

PATENT SPECIFICATION

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(54) METHOD OF ENVELOPING ARTICLES WITH
 THERMOPLASTIC STRIP MATERIAL

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a method of enveloping articles, in particular electrical components, with thermoplastic strip material, in which two strips of thermoplastic material extending on either side of the article are pressed on to the article and also on to each other at their edges which project beyond the circumference of the article, and in which the edges are then bonded together.

Articles, for example, electrical components, are usually provided with an envelope which protects the articles from the influences of the atmosphere, for example moisture and dust, so as to obtain satisfactory operation and a long life. It is known to envelop articles, for example foil capacitors, semiconductor devices, and so on, with thermoplastic material by melting said material and injecting it under pressure in a mould in which the component to be enveloped is present. The melted thermoplastic material solidifies upon cooling. Since much thermal energy has to be dissipated, the process times are long. A reasonable yield can be obtained by simultaneously enveloping several articles in a multiple mould. In that case, however, the moulds are complicated and expensive and the operation is very critical.

It is the object of the invention to provide a method of enveloping articles, for example electrical components, in which the means used are comparatively simple and in which the time required for

enveloping is extremely short, while a qualitatively excellent product is obtained. According to the invention this object is achieved in that thermal energy is supplied to one of the two surfaces of each of the two strips in such manner that the strip material on the relevant surface is heated to above the softening temperature or melting temperature thereof, while the remaining part of the strip material remains below the softening temperature or melting temperature in that in this condition the two strips with the softened or melted surfaces facing each other are pressed on to the article and, at their projecting edges, on to each other, a bond between the two strips being produced by cooling the softened or melted material, and in that the thermoplastic strip material contains minuscule gas bubbles.

The heating of only a thin layer of the strip to above the softening or melting temperature can be carried out with simple means and in a rapid manner. During the pressing together, the softened or melted surface parts adhere to the article and the edges thereof adhere together. The thermal energy to be dissipated is very small as a result of the small thickness of the layer; consequently the time to realize the bond can be extremely short. This enables articles to be enveloped at a very high rate and thus to obtain an economically remunerative process.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic representation of an arrangement with which the method can be carried out.

Figure 2 shows an initial position of the tapes relative to the mould.

Figure 3 shows the ends of the tapes introduced in to the mould,

Figure 4 shows the closing of the mould and the cutting of the tapes,

Figure 5 shows the exertion of pressure on the cut off tapes,

5 Figure 6 shows the opening of the mould and the withdrawal of the dies,

Figure 7 is a cross-sectional view taken on the line VII-VII of Figure 2, and

Figures 8 to 10 show various stages in obtaining a defined shape of the envelope.

The arrangement shown in Figure 1 comprises two tapes 2 which are unwound from storage reels 1; the desired displacement of the tapes 2 being carried out by means of a tape feed mechanism 3. A thermoplastic synthetic resin, for example polypropylene, is used as an enveloping material. The material preferably contains 25% by volume of minuscule gas bubbles. The gas bubbles may be formed, for example, by the addition of a foam to the granular starting material; at the temperature used for extrusion of the material to form a tape, for example 180°C, the foam forms gas-filled bubbles in the tape material.

In a pre-heating furnace 4, which surrounds the tapes, the tapes 2 are heated to a temperature which is ten or a few tens of 30 °C below the softening or melting temperature of the tape material, for example a temperature of 150°C. An after-heating element 5 heats a thin layer of the facing surfaces of the tapes 2 to a temperature above the softening or melting point of the tape material, for example, to 210°C. Although the heating of the relevant surfaces to this latter temperature is possible in one temperature treatment, the described two-stage heating is preferred. The two-stage heating has proved extremely suitable to obtain a surface layer of melted tape material in a short period of time and with the use of simple means, the temperature 45 adjustment both of the pre-heating furnace and of the after-heating element not being very critical. The thickness of the melted surface layer may be, for example, 150 microns. It has been found that this can readily be achieved by continuing the after-heating to such an extent that, at the instant at which the tapes are pressed on to the article and on to each other, the temperature gradient produced by such heating 55 extends over less than half the strip thickness.

An article 6 which is to be enveloped and which is carried on a movable support 7 is located in a mould 8. Dies 9 can exert 60 a predetermined pressure, by means of respective pressure mechanisms 10, on material strips introduced into the mould. The melted surface layers of the strips are pressed against and around the article 6 65 and the projecting edges are pressed

against each other. Due to the small thickness of the melted surface layer, hardening occurs very rapidly and the two strips are thereby bonded. In the mould, the enveloping material may be given a desired 70 outer shape. The pre-heating in furnace 4 enables rapid plastic deformation of the strip material in the mould. The enveloped article may now be removed from the mould and the process can be repeated. 75

Figures 2 to 6 show successive steps in carrying out the enveloping method and figure 7 is a cross-sectional view taken on the line VII-VII of Figure 2.

In figure 2 the ends of the tapes 2 of 80 thermoplastic material have been moved adjacent to after-heating elements 5. The after-heating elements 5 ensure that a surface layer of a small thickness, for example 150 microns, of the ends of the tapes 2 is heated to above the melting temperature, for example to the said 210°C. The length of the after-heating elements 5 is equal to or larger than the length of strips 23 subsequently processed in the 90 mould (Figure 4). A mould housing 15 has slot-like apertures 16 through which the tapes 2 can be introduced into the mould cavity 17. The mould consists of two parts 18 having projections 19 co-operating with 95 each other. During enveloping, conductors 20 of an electric component 21, for example a capacitor, are held in the projections 19. Dies 24 can reciprocate in the mould 18, the mould housing 15 further 100 comprises a closing plate 22 which is clearly shown in the cross-sectional view of Figure 7.

Figure 3 shows the ends of the tapes 2 introduced into the mould cavity 17 until 105 they abut parts of the mould 18, said ends having been heated to above the melting temperature on the facing surfaces. The mould parts 18 are now closed (Figure 4) and hold the electric component 21 by the 110 wires 20. The dies 24 are then moved towards each other with the result that a respective strip 23 is cut off each tape 2 and is moved against the component 21. As shown in Figure 5, the movement of the 115 dies 24 is continued so that the melted surface layers of the foil strips 23 are pressed against and around the electrical component 21 and the projecting edges of the strips are pressed against each other. The mould 120 18 and the dies 24 are not heated and therefore a rapid cooling of the thin melted surface layers of the strips 23 occurs upon pressing so that an adhesion to the component 21 and a bond of the edges of the 125 strips 23 is very rapidly produced. The strips 23 are compressed to an outer shape which is defined by the mould 18 and the dies 24. The presence of gas bubbles in the strip material is particularly useful, as will 130

be explained hereinafter. The mould 18 is then opened (Figure 6) and the dies 24 are also moved back to enable the enveloped article to be removed, after which the manufacture of a following product can begin.

The recognition that only a thin surface layer of the strips 23 has to be heated to the melting temperature has enabled the envelopment of components at a very high rate. The use of an unheated mould and of unheated dies 24 upon pressing the foil strips 23 ensures rapid hardening of the parts to be bonded. The manufacture of five products per second has proved readily achievable and a further increase of the production rate is possible. This makes the described method economically very attractive.

Figures 8 to 10 show the shaping of an enveloped product to a defined shape. The strips 23, which in this example have a thickness of 2 mm, contain gas bubbles 25 as already indicated. The total volume of the bubbles 25 is at least 10% of the strip volume and preferably approximately 25%. The use of a pre-heating furnace 4 in which the thermoplastic as a whole is heated to just below the melting temperature, approximately 150°C in the example chosen, is favourable for obtaining rapid plastic deformation of the strip material in shaping the envelope. From the initial position shown in Figure 8 the dies 24 press on the material of the strips 23 with a predetermined maximum pressure. First the bubbles 25 in the part 26 of the material are squeezed, which part is adjacent the body 21 of the electrical component which, in this example, has a thickness of approximately 2 mm (Figure 9). When the movement of the dies is continued the material where the bubbles have been squeezed is plastically deformed while simultaneously the edges 27 are squeezed and possibly plastically deformed (Figure 10). It will be obvious that the resilience of bubbles 25 enables the strips 23 to be rapidly deformed to provide an envelope having a defined outer shape. The plastic deformation of the strip material need only be small, which, in combination with the pre-heating of the strips 23, contributes to a considerable extent to the production rate of enveloping the articles.

Variations in the method described are possible without departing from the scope of this invention. For example, the end of the thermoplastic tape material, after clipping off the strip 23, may be withdrawn until it is located exactly along the after-heating element 5. The construction of the mould may also be chosen to be different and further variations of the embodiment described are possible.

WHAT WE CLAIM IS:—

1. A method of enveloping articles, in particular electrical components, with a thermoplastic strip material, in which two strips of thermoplastic material extending on either side of the article are pressed on to the article and on to each other at their edges which project beyond the circumference of the article, and in which the edges pressed on each other are bonded together, wherein thermal energy is supplied to one of the two surfaces of each of the two strips in such manner that the strip material on the relevant surface is heated to above the softening or melting temperature thereof, while the remaining part of the strip material remains below the softening or melting temperature, wherein in this condition the two strips with the softened or melted surfaces facing each other are pressed on to the article and, at their projecting edges, on to each other, a bond between the two strips being produced by cooling the softened or melted material, and wherein the thermoplastic strip material contains miniscule gas bubbles.

2. A method as claimed in claim 1, wherein the supply of thermal energy, with which the softening or melting of the material of the relevant strip surface is obtained, is carried out in a second heating stage which succeeds a first heating stage in which the two strips as a whole are heated to an elevated temperature which is below the softening or melting temperature of the thermoplastic material.

3. A method as claimed in claim 2, wherein the temperature to which the two strips as a whole are heated is at least ten degrees Celsius lower than the softening or melting temperature of the strip material.

4. A method as claimed in any of the preceding claims, wherein the unilateral heating of the strips which produces softening or melting of the surface material is continued only to such an extent that, at the instant at which the strips are pressed on of the article and on to each other, the temperature gradient produced by said heating extends over less than half the strip thickness.

5. A method as claimed in any of the preceding claims, wherein the two strips are subjected to a pressure which is increased to a previously determined value in a mould which is closed on all sides, by which a plastic deformation of the strip material is produced and the strips form an envelope the outer shape of which is determined by the closed mould.

6. A method as claimed in claim 5, wherein the mould is unheated and has two unheated dies which can be moved towards each other, in which mould, prior



be explained hereinafter. The mould 18 is then opened (Figure 6) and the dies 24 are also moved back to enable the enveloped article to be removed, after which the manufacture of a following product can begin.

The recognition that only a thin surface layer of the strips 23 has to be heated to the melting temperature has enabled the envelopment of components at a very high rate. The use of an unheated mould and of unheated dies 24 upon pressing the foil strips 23 ensures rapid hardening of the parts to be bonded. The manufacture of five products per second has proved readily achievable and a further increase of the production rate is possible. This makes the described method economically very attractive.

Figures 8 to 10 show the shaping of an enveloped product to a defined shape. The strips 23, which in this example have a thickness of 2 mm, contain gas bubbles 25 as already indicated. The total volume of the bubbles 25 is at least 10% of the strip volume and preferably approximately 25%. The use of a pre-heating furnace 4 in which the thermoplastic as a whole is heated to just below the melting temperature, approximately 150°C in the example chosen, is favourable for obtaining rapid plastic deformation of the strip material in shaping the envelope. From the initial position shown in Figure 8 the dies 24 press on the material of the strips 23 with a predetermined maximum pressure. First the bubbles 25 in the part 26 of the material are squeezed, which part is adjacent the body 21 of the electrical component which, in this example, has a thickness of approximately 2 mm (Figure 9). When the movement of the dies is continued the material where the bubbles have been squeezed is plastically deformed while simultaneously the edges 27 are squeezed and possibly plastically deformed (Figure 10). It will be obvious that the resilience of bubbles 25 enables the strips 23 to be rapidly deformed to provide an envelope having a defined outer shape. The plastic deformation of the strip material need only be small, which, in combination with the pre-heating of the strips 23, contributes to a considerable extent to the production rate of enveloping the articles.

Variations in the method described are possible without departing from the scope of this invention. For example, the end of the thermoplastic tape material, after clipping off the strip 23, may be withdrawn until it is located exactly along the after-heating element 5. The construction of the mould may also be chosen to be different and further variations of the embodiment described are possible.

WHAT WE CLAIM IS:—

1. A method of enveloping articles, in particular electrical components, with a thermoplastic strip material, in which two strips of thermoplastic material extending on either side of the article are pressed on to the article and on to each other at their edges which project beyond the circumference of the article, and in which the edges pressed on each other are bonded together, wherein thermal energy is supplied to one of the two surfaces of each of the two strips in such manner that the strip material on the relevant surface is heated to above the softening or melting temperature thereof, while the remaining part of the strip material remains below the softening or melting temperature, wherein in this condition the two strips with the softened or melted surfaces facing each other are pressed on to the article and, at their projecting edges, on to each other, a bond between the two strips being produced by cooling the softened or melted material, and wherein the thermoplastic strip material contains miniscule gas bubbles.

2. A method as claimed in claim 1, wherein the supply of thermal energy, with which the softening or melting of the material of the relevant strip surface is obtained, is carried out in a second heating stage which succeeds a first heating stage in which the two strips as a whole are heated to an elevated temperature which is below the softening or melting temperature of the thermoplastic material.

3. A method as claimed in claim 2, wherein the temperature to which the two strips as a whole are heated is at least ten degrees Celsius lower than the softening or melting temperature of the strip material.

4. A method as claimed in any of the preceding claims, wherein the unilateral heating of the strips which produces softening or melting of the surface material is continued only to such an extent that, at the instant at which the strips are pressed on of the article and on to each other, the temperature gradient produced by said heating extends over less than half the strip thickness.

5. A method as claimed in any of the preceding claims, wherein the two strips are subjected to a pressure which is increased to a previously determined value in a mould which is closed on all sides, by which a plastic deformation of the strip material is produced and the strips form an envelope the outer shape of which is determined by the closed mould.

6. A method as claimed in claim 5, wherein the mould is unheated and has two unheated dies which can be moved towards each other, in which mould, prior

to said movement, the article to be enveloped is arranged and the strips are introduced into the mould as end parts of respective tapes, the end parts having a softened or melted surface, and are cut from said tapes by co-operation of the moving dies and the mould, after which the movement of the two dies is continued and the strips are pressed on to the article 10 and on to each other.

7. A method as claimed in claim 6, wherein the heating which results in softening or melting of the facing surfaces of the end parts of the tapes is produced by heating means arranged between the said end parts and near introduction apertures for the tapes in the mould, which means extends parallel to a tape over a length which is at least equal to the length of the strip subsequently cut from the end of the tape. 15 20

8. A method as claimed in claim 2 or 3 or any of claims 4 to 7 when dependent on

claim 2 in which the first heating stage is carried out in a furnace which surrounds 25 the tapes.

9. A method as claimed in any of the preceding claims, wherein the thermoplastic strip is polypropylene.

10. A method as claimed in any of the preceding claims, wherein the gas bubbles form at least 10% of the volume of the strips. 30

11. An article enveloped with thermoplastic strip material by means of the method as claimed in one or more of the preceding claims. 35

12. A method of enveloping an article substantially as hereinbefore described with reference to the accompanying drawings. 40

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