

The invention concerns a method for the heat treatment of a product web provided with a liquid or pasty preparation, and a device for operating such a method in accordance with the introductory part of claim 1 and claim 11 respectively.

Such a method and such a device are known from the GB-PS 12 34 956. In the known method, a product web provided with a liquid preparation is treated in a processing chamber by means of radiant heat and hot air. The processing chamber is arranged vertically. The product web passes through the processing chamber in the form of an up-ended U. The process air is passed in a contraflow to the product web. It is blown in at the side. In the processing chamber, a plurality of heating tubes are arranged on both sides of the product web respectively, which are traversed by hot steam.

From the DD-PS 212 574, a method is known for the drying and cross-linking of polymers deposited on flat formations, which serves in particular for the drying and partial cross-linking of carrier materials impregnated with polymer binders for producing prepregs. The dryer is traversed by an air flow. So as to use the energy to a large extent only for evaporating the solvent and for the further heating of the prepreg web and to obtain thereby substantial energy savings, the air flow entering the dryer at an inlet slot is divided into a main air flow and a considerably smaller air flow. The main air flow is unheated and is passed through an outer dryer compartment. The other, substantially smaller air flow enters an inner dryer compartment and is heated by heating plates. Thus, the heating plates serve to heat the air flow.

From the WO-A-8904 890 a method and an apparatus are known for drying paper webs. The apparatus has two individual processing chambers disposed one after the other, in which arrangement the first chamber is designed as an infrared dryer and the second chamber as a float dryer.

From the DE-A-32 09 475 a method and apparatus are known for conditioning paper and for drying such products. In this arrangement, the product web to be processed is acted on by a pure hot steam atmosphere. The hot steam processing may be preceded by a preheating zone.

The DE-A-25 02 367 describes a drying installation for fabrics. The fabric to be dried is conveyed through a plurality of chambers, being held at its edges by clips. Each of the chambers has three zones. In the first zone, air is passed onto the fabric. In the second zone, the fabric and the introduced air are heated by heating plates. The air is circulated in the third zone.

It is the object of the invention to propose a method and an apparatus respectively, by means of which it is possible to obtain a better quality.

In accordance with the invention, this problem is solved by the characterizing features of claims 1 and 11 respectively. Particularly preferred modes of embodiments of the invention form the objects of claims 2 to 10 and 12 to 20.

The method in accordance with the invention is particularly suitable for manufacturing prepregs. A prepreg is a flat formation that is provided with a hardenable resin, whereon the synthetic resin applied in the form of a solution or dispersion is hardened to a specified extent by a chemical reaction. The industrial properties for use of a prepreg are determined by its hardened state, so that the hardening reaction must be carried out very carefully and accurately to the desired degree of hardening. In particular, a constant quality, and hence a constant degree of hardening over the whole flat formation are desired.

To be sure, the method in accordance with the invention and the apparatus in accordance with the invention may also be used for the heat treatment of other product webs. They may be product webs that have been coated on one side or on both sides. As product webs, there may be considered for example, fleeces, fabrics, metallic webs such as steel and aluminium and high temperature-resistant synthetic sheets. The materials deposited on the product web may be acrylic polymers, polyvinyl chloride, polyurethane, melamine resins, epoxy resins etc. The product may then be a lacquered or printed metallic web or plastic sheet, a decorating material, floor covering, artificial leather or treated paper.

According to the state of the art, paper-based prepregs are manufactured in so-called float dryers. In this arrangement these are horizontal processing chambers wherein the impregnated paper web is blasted by hot air and is passed in a floating mode through the processing chamber. The floating may be obtained by means of the carrier wing principle or the air cushion principle. Both principles make use of the turbulence occurring at high air velocities. In this arrangement, the product web is acted on from above and below by air by means of air nozzle arrangements, which permits a steady guidance in a floating position even at high speeds of the product web. It is essential that the product web should not flutter and should not impact on the nozzles. Apart from the floating conveyance, the air introduced also serves for the drying, that is to say, for blowing out volatile constituents, for example, of the solvent or water, for thinning and removal of these substances and for subjecting the product web to heat, that is to say, producing the hardening reaction.

To be sure, prepregs produced in this way can no longer meet the constantly increasing demands of the modern electronics industry. In particular, exception is taken to the lack of uniformity in the hardening over the area.

Admittedly, a uniform temperature in the air flow may be obtained over the width of the processing chamber irrespective as to whether the nozzles are fed from one side, both sides or from the centre. Since, however, the degree of hardening does not depend solely on the temperature but also on the speed of the air whereby the heat is applied to the product web, the main problem is that of producing a uniform blasting speed. This cannot be adequately mastered at air speeds of 8 to 40 m/sec, in particular in wide installations. If, for example, the air speed varies by $\pm 3\%$ at a product width of 3 m, the variation in the degree of hardening of the prepreg resulting therefrom is no longer acceptable. Accordingly, the known float dryers are severely restricted in their use.

The heat treatment of the product web may serve to dry the product web. To be sure, it may also serve to dry and set the product web. It can, moreover, serve merely for hardening the resin, for example, in the application of a melting resin. "Hardening" is understood to mean a chemical reaction, thus for example, a prepolymerisation (in the case of epoxy resins) or a prepolycondensation (in the case of phenolic resins). A complete hardening may also occur, for example in the case of acrylic resins.

The invention is suitable both for manufacturing finished products and for manufacturing semifinished products.

With the invention, the advantage is obtained that with the preferably horizontal guidance of the product web and also with the vertical guidance of the product web by means of air blasting, a qualitatively satisfactory hardening of the product web, especially of the prepreg, is effected by means of the air blasting, in particular one that is sufficient as regards the flow profile for the electronics industry.

The measurement of the flow profile constitutes a generally known method for the measurement of the degree of hardening. With a 15 % hardening, a uniform flow profile is understood to mean in this connection a tolerance of $\pm 1\%$, thus a hardening of 14 to 16 %.

Surprisingly it has been found that a break in the uniformity, in particular a pronounced break in uniformity, in the air blasting of the product web, that is to say, an interruption of the air feeding over preferably wide stretches by radiant heat stretches or zones, does not have any adverse effect either on the conveyance of the product web or on the quality, that is to say, the uniformity of the hardening. On the contrary and against all expectations, the effect obtained thereby is that the hardening reaction, and hence the degree of hardening, is rendered more uniform. A further advantage of the invention lies in the fact that paradoxically a better performance is obtained with fewer float nozzles. Moreover, the maintenance of the installation is simpler and more economical since, while

float nozzles are fouled by the impregnating resin and have to be periodically cleaned, the radiant heaters which preferably have a smooth surface, do not show any fouling. Although known float dryers are only used for manufacturing prepregs on a paper base, the installation in accordance with the invention is also suitable for manufacturing prepregs on a base of fleeces and fabrics and for processing other product webs provided with a liquid preparation, for example, coated or printed metallic webs and impregnated or painted paper webs. The deposit on the product web can be applied in different ways, for example, by coating, a doctor application or in another way.

In accordance with the invention, the product web is first subjected in the processing chamber to blasts of hot air and is subsequently subjected to radiant heat, in which process, it is kept floating by being blasted with hot air. Thus in essence a method is carried out that is known from the known float dryers or float furnaces. In the apparatus for operating this method, one or more air nozzles are removed from a float furnace and radiant heaters are arranged in their place.

Advantageous further developments form the objects of the dependent claims.

The product web is preferably carried substantially horizontally through the processing chamber.

It is particularly advantageous if the product web is subjected in the processing chamber alternately to blasts of hot air and radiant heat.

The product web can in the same blasting zone be subjected to blasting with hot air alternately from both sides.

If the product web is subjected to radiant heat from one side, it is possible to convert a known float dryer in a particularly simple way. This is because the product web must be introduced through the whole apparatus. If provision is made for radiant heaters on both sides of the product web, it is, therefore advantageous if at least one of them is designed to be removable. As the product web is introduced, this radiant heater is moved away, thus the distance between two radiant heaters is increased, so that the product web can be properly introduced. During operation, the distance is reduced again. If a radiant heater is converted that is already available, it is expensive and/or difficult to mount a removable radiant heater. It is then advantageous to make provision for only one radiant heater, so that the problem described above does not arise at all when the product web is introduced.

According to an advantageous further development, the product web is subjected simultaneously to radiant heat from above and below. Thus provision is made for radiant heaters on both sides of the product web. Preferably at least one of these two

radiant heaters is removable. This design is particularly suitable for newly manufactured apparatuses. Because of this irradiation from both sides, the radiant heat is doubled and the apparatus is correspondingly more effective.

According to an advantageous further development, the product web is heated over its width with radiant heat at different temperatures, preferably with radiant heat at three different temperatures. Thus the radiant heaters have, transversely to the direction of movement of the product web, preferably three zones whose temperatures can be adjusted independently of one another.

Because the radiant heaters are subdivided over the width of the processing chamber into individual zones that can be individually controlled, that is to say, that the product web is acted on over its width by radiant heaters with different amounts of heat, it is possible to increase the evening out of the hardening reaction, and hence that of the degree of hardening, still further. The experiences made to date have shown that a subdivision into three different temperature zones is sufficient up to a width of the product web of 1.3 to 2.0 m. As from a width of the product web of 2.0 m, it may be advantageous to make provision for four or more temperature zones. The greater the number of temperature zones that are provided, the easier it is to control the heat supply over the width of the product web; admittedly the arrangement becomes correspondingly more expensive.

It is advantageous if the irradiation temperature is higher, preferably at least 15°C higher, in particular 30°C higher, than the air temperature. To allow this increased temperature to be maintained, it is advantageous if the radiant heater has a heat storage capacity. This cannot be achieved with plain electric heaters but with heating plates preferably made of metal which have a heat storage capacity. The plates may for example have tubes on their side remote from the product web which are traversed by oil, water, steam or a similar liquid. Heating of the plates by means of electric energy is also possible.

An advantageous further development of the apparatus in accordance with the invention is characterized in that the surface of the radiant heater facing the product web is smooth.

The invention will be illustrated below with reference to Figures 1 to 3. There are shown schematically in:

Fig. 1 a side view of the relative arrangement of the main elements in an installation in accordance with the invention;

Fig. 2 a top view of the relative arrangement of the main elements in an installation in accordance with the invention; and

Fig. 3 a section through an installation in accordance with the invention transversely to the conveyance direction of the product web.

5 The same elements in the Figures are designated by the same reference numerals. In the processing chamber or in the float furnace 1, whose walls 2 are only represented in Figure 3, a first group 3 of three nozzle boxes 4, 5, 6 of a conventional design is arranged at the inlet side (in Figures 1 and 2) transversely to the product web 7. The first nozzle box 4 from the inlet side is arranged beneath the product web 7, the second 5, is offset in the movement or conveyance direction (T) of the product web above the product web 7, and the third 6, is again offset beneath the product web. Each nozzle box 4, 5, 6, has 10 two slotted nozzles 8, 9 extending in the transverse direction of the product web 7 through which there emerges one blast jet each directed against each other and against the product web. The two blast jets of hot air impinge on each other and form an air cushion holding the product web in a floating mode. At the 15 same time, the air heats the product web, blows out solvents from the impregnating resin and removes the solvent. The out-flow direction of the air is illustrated by small arrows A.

20 The installation represented operates according to the air cushion principle. However, in accordance with the invention, it is also possible to use installations whose nozzles operate according to the so-called aerofoil principle. This principle is described for example in the DE-PS 36 07 370.

25 The first group 3 of nozzle boxes 4, 5, 6 is followed in the conveyance direction T of the product web 7 by one radiant heater 11, 12 each that is arranged on both sides above and beneath the product web 7 with one flat smooth radiant heating surface 13, 14 each that faces the product web 7. Each radiant 30 heater 11, 12 is subdivided in the conveyance direction T into three individual heating zones 15, 16, 17 (Figure 2). Each of these zones has its own calorifier 18, 19, 20 that is independent of the others, with one heating medium inlet 21, 22, 23 each and one heating medium outlet 24, 25, 26 each. This arrangement allows a heating of the product web that differs over 35 the width of the product web as required, and hence allows the uniformity of the degree of hardening over its area to be optimized. The heating zones 15, 16, 17 shown have the same width. However, the radiant heaters 11, 12 may also be subdivided into zones of different widths, for example, two wide 40 outer zones and one narrow median zone, or two narrow outer zones and one wide median zone. The radiant heaters may also be subdivided into only two, or more than three, zones that are adjustable independently of one another.

45 50 The two radiant heaters 11, 12 are followed in the conveyance direction T by a further group 27 of three nozzle boxes in a similar arrangement as in the first group 3, whereupon there follow two further radiant heaters 28, 29 arranged on both sides

of the product web 7.

The nozzle boxes 4, 5, 6 are preferably fed by a mixture of fresh air and ambient air. An appropriate device 31 is shown in Figure 3. Fresh air is fed via a fresh air intake 32 and a filter 33 via a heat exchanger or a direct burner to an ambient air fan 34; the nozzle boxes 4, 5, 6 are fed with a mixture of this air and ambient air. The used solvent-charged air is then removed from the inside of the float furnace 1 through an air outlet 35. The fresh air may be preheated.

A processing chamber in an installation in accordance with the invention may be combined into an aggregate furnace with a length of up to 60m or more out of several units of the kind represented, of 2 to 6 m in length.

The nozzle boxes and the heating plates may be arranged to be adjustable in their distance from the product web.

Borne by the air that is blown in, the product web is passed through the float furnace in the form of a sine curve. The amplitude height of the curve depends on the one hand, on the tension in the product web, which is, for example, set by a dancer-controlled pull-off means and depends on the speed/quantity of the air that is blown in. By reducing the tension of the product web, one increases the amplitude height, and hence the residence time in the float furnace.

According to a particular mode of embodiment, the radiant surfaces of the radiant heaters are bent according to the product web conveyed in the processing chamber, which produces a constant interspacing between the product web and the radiant heat surface over its whole length, and hence a further optimization of the uniformity of the hardening.

Apart from being arranged in groups of threes as shown, the nozzle boxes may also be arranged in groups ranging from twos to sixes. It is also possible to arrange only a single nozzle box between two radiant heaters. In the case of radiant heaters arranged on one side of the product web, the single nozzle box may be arranged on the same side or on the opposite side to the heaters of the product web. In an arrangement of the radiant heaters and nozzle boxes above the product web, one is concerned with nozzles operating according to the aerofoil principle. Advantageously, one nozzle box each is arranged on the same side of the product web ahead of and behind a radiant heater that is arranged on one side of the product web.

The method in accordance with the invention is suitable for product webs of paper, fleeces or fabrics and for the known hardenable resin types, as, for example, phenolic, epoxy and melamine resins.

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5 The individual conditions required for the respective type of material in the respective installation depend on the carrier material of the product web, the type of resin, the resin application and on the desired degree of hardening and will be readily set by the expert after preliminary experiments.

10 In general, one operates with blow-through speeds of 5 to 50 m/sec. The air temperature is advantageously 20° to 25°C below the temperature of the radiant heaters.

The operating conditions in the manufacture in accordance with the invention of a prepreg are indicated below by way of an example.

15	Product web:	Paper 180 g/m ² (raw)
	Resin:	Phenolic resin
	Weight of resin application:	60% dry
	Speed of product web:	40 m/min
	Air temperature:	180°C
20	Air speed:	20 m/sec
	Temperature of radiant heater:	200°C

Patent Claims

1. A method for the heat treatment of a product web provided with a liquid or pasty preparation in at least one processing chamber by means of radiant heat and hot air, characterized in that the product web in the processing chamber is in a first zone first subjected to blasts of preheated air and is in a following second zone subjected to radiant heat, in which process the product web is kept floating by being blasted with hot air.

2. A method according to claim 1, characterized in that the product web is carried substantially horizontally through the processing chamber.

3. A method according to one of the preceding claims, characterized in that the product web is subjected in the processing chamber alternately to blasts of hot air and radiant heat.

4. A method according to one of the preceding claims, characterized in that the product web is, in the same blasting zone, subjected to blasting with hot air alternately from both sides.

5. A method according to one of the preceding claims, characterized in that the product web is subjected to radiant heat on one side.

6. A method according to one of claims 1 - 4, characterized in that the product web is simultaneously subjected to radiant heat from above and below.

7. A method according to one of the preceding claims, characterized in that the product web is heated over its width with radiant heat at different temperatures.

8. A method according to one of the preceding claims, characterized in that the product web is heated over its width with radiant heat at three different temperatures.

9. A method according to one of the preceding claims, characterized in that the temperature of the radiant heat is higher, preferably at least 15° higher, than the air temperature.

10. A method according to one of the preceding claims, characterized in that the product web is impregnated with a hardenable resin, in particular a thermosetting synthetic resin.

11. An apparatus for operating the method according to one of the preceding claims, with a processing chamber (1) through which a product web (7) is carried and wherein there are arranged at least one radiant heater (11, 12, 28, 29) and at



least one air intake for hot air, characterized in that in the processing chamber (1), there is arranged at first in the direction of movement (T) of the product web (7) at least one air nozzle (8, 9) or an array of air nozzles and following on, at least one radiant heater (11, 12, 28, 29), and that the processing chamber (1) is designed as a float dryer.

12. An apparatus according to claim 11, characterized in that the processing chamber (1) is arranged horizontally.

13. An apparatus according to one of claims 11 to 12, characterized in that in the processing chamber (1), there is arranged alternately in the direction of movement (T) of the product web (7) an air nozzle or an array (3, 27) of air nozzles and at least one radiant heater (11, 12, 28, 29).

14. An apparatus according to one of claims 11 to 13, characterized in that the air nozzles or the arrays (3, 27) of air nozzles extend transversely to the direction of movement (T) of the product web (7).

15. An apparatus according to one of claims 11 or 14, characterized in that the air nozzles (4, 5, 6) are arranged in an array (3, 27) of air nozzles alternately above and below the product web, so that the product web is subjected in the respective array (3, 27) of air nozzles to a blast of hot air alternately from above and from below, in which arrangement, the one or more lower air nozzles (4, 6) are offset relative to the one or more upper air nozzles (5).

16. An apparatus according to one of claims 11 to 15, characterized in that in the same zone, a radiant heater is arranged only on one side of the product web (7), so that the product web is subjected to radiant heat only on one side.

17. An apparatus according to one of claims 11 to 15, characterized in that in the same zone, there is arranged one radiant heater (11, 12, 28, 29) each on each side of the product web (7), so that the product web is subjected to radiant heat on both sides.

18. An apparatus according to one of claims 11 to 17, characterized in that the radiant heaters (11, 12, 28, 29) have, transversely to the direction of movement (T) of the product web (7), several, preferably three, zones (15, 16, 17), whose temperature can be adjusted independently of one another.

19. An apparatus according to one of claims 11 to 18, characterized in that the surface of the radiant heater facing the product web is smooth.

20. An apparatus according to one of claims 11 to 19, characterized in that the temperature of the radiant heat of the radiant heater is higher, preferably at least 15° higher, than the air temperature.

[KA3]

