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(54) **Moulding curved reinforced plastics objects**

(57) The invention relates to the manufacture of a curved member of reinforced plastics comprising at least one unidirectional fibrous reinforcement and one multidirectional fibrous reinforcement in separate, adjacent regions of the member. The unidirectional and multidirectional reinforcements are impregnated with at least one thermosetting resin in a die and during heat setting in the die the unidirectional and multidirectional reinforcements cause differential shrinkage of the reinforced plastics member thereby producing a curved member.

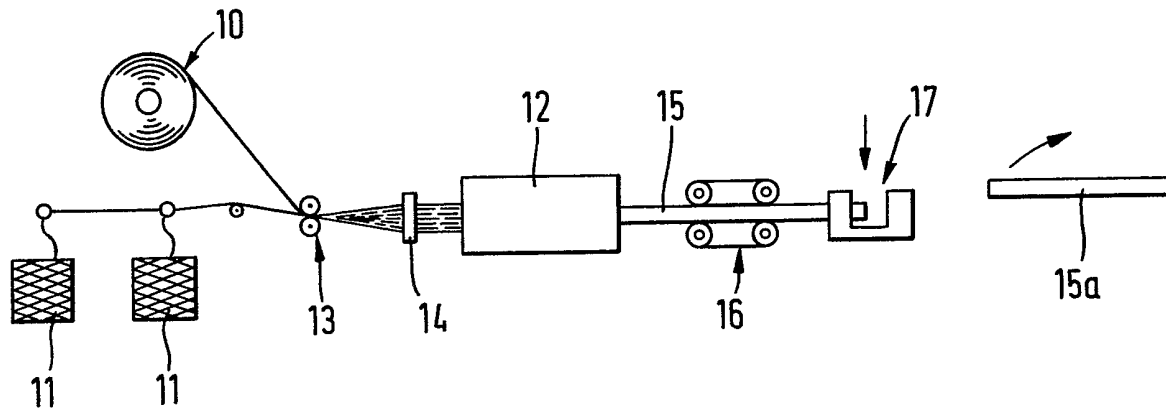


Fig. 1

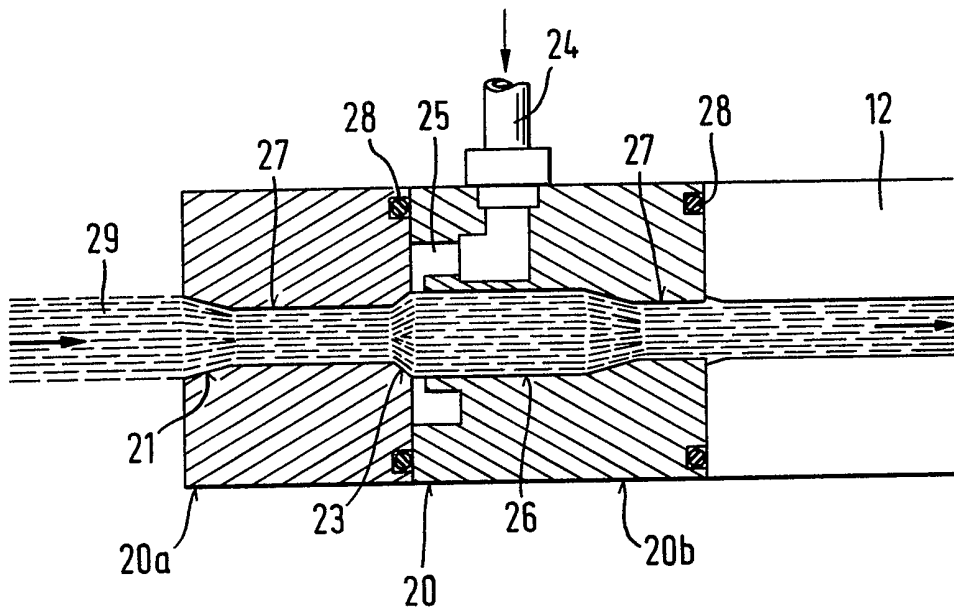


Fig. 2

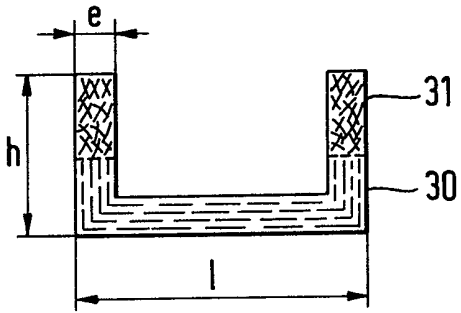


Fig. 3

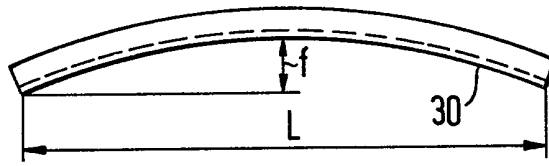


Fig. 3A

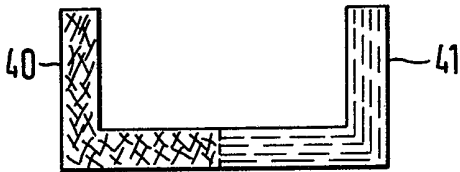


Fig. 4

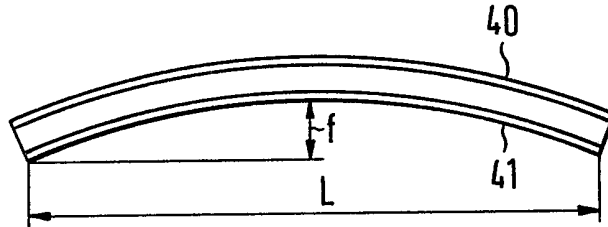


Fig. 4A

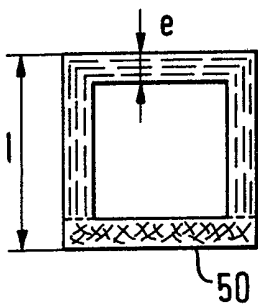


Fig. 5

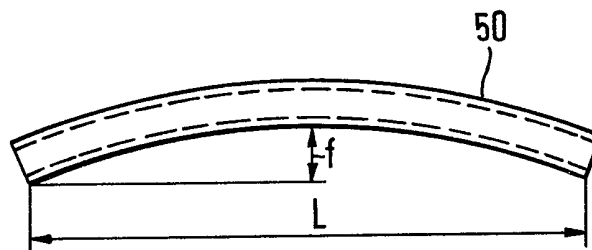


Fig. 5A

SPECIFICATION

A method of manufacturing curved members of reinforced plastics

- 5 This invention relates to the continuous manufacture of curved members of reinforced plastics including at least one unidirectional reinforcement and one multidirectional reinforcement. 5
- It is known to manufacture members from thermosetting material, e.g. polyester or epoxy material reinforced with glass fibre. The section members are manufactured by moulding under pressure or by continuous moulding or extrusion of resin-impregnated reinforcements.
- 10 The first of the aforementioned method of manufacture is discontinuous and preferably reserved for members having a variable cross-section or shape or having a uniform cross-section but a short length. 10
- The second method is continuous and therefore economically more advantageous, but is limited to the manufacture of rectilinear straight section members.
- Hitherto, continuous manufacture of curved components has been possible only by combining the 15 conventional manufacturing line comprising a die for shaping the cross-section with a second downstream curved die having a cross-section corresponding to that of the component which is to be obtained. 15
- The invention is directed to providing a method of directly manufacturing curved sectional members on a conventional production line. According to the invention, a method of continuously manufacturing curved members reinforced with filaments, in which at least one unidirectional reinforcement and one multi- 20 directional reinforcement are preshaped when dry and impregnated by injecting a mixture based on a thermosetting synthetic resin or resins, for example a polyester resin or resins, the impregnated reinforcements being fed to a shaping die, characterised in that the unidirectional and multi-directional reinforcements are juxtaposed so as to define at least two separate regions joined along a portion of their surfaces; different dimensional shrinkages from one region to another being produced by polymerization. 20
- 25 The invention will now be described by way of example with reference to the drawings in which:- 25
- Figure 1* is a side view of a production line for manufacturing curved members in accordance with the invention;
- Figure 2* shows the upstream part of a shaping device in longitudinal section;
- Figures 3 and 3A* are respectively a cross-section and a side view of a sectional member manufactured in 30 accordance with the invention; 30
- Figures 4 and 4A* are respectively a cross-section and a plan view, of another sectional member; and
- Figures 5 and 5A* are a cross-section and side view of a third sectional member.
- Referring to *Figure 1*, curved sectional members of reinforced plastics are formed by bringing together a 35 series of continuous filaments joined in a rove and called "stratifil". 35
- The reinforcement materials are supplied from rolls of tape 10 for the mat and rolls of rove 11 for the stratifil. These supply a shaping die 12 after travelling along a path determined by guide means 13 and at least one pre-shaping guide 14. The reinforcement materials can be impregnated with resin when they travel through an impregnating tank, or by injecting the resin into the reinforcement materials when they enter the 40 die as described hereinafter. 40
- Downstream of the die 12 the extruded section member 15 is moved forward by a drive conveyor 16 to a cutting station 17 where the section member 15a is cut and subsequently ejected.
- Die 12 can be followed if necessary by a heating device, e.g. an air-circulation oven, for completing the polymerization of the section member.
- 45 Preferably, the reinforcements are impregnated before being inserted into the die 12, as diagrammatically shown in *Figure 2*. 45
- An injection head 20, made up of two parts 20a and 20b, is joined to die 12.
- Part 20a defines a passage having substantially the same cross-section as the section member to be constructed. The passage comprises a tapered inlet portion 21, a compression chamber 22 and ends in a 50 flared portion 23 immediately prior to an impregnation region. 50
- Part 20b includes a feed duct 24 for supplying resin under pressure, which leads into distribution channels 25 communicating with a decompression chamber 26 connected to the flared portion 23. Chamber 26 is followed by a narrower passage 27 connected to the entrance of the die 12 and having the same internal section as the die 12. Seals 28 seal the joints between the injection head parts 20a, 20b and die 12.
- 55 Part 20b can be formed with a second duct (not shown) similar to duct 24 for injecting a second resin of different shrinkage characteristics from those of the first resin. 55
- Shaping and impregnation takes place as follows: Reinforcements 29, before being impregnated but after being brought together as illustrated in the following examples, are compressed in chamber 22 for the purpose of pre-shaping, which is initiated by guide 14. After pre-shaping, the reinforcements are allowed to 60 expand on entering chamber 26 at the point where resin is injected. The resin is injected at a pressure of the order of one bar and distributed around the periphery of the section member. The reason for decompressing the reinforcements at the moment of injection is to enable the resin to penetrate right into the reinforcements whilst in the chamber 26. 60
- Passage 27 corresponds to a calibration region where the reinforcement resin ratio is adjusted in the 65 finished section member. 65

The die 12, which usually comprises a steel body in two parts, is heated to polymerize the resin. However, the inlet of die 12 is cooled by an attached device (not shown) to prevent premature polymerization of the resin in this region and in the injection head.

The dry-shaping process made possible by this method of impregnation enables the reinforcements to be accurately disposed relative to one another in positions which they retain in the finished section member.

As is known, the dimensional shrinkage of a glass fibre reinforced plastics object depends on the nature of the resin, the orientation of the fibres and the proportion of resin, which varies with the form of the reinforcements.

Thus, the method of the invention, by associating a unidirectional reinforcement and a multidirectional reinforcement so as to juxtapose separate regions, results in differential shrinkage and predetermined deformation of the desired section member.

This is clearly shown by the following examples, given by way of illustration, where the reinforcements are of the same nature and each region contains only one form of reinforcement.

Figures 3 and 3A show a U-section member having a width l of 38 mm, a height h of 24 mm and a uniform thickness of 4.5 mm.

The section member comprises three separate regions: a region 30 reinforced with a mat of cut filaments and connecting two regions 31 reinforced only with stratifil and forming the tops of the flanges of the section member.

The two thus-associated reinforcements are impregnated by a mixture prepared from the following components:

	<i>Components</i>	<i>Number of parts</i>	
25	Unsaturated polyester resin	95	25
	Styrene	5	
	Calcium carbonate	30	
30	Catalyst	1	30
	Internal mould releasant	0.5	

The unsaturated polyester resin may e.g. be a resin marketed under the reference PCUK T 133 SK by Société Pechiney Ugine Kuhlman; the catalyst is tertibutyl peroctoate sold under the name TRIGONOX (Registered Trade Mark) 21S by Société Akzo, and the mould releasant is a mixture of mono and dialkyl phosphates marketed under the name ORTHOLEUM by Dupont de Nemours.

Since the die is brought to a uniform temperature of 130°C the section member can be produced at a speed of the order of 80 cm/minute. The final section member has a rise f of 16 mm over a length L of 1 m. The reinforcements can be chosen so that the finished section member contains 65% by weight of glass in regions 31 and 35% in region 30.

Figure 4 shows a straight U section member having identical dimensions with the preceding example but differently reinforced. It has two separate regions 40, 41 symmetrical relative to the vertical plane extending through the longitudinal axis of the section member. Regions 40, 41 are reinforced with stratifil and a mesh of cut filaments respectively.

The conditions of impregnation and polymerization are the same as in the preceding example, the product being a section member as shown in Figure 4A. The rise f obtained over a length L of 1 m is 14 mm. The percentages by weight of glass in the section member are 65% in region 40 and 35% in region 41.

Figure 5 shows a hollow square cross-section having an outer side length l of 30 mm and a wall thickness e of 3 mm. The section member has two separate regions, the first being made up of side 50 and reinforced with stratifil only and connected at its ends to the second, which is reinforced with a mesh of cut filaments only and forms the other three sides.

The impregnation and polymerization conditions are the same as in the preceding examples, giving a section member as shown in Figure 5A. The rise f over a length l of 1 m is equal to 8 mm. The percentages by weight of glass are 65% in side 50 and 35% in the other sides.

These examples show some simple embodiments among the numerous combinations which can be imagined, depending on the radius of curvature and the desired mechanical properties of the section member. For example use can be made of voile, unidirectional fabric, balanced or non-balanced fabric, bouclé roves, or a mat of continuous filaments. Section members can be constructed such that at least one region contains a number of different forms of glass fibres.

Alternatively, one region may be impregnated with a first resin having a high shrinkage characteristic after polymerization, whereas the other region or regions can be impregnated with a resin with a relatively low shrinkage characteristic.

Permanent bending can easily be obtained by using an impregnation mixture based on resins such as polyester resin, and simultaneously using reinforcements which facilitate shrinkage of some regions and hinder shrinkage in other regions. The resulting bending can be further accentuated if necessary by placing the section member in a mould in an oven and giving additional heat treatment.

5 In the preceding description, mention has been made only of reinforcements of similar nature, i.e. glass fibres in various forms. The invention also includes within its reinforcements of different kinds, e.g. carbon, steel or boron filaments, which may or may not be associated with glass fibres. 5

CLAIMS

10 CLAIMS 10

1. A method of continuously manufacturing curved members reinforced with filaments, in which at least one unidirectional reinforcement and one multidirectional reinforcement are preshaped when dry and impregnated by injecting a mixture based on a thermosetting synthetic resin or resins, for example a polyester resin or resins, the impregnated reinforcements being fed to a shaping die, characterised in that 15 the unidirectional and multidirectional reinforcements are juxtaposed so as to define at least two separate regions joined along a portion of their surfaces; different dimensional shrinkages from one region to another being produced by polymerization. 15

2. A method according to claim 1, characterised in that one region is impregnated with a relatively high shrinkage resin and the other region or regions are impregnated with a relatively low shrinkage resin.

20 3. A method according to claim 1 or claim 2, characterized in that the unidirectional and multidirectional reinforcements in the structure of a given section member have the same nature. 20

4. A method according to any of claims 1 to 3, characterised in that the reinforcements used are glass fibres.

25 5. A method according to any of the preceding claims, characterised in that each region contains only one form of reinforcement. 25

6. A method according to any of claims 1 to 5, characterised in that at least one of the aforementioned regions is reinforced with cut filaments.

30 7. A method according to any of claims 4 to 6, characterised in that at least one region containing less than 40% by weight of reinforcement is joined to at least one other region containing more than 60% by weight of reinforcement. 30

8. A method of continuously manufacturing curved members reinforced with filaments, the method being substantially as herein described with reference to the drawings.