

Figs. 11, 12 and 13 are flowcharts explaining the operation of the control unit of Fig. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First, examples of wound cores will be explained with references to Figs. 1, 2, 3, 4, 5, 6A and 6B.

In Figs. 1 and 2, a wound core 1 is obtained by winding a strip material having excellent magnetic characteristics, which material is cut in advance to a predetermined shape. That is, the cross section of the wound core 1 is square (Fig. 3), rectangular, stepwise (Fig. 4), or circular (Fig. 5). For this wound core 1, two split pieces forming a cylindrical coil bobbin 2 are pressure welded at pressure welding faces 3, and the windings (not shown) are wound onto the coil bobbin 2 by rotation. Therefore, in this case, an air gap 4 or 4' (Figs. 3, 4, and 5) between the wound core 1 and the coil bobbin 2 is reduced, thus obtaining excellent magnetic characteristics. Also known is a cut-core type in which a core is cut and separated at the leg portions thereof, into which the windings are to be inserted, and the windings are inserted therein, to thereby complete the core.

For example, a plurality of pieces of a continuous strip for the wound core 1 are illustrated in Figs. 6A and 6B. That is, one or more pieces of strip are cut from a material having two straight edges, i.e. on both sides thereof. Note that, in practice, the length of a strip piece for one wound core 1 is very long, for example about 20 m, but the width thereof is very small, for example, about 1 to 3 cm.

Referring to Figure 7, which illustrates a first apparatus carrying out the method of the present invention, a material 12 is cut into one or more strips 12' whilst simultaneously being wound on a winding spool 14 to form a wound core. The material 12 is supplied from a material coil 11 to the winding spool 14 via, in turn, a tension adjusting mechanism 13, a thickness meter 15 and a slitter unit 20. A motor 16 is used to drive the winding spool 14 and has a start switch 18 which is connected to an input/output interface 195 of a control unit 19. A rotational position detector 17 is provided for detecting a predetermined rotational angular position of the winding spool 14. Both the drive motor 16 and the detector 17 are connected to the input/output interface 195 of the control unit 19.

The thickness meter 15, which may for example be a differential transformer type meter or an electrostatic capacity type meter, measures the thickness of the material 12 (or strip 12') as it passes by. The output of the thickness meter 15 is supplied to an analogue/digital converter 191 of the control unit 19.

The slitter unit 20 comprises one or two pairs of slitter blades and is driven by a drive motor 21

which is also connected to the input/output interface 195 of the control unit 19. Only one pair of slit blades are required if the material 12 is to be cut into a strip 12' of the form illustrated in Figure 8A (1), but two pairs of slit blades are required if the material 12 is to be cut in the manner illustrated in Fig. 16 to provide two strips 12'. The cut strip 12' (or strips) is/are then wound onto the winding spool 14.

The control unit 19, which may comprise a microcomputer, includes a central processing unit (CPU) 192, a Read Only Memory (ROM) 193 for storing programs, tables (maps), constants etc., a Random Access Memory (RAM) 194 for storing temporary data and the like, in addition to the analogue/digital converter 191 and input/output interface 195.

The winding operation is controlled by the control unit 19 in accordance with the routines illustrated by the flowcharts of Figs. 8 and 9.

The routine of Figure 8 is an interrupt routine which is started by turning ON the start switch 18. At step 801 a summed thickness T is cleared, then at step 802 the drive motor 16 is turned ON. The routine is completed at step 803. The winding spool 14 is then rotated in the direction indicated by the arrows in Fig. 7 thus initiating the winding of the material 12 (or the strip 12').

As the winding spool 14 rotates to perform the winding operation of the material 12 (or the strip 12') the rotational position detector 17 generates a detection pulse signal which is used to carry out an interrupt routine illustrated by the flowchart of Fig. 9. That is, the routine of Fig. 9 is carried out at every revolution of the winding spool 14.

At step 901 of the routine indicated in Figure 9, an analogue/digital conversion is performed on the output t_i of the thickness metre 15. At step 902 the summed thickness T is renewed by

$$T \leftarrow T + t_i$$

The next step, step 1101 is the control of the slit unit 20. This procedure relies on the fact that the summed thickness T indicates the thickness of the wound core, T' say, (i.e. the dimension of the core in a direction perpendicular to the strip 12' and the axis of the winding) at the time of measurement, and that the resultant cross-section of the core is dependent upon the width of the strip 12' at any value of T' . Thus, using an interpolation method from a predetermined cut curve (one dimensional map) stored in the ROM 193, the summed thickness T is used to calculate the required cut width of the strip 12' to produce the desired cross-section. The slit blade drive motor 21 is then controlled in accordance with this calculation to adjust the traverse position of the slit

blades to cut the strip 12' to the required width.

The routine then proceeds to step 903 at which it is then determined whether or not the summed thickness T has reached a predetermined value t_R . If $T < t_R$, the control routine proceeds directly to step 905. If $T \geq t_R$ the routine proceeds to step 904 at which the drive motor 16 is turned OFF. The routine is completed at step 905. Thus, when a summed thickness T of the material 12 (or the strip 12') wound on the winding spool 14 reaches a predetermined value t_R , the winding operation by the winding spool 14 is stopped.

After the winding operation of the winding spool 14 is stopped, the material 12 (or the strip 12') is cut manually or automatically, and a complete wound core of the desired cross-section is obtained.

Thus, according to the present invention, a desired cross-sectional wound core is obtained directly from the material 12.

In an alternative embodiment of the invention each thickness t_i may be estimated by measuring running lengths $0, 1, 2, \dots$ of the strip corresponding to a predetermined rotation of the winding spool 14. In this case, a running length meter (see: reference numeral 23 of Figure 10) is provided instead of the rotational position detector 17. Figure 10 illustrates a second apparatus carrying out the method of the present invention, incorporating such an arrangement, in which a material is cut into a strip (or strips) and the strip is wound on a temporary winding frame. Therefore, in Figure 10, a temporary winding frame 11' and a drive motor 22 therefor are provided instead of the winding spool 14 and the elements 16 and 17 of Figure 10. Also, in Figure 10, reference 23 designates a running length meter for measuring the running length of the strip 12', which meter 23 generates a pulse signal in accordance with the rotation of the slit blades of the slit unit 20.

The operation of the control unit 19 of Fig. 10 will be explained with reference to the flowcharts of Figs. 11, 12, and 13.

The routine of Fig. 11 is an interrupt routine which is started by turning ON the start switch 18. At step 1301, a running length count L of the total running length of the strip 12' is cleared, and at step 1302, a summed thickness T is cleared. Also, at step 1303, the drive motor 22 is turned ON, and this routine is completed at step 1304. The temporary winding frame 11' is then rotated as indicated by an arrow in Fig. 10, thus initiating the cutting of the material 12 and the winding of the strip 12'.

As explained above, when the cutting operation of the material 12 and the winding operation of the strip 12' are carried out, an interrupt routine of Fig. 12 is carried out every time the running length

meter 23 generates a pulse signal. At step 1401, the running length count L is counted up by +1 and is then stored in the RAM 194, and this routine is completed at step 1402.

In Fig. 13, which is a thickness measuring routine executed at predetermined time periods, at step 1501, the running length count L is read out of the RAM 194, and it is determined whether or not the value thereof has reached a predetermined value L_0 , i.e., whether or not the strip 12' has run for a predetermined length. As a result, only when the strip 12' has run for the predetermined length ($L > L_0$), does the control proceed to steps 1502 to 1507. Otherwise, the control proceeds directly to step 1508.

At step 1502, the running length count L is cleared, and then at step 1503, an A/D conversion is performed upon the output t_i of the thickness meter 15, and at step 1504, the summed thickness T is renewed by

$$T \leftarrow T + t_i.$$

Then, at step 1505, it is determined whether or not the summed thickness T has reached a predetermined value t_R . As a result, when the summed thickness T has reached the predetermined value t_R ($T > t_R$), the control proceeds to step 1506 which clears the summed thickness T.

At step 1507, the traverse position of the slit blades of the slit unit 20 is calculated by the interpolation method from a predetermined cut curve (one-dimensional map) stored in the ROM 193, by using the summed thickness T, and the drive motor 21 is controlled in accordance with this calculated traverse position, to thereby change the positions of the slit blades of the slit unit 20.

Then, this routine is completed by step 1508.

Thus, the thickness t_i is fetched at a predetermined length of the strip 12 (i.e. the material 12), and the cutting operation is controlled in accordance with the summed thickness T ($= \Sigma t_i$). The control for the slit blades is repeated for each summed thickness t_R . Therefore, when the strip wound on the temporary winding frame 11' of Fig. 10 is wound on a winding spool complete wound cores having a predetermined shape, such as a stepwise wound core as shown in Fig. 4 and a circular cross sectional wound core as shown in Fig. 5, are continuously obtained.

As explained above, according to the present invention, a predetermined thickness of a wound core is directly obtained without the need for subsequent processes, so that the efficiency of a winding operation of the wound core can be enhanced, and thus the cost of manufacturing transformers (wound cores) can be reduced.

Also, in the slit unit, since the traverse position of slit blades is controlled in accordance with the summed thickness of the strip, the cross section of a wound core is accurate, which contributes to an enhancement of the effective cross-section of wound cores, and increases the magnetic flux thereof.

Claims

1. A method for manufacturing a wound core by winding a continuous strip on a winding spool, comprising steps of:
 - a) preparing a material having two straight edges on sides thereof;
 - b) winding said material on a winding spool to obtain a wound core;
 - c) periodically measuring a thickness of the said material which is being wound onto said winding spool; and
 - d) cutting the material in accordance with the measured thickness;
 characterised in that the method comprises the further steps of:
 - e) summing said measured thickness of the material at predetermined periods;
 - f) performing a cutting operation using slit blades upon said material to obtain a strip having a width which varies along the length thereof;
 - g) controlling the cut width of said slit blades in accordance with said summed thickness of the strip;
 - h) determining whether or not said summed thickness of the said strip has reached a predetermined value;
 - i) stopping the winding operation by said winding spool when said summed thickness of said strip has reached a predetermined value.
2. A method as claimed in claim 1, comprising a further step of detecting particular rotational positions of said winding spool, wherein said predetermined periods for measuring the strip thickness are determined in accordance with the detected rotational positions of said winding spool.
3. A method as claimed in claim 1, comprising a further step of measuring a running length of the strip wherein said predetermined periods for measuring the strip thickness are determined in accordance with said measurement of the running length.
4. A method as claimed in any preceding claim, wherein said winding spool comprises a tem-



meter 23 generates a pulse signal. At step 1401, the running length count L is counted up by +1 and is then stored in the RAM 194, and this routine is completed at step 1402.

In Fig. 13, which is a thickness measuring routine executed at predetermined time periods, at step 1501, the running length count L is read out of the RAM 194, and it is determined whether or not the value thereof has reached a predetermined value L_0 , i.e., whether or not the strip 12' has run for a predetermined length. As a result, only when the strip 12' has run for the predetermined length ($L > L_0$), does the control proceed to steps 1502 to 1507. Otherwise, the control proceeds directly to step 1508.

At step 1502, the running length count L is cleared, and then at step 1503, an A/D conversion is performed upon the output t_i of the thickness meter 15, and at step 1504, the summed thickness is renewed by

$$T \leftarrow T + t_i.$$

Then, at step 1505, it is determined whether or not the summed thickness T has reached a predetermined value t_R . As a result, when the summed thickness T has reached the predetermined value t_R ($T > t_R$), the control proceeds to step 1506 which clears the summed thickness T.

At step 1507, the traverse position of the slit blades of the slit unit 20 is calculated by the interpolation method from a predetermined cut curve (one-dimensional map) stored in the ROM 193, by using the summed thickness T, and the drive motor 21 is controlled in accordance with this calculated traverse position, to thereby change the positions of the slit blades of the slit unit 20.

Then, this routine is completed by step 1508.

Thus, the thickness t_i is fetched at a predetermined length of the strip 12 (i.e. the material 12), and the cutting operation is controlled in accordance with the summed thickness T ($= \sum t_i$). The control for the slit blades is repeated for each summed thickness t_R . Therefore, when the strip wound on the temporary winding frame 11' of Fig. 10 is wound on a winding spool complete wound cores having a predetermined shape, such as a stepwise wound core as shown in Fig. 4 and a circular cross sectional wound core as shown in Fig. 5, are continuously obtained.

As explained above, according to the present invention, a predetermined thickness of a wound core is directly obtained without the need for subsequent processes, so that the efficiency of a winding operation of the wound core can be enhanced, and thus the cost of manufacturing transformers (wound cores) can be reduced.

Also, in the slit unit, since the traverse position of slit blades is controlled in accordance with the summed thickness of the strip, the cross section of a wound core is accurate, which contributes to an enhancement of the effective cross-section of wound cores, and increases the magnetic flux thereof.

Claims

1. A method for manufacturing a wound core by winding a continuous strip on a winding spool, comprising steps of:
 - a) preparing a material having two straight edges on sides thereof;
 - b) winding said material on a winding spool to obtain a wound core;
 - c) periodically measuring a thickness of the said material which is being wound onto said winding spool; and
 - d) cutting the material in accordance with the measured thickness;
 characterised in that the method comprises the further steps of:
 - e) summing said measured thickness of the material at predetermined periods;
 - f) performing a cutting operation using slit blades upon said material to obtain a strip having a width which varies along the length thereof;
 - g) controlling the cut width of said slit blades in accordance with said summed thickness of the strip;
 - h) determining whether or not said summed thickness of the said strip has reached a predetermined value;
 - i) stopping the winding operation by said winding spool when said summed thickness of said strip has reached a predetermined value.
2. A method as claimed in claim 1, comprising a further step of detecting particular rotational positions of said winding spool, wherein said predetermined periods for measuring the strip thickness are determined in accordance with the detected rotational positions of said winding spool.
3. A method as claimed in claim 1, comprising a further step of measuring a running length of the strip wherein said predetermined periods for measuring the strip thickness are determined in accordance with said measurement of the running length.
4. A method as claimed in any preceding claim, wherein said winding spool comprises a tem-



porary winding frame.

Patentansprüche

1. Verfahren zur Herstellung eines Wickelkernes durch Wickeln eines kontinuierlichen Streifens auf eine Wickelspule mit den folgenden Schritten:
 - a) Herstellen eines Materiales mit zwei geraden Kanten an seinen Seiten;
 - b) Aufwickeln des Materiales auf eine Wickelspule, um einen Wickelkern zu erhalten;
 - c) periodisches Messen der Dicke des Materiales, das auf die Wickelspule gewickelt wird; und
 - d) Schneiden des Materiales in Abhängigkeit von der gemessenen Dicke; dadurch gekennzeichnet, daß das Verfahren die folgenden weiteren Schritte aufweist:
 - e) Summieren der gemessenen Dicke des Materiales in vorgegebenen Perioden;
 - f) Durchführen eines Schneidvorganges unter Verwendung von Schlitzmessern am Material, um einen Streifen mit einer Breite zu erhalten, die sich über seine Länge ändert;
 - g) Steuern der Schnittbreite der Schlitzmesser in Abhängigkeit von der summierten Dicke des Streifens;
 - h) Bestimmen, ob die summierte Dicke des Streifens einen vorgegebenen Wert erreicht hat oder nicht; und
 - i) Stoppen des Wickelvorganges der Wickelspule, wenn die summierte Dicke des Streifens einen vorgegebenen Wert erreicht hat.
2. Verfahren nach Anspruch 1 mit dem weiteren Schritt des Detektierens von speziellen Drehlagen der Wickelspule, wobei die vorgegebenen Perioden zum Messen der Streifendicke in Abhängigkeit von den detektierten Drehlagen der Wickelspule festgelegt werden.
3. Verfahren nach Anspruch 1 mit dem weiteren Schritt des Messens einer Lauflänge des Streifens, wobei die vorgegebenen Perioden zum Messen der Streifendicke in Abhängigkeit von der Messung der Lauflänge festgelegt werden.
4. Verfahren nach einem der vorangehenden Ansprüche, bei dem die Wickelspule einen temporären Wickelrahmen umfaßt.

Revendications

1. Procédé pour fabriquer un noyau enroulé en enroulant une bande continue sur un touret d'enroulement, comprenant les étapes suivantes :

tes :

- a) on prépare un matériau ayant deux bords rectilignes sur ses côtés ;
 - b) on enroule ledit matériau sur un touret pour obtenir un noyau enroulé ;
 - c) on mesure périodiquement l'épaisseur dudit matériau qui est en cours d'enroulement sur ledit touret d'enroulement ; et
 - d) on découpe le matériau en fonction de l'épaisseur mesurée ;
- caractérisé en ce que le procédé comprend en outre les étapes suivantes :
- e) on fait la somme desdites épaisseurs du matériau mesurées à des intervalles périodiques prédéterminés ;
 - f) on exécute une opération de coupe en appliquant des lames de refente sur ledit matériau pour obtenir une bande ayant une largeur qui varie sur sa longueur ;
 - g) on commande la largeur de coupe desdites lames de refente en fonction de ladite épaisseur cumulée de la bande ;
 - h) on détermine ladite épaisseur cumulée de ladite bande pour savoir si elle a atteint ou n'a pas atteint une valeur déterminée d'avance ;
 - i) on arrête l'opération d'enroulement par ledit touret d'enroulement lorsque ladite épaisseur cumulée de ladite bande a atteint une valeur prédéterminée.

2. Procédé selon la revendication 1, comprenant une étape supplémentaire qui consiste à détecter des positions de rotation particulières dudit touret d'enroulement, dans lequel lesdites périodes prédéterminées de mesure de l'épaisseur de la bande sont définies en fonction des positions de rotation détectées dudit touret d'enroulement.
3. Procédé selon la revendication 1, comprenant une étape supplémentaire qui consiste à mesurer une longueur déroulée de la bande, dans lequel lesdits intervalles périodiques prédéterminés de mesure de l'épaisseur de la bande sont définis en fonction de ladite mesure de la longueur déroulée.
4. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit touret d'enroulement comprend un cadre d'enroulement provisoire.