

SPECIFICATION

Apparatus for Shooting Fibres, Methods of Producing and Bonding Fibres, Methods of Forming Sandwich Constructions, and

5 Sandwich Constructions So-formed

This invention relates to apparatus for shooting fibres, methods of producing and bonding fibres, methods of forming sandwich constructions, and sandwich constructions so-formed.

- 10 According to a first aspect of the invention there is provided apparatus for shooting fibres with stable orientation, the apparatus comprising a cutting mechanism, a feed mechanism operative to feed a continuous fibre at high speed
15 through the cutting mechanism, which is operative to cut the continuous fibre into individual fibres, and a duct arranged to receive the fibres which are projected by their inertia, in use, from the cutting mechanism, the transverse
20 dimension or the maximum transverse dimension of the duct being less than the length of each individual fibre.

- According to a second aspect of the invention there is provided a method of producing and
25 bonding fibres, wherein the fibres are produced by means of apparatus according to the first aspect of the invention and the fibres are oriented and projected at a suitable speed towards a surface of a base, which the fibres partially enter.

- 30 According to a third aspect of the invention there is provided a method of forming a sandwich construction comprising two outer retaining panels separated by spacing material, wherein fibres are bonded to two bases, each in the form
35 of a panel, by a method according to the second aspect of the invention, and the spacing material is injected and foamed between the panels, which serve as a mould for the spacing material, the panels being disposed so that fibre-coated
40 surfaces thereof face each other.

- According to a fourth aspect of the invention there is provided a method of forming a sandwich construction comprising two outer retaining panels separated by spacing material, wherein
45 fibres produced by means of apparatus according to the first aspect of the invention are oriented and projected at a suitable speed towards a surface of the spacing material so that they partially enter the spacing material, and at least
50 one of the panels is formed by applying a matrix material to the surface of the base having the fibres projecting therefrom.

- According to a fifth aspect of the invention there is provided a method of producing and
55 bonding fibres, wherein the fibres are produced by means of apparatus according to the first aspect of the invention and the fibres are oriented and projected at a suitable speed towards a base in the form of a foil, fabric or layer of material, which
60 the fibres penetrate.

Apparatus embodying the invention can be used for producing from a continuous fibre, which is preferably a thin wire, a large number of oriented, cut fibres which can be given a very high

- 65 initial speed, thereby making possible new applications for the fibres. In a typical application the fibres may, for example, be used to bond various materials to a base. In this case, the wire can be fed between a pair of feed rollers and cut
70 by a suitable rotating cutting device or mechanism at a predetermined rate so that one end of each fibre enters the base. In order for the fibres to strike the base with one end it is appropriate to orient them so that their direction
75 of travel is longitudinal. The orientation of the fibres is stabilised with the aid of the cutting method used. In a preferred arrangement, rotating cutting edges cut and sharpen the wire against a counterroller which gives the fibres a stable
80 longitudinal direction of travel. The fibres are shot through a duct having a transverse dimension or maximum transverse dimension less than the length of the fibres, e.g. a pipe having an internal diameter less than the length of the fibres, so that
85 further control is achieved. The cutting device may be built into the feed rollers or arranged separately. In the latter case close control of the speed of the cutting device is desirable.

- In one practical design a wire 0.5 mm in
90 diameter was cut into individual fibres having a length of about 30 mm at a rate of feed of the wire of about 25 m/s before being shot through a passage consisting of a funnel and a pipe at a base of wood into which the individual fibres
95 entered sufficiently to become well anchored. In this way it is possible for the fibres to serve as a means of bonding a matrix material such as concrete or plaster to the base while providing a certain degree of reinforcement. Using steel
100 fibres, a fibre-reinforced composite material with good characteristics has been achieved. Examples of suitable bases are wood, plasterboard, chipboard, foam plastics of the polystyrene or polyurethane type and damp, uncured concrete or
105 plaster. Materials such as mineral wool or plastic foil have also proved to be suitable bases.

- Techniques of shooting a wire or a nail into material are not new. Bolt guns and staple guns are two examples of apparatus in which a metallic
110 fixing is shot into and fixed in a base. Embodiments of the present invention described herein differ, however, from previously known techniques, in that they start with a wire, which is normally wound on a reel, the wire being cut into
115 lengths which are shot at such a speed that they enter a base. Since the speed is high, for instance 25 m/s, a very high capacity is achieved. With a fibre diameter of 0.5 mm, a wire throughput of 39 g/s (2.3 kg/min) can be achieved. This produces
120 more than 800 fibres (of a length of 30 mm) per second, which makes it possible both to bond and reinforce a surface material in an economic way.

- This invention has a number of applications. The above describes its use in conjunction with
125 bonding and reinforcing, for example, concrete. The method and equipment for fixing fibres in a base can also be used for producing mats, filters, heat exchangers, brushes and for reinforcement purposes where a fibre-carrying foil is employed

to hold the fibres in a certain orientation before application of a matrix material. In such an application it may be appropriate to use comparatively long fibres of, for example 150—
 5 200 mm length. There are also applications in which the impact energy is utilised, for instance to clean surfaces or in weapons. By offsetting the axes of the drive rollers in different planes the fibres can be caused to rotate around their own
 10 longitudinal axis. In this way the continuous wire can be given better qualities when unwinding from the reel, as well as better transport between the feed device or mechanism for the wire and the cutting device or mechanism. In addition,
 15 improved ballistic qualities of the fibres are obtained with better penetration of the base into which the fibres are shot.

In sprayed concrete technology today there are various methods of spraying fibres with
 20 compressed air so that they mix with the concrete either in a transport pipe or in a spray nozzle. Fibres which are sprayed in this way are, however, subject to tumbling and generally strike the base sideways on, whereupon they often

rebound. The problem of fibres rebounding from sprayed concrete is considerable; figures of between 30 and 60% have been quoted.

Apparatus embodying the present invention can orient the fibres so that the impact attitude of
 30 each fibre will generally be end-on if the mouth of the pipe is held at a suitable distance from the base. This permits the fibres to enter into and become fastened in the newly sprayed, wet concrete much more easily. Very little rebounding
 35 occurs.

The invention will now be described in further detail, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which the same reference numerals indicate corresponding items throughout, and in which:

Figure 1 shows a feeding and cutting apparatus embodying the invention spraying fibres onto a base;

Figure 2 shows fibres shot into a base and a layer being built up on the base by spraying it with a matrix material;

Figure 3 shows a part of a sandwich construction;

Figure 4 shows a sandwich construction built up by spraying a matrix material; and

Figure 5 shows fibres being shot into a foil or the like so as to penetrate it.

In the apparatus shown in Figure 1, a
 55 continuous wire 1 stored on a reel 2 is fed at high speed by a pair of feed rollers 3 to a rotating cutting device 4 where it is cut up into individual short fibres 5 before being shot at high speed directly into a funnel 6 which ends in a pipe 7 of
 60 circular cross-section whose internal diameter is less than the length of the individual fibres 5. This orients the fibres 5 efficiently so that they travel substantially longitudinally towards a suitable base 8 (e.g. of one of the materials mentioned
 65 above) which they penetrate to a certain depth

depending on their impact energy.

The cutting device 4 comprises rotating cutters (one of which is shown at 9) whose speed is at least approximately equal to or greater than the feed rate of the feed rollers 3 and which are operative to cut the wire 1 against a counter-roller 10. The cutting device 4, when cutting the individual fibres 5, may simultaneously sharpen their leading ends and accelerate them by
 75 increasing their kinetic energy in their direction of travel. The cutting device 4 may be drivable by compressed air, in which case means may be provided to employ exhaust air to increase the kinetic energy of the fibres 5.

If desired, the axes of the feed rollers 3 may be offset in different planes whereby the wire 1 and the fibres 5 rotate around their longitudinal axis.

Figure 2 shows the fibres 5 shot into the base 8 and a matrix material 11 being sprayed on to the surface of the base 8 from which the fibres 5 project. Figure 2 shows a stream 12 of the matrix material being sprayed on, the stream having a certain amount of impact energy so that it can be made to satisfactorily fill out and pack the space
 90 around the fibres.

The matrix material 11 is, for example, a surface covering material, for instance concrete or plaster.

Figure 3 shows a sandwich construction comprising hard outer retaining panels 19 and 20, each precoated with fibres 5 as described above, and separated by foamed spacing material 21. The construction is formed by disposing the panels 19 and 20 as shown, to form a mould and injecting the spacing material between them, whereby the material 21 becomes bonded to the fibres 5. A rational method of production involves placing a battery of hard panels coated with fibres so that a suitable spacing material 21 (e.g. polyurethane) can be poured in and foamed in the same way as shown in Figure 3, but in sequence.

Figure 4 shows another method of forming a sandwich construction wherein a first hard, fibre-coated outer retaining panel 20 has been foam-coated with a spacing material 21 of, for example, polyurethane. The spacing material 21 is then projection-coated with fibres 5 as described with reference to Figure 1 and matrix material 11 is then applied by spraying as described with reference to Figure 2 to form a second outer retaining panel. In a variant of this method, both of the outer retaining panels are formed by applying a matrix material 11 to fibres 5 shot into both sides of the spacing material 21.

Figure 5 shows a thin foil, fabric or layer of material or the like 22 against which fibres are shot as described with reference to Figure 1, the fibres being shot with a predetermined impact energy so that they penetrate the foil 22 or the like which thereby serves as a medium for retaining the fibres 5 and can be used, for example, as a fibre mat.

The embodiments of the invention disclosed herein are not by any means the only ones. For instance, the wire 1 may alternatively consist of a

continuous fibre of plastics or some form of mineral or natural fibre. It is also possible to manufacture fibres in advance and to use a feed mechanism to force them through rollers which give them the necessary speed. In another design the fibres are driven by air through a pipe for directional stability. A magnetic field can be arranged both for driving and directional stability.

- Further applications include short fibres for blasting and stress relieving processes (welding). In one variant mineral wool, for example, can be penetrated by fibres and attached to material placed behind it.

Claims

1. Apparatus for shooting fibres with stable orientation, the apparatus comprising a cutting mechanism, a feed mechanism operative to feed a continuous fibre at high speed through the cutting mechanism, which is operative to cut the continuous fibre into individual fibres, and a duct arranged to receive the fibres which are projected by their inertia, in use, from the cutting mechanism, the transverse dimension or the maximum transverse dimension of the duct being less than the length of each individual fibre.

2. Apparatus according to claim 1, wherein the duct is of circular transverse cross-section and the diameter of the duct is less than the length of each individual fibre.

3. Apparatus according to claim 1 or claim 2, wherein the duct comprises a pipe.

4. Apparatus according to claim 1, claim 2 or claim 3, wherein the cutting mechanism is incorporated in the feed mechanism.

5. Apparatus according to claim 1, claim 2 or claim 3, wherein the feed mechanism comprises a pair of rollers operative to feed the continuous fibre at high speed to the cutting mechanism and the cutting mechanism comprises rotating cutters whose speed is at least approximately equal to or greater than the feed rate of the feed mechanism and which are operative to cut the continuous fibre against a counter-roller, the individual fibres thus produced, in use, being projected into the duct.

6. Apparatus according to claim 5, wherein the axes of the rollers are offset in different planes.

7. Apparatus according to any one of the preceding claims, wherein the cutting mechanism, when cutting the individual fibres, is operative simultaneously to sharpen ends of the fibres and accelerate the fibres by increasing their kinetic energy in their direction of travel.

8. Apparatus according to any one of the preceding claims, wherein the cutting mechanism is drivable by compressed air and means is provided to employ exhaust air to increase the kinetic energy of the fibres.

9. Apparatus for shooting fibres, the apparatus being substantially as herein described with reference to Figure 1 of the accompanying drawings.

10. A method of producing and bonding fibres,

- wherein the fibres are produced by means of apparatus according to any one of claims 1 to 9 and the fibres are oriented and projected at a suitable speed towards a surface of a base, which the fibres partially enter.

11. Apparatus according to claim 10, wherein a matrix material is applied to the surface of the base having the fibres projecting therefrom.

12. Apparatus according to claim 11, wherein the matrix material is a surface covering material.

13. Apparatus according to claim 11 or claim 12, wherein the matrix material comprises concrete or plaster.

14. Apparatus according to claim 11, claim 12 or claim 13, wherein the matrix material is applied by spraying.

15. A method according to claim 10, substantially as hereinbefore described with reference to Figure 1 or Figure 2 of the accompanying drawings.

16. A method of forming a sandwich construction comprising two outer retaining panels separated by spacing material, wherein fibres are bonded to two bases, each in the form of a panel, by a method according to claim 10, and the spacing material is injected and foamed between the panels, which serve as a mould for the spacing material, the panels being disposed so that fibre-coated surfaces thereof face each other.

17. A method according to claim 16, substantially as hereinbefore described with reference to Figure 3 of the accompanying drawings.

18. A method of forming a sandwich construction comprising two outer retaining panels separated by spacing material, wherein fibres produced by means of apparatus according to any one of claims 1 to 9 are oriented and projected at a suitable speed towards a surface of the spacing material so that they partially enter the spacing material, and at least one of the panels is formed by applying a matrix material to the surface of the base having the fibres projecting therefrom.

19. Apparatus according to claim 18, wherein the matrix material comprises concrete or plaster.

20. Apparatus according to claim 18 or claim 19, wherein the matrix material is applied by spraying.

21. A method according to claim 18, substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.

22. A sandwich construction formed by a method according to any one of claims 16 to 21.

23. A method of producing and bonding fibres, wherein the fibres are produced by means of apparatus according to any one of claims 1 to 9 and the fibres are oriented and projected at a suitable speed towards a base in the form of a foil, fabric or layer of material, which the fibres penetrate.



- continuous fibre of plastics or some form of mineral or natural fibre. It is also possible to manufacture fibres in advance and to use a feed mechanism to force them through rollers which
- 5 give them the necessary speed. In another design the fibres are driven by air through a pipe for directional stability. A magnetic field can be arranged both for driving and directional stability.
- 10 Further applications include short fibres for blasting and stress relieving processes (welding). In one variant mineral wool, for example, can be penetrated by fibres and attached to material placed behind it.

Claims

- 15 1. Apparatus for shooting fibres with stable orientation, the apparatus comprising a cutting mechanism, a feed mechanism operative to feed a continuous fibre at high speed through the cutting mechanism, which is operative to cut the
- 20 continuous fibre into individual fibres, and a duct arranged to receive the fibres which are projected by their inertia, in use, from the cutting mechanism, the transverse dimension or the maximum transverse dimension of the duct being
- 25 less than the length of each individual fibre.
2. Apparatus according to claim 1, wherein the duct is of circular transverse cross-section and the diameter of the duct is less than the length of each individual fibre.
- 30 3. Apparatus according to claim 1 or claim 2, wherein the duct comprises a pipe.
4. Apparatus according to claim 1, claim 2 or claim 3, wherein the cutting mechanism is incorporated in the feed mechanism.
- 35 5. Apparatus according to claim 1, claim 2 or claim 3, wherein the feed mechanism comprises a pair of rollers operative to feed the continuous fibre at high speed to the cutting mechanism and the cutting mechanism comprises rotating cutters
- 40 whose speed is at least approximately equal to or greater than the feed rate of the feed mechanism and which are operative to cut the continuous fibre against a counter-roller, the individual fibres thus produced, in use, being projected into the
- 45 duct.
6. Apparatus according to claim 5, wherein the axes of the rollers are offset in different planes.
7. Apparatus according to any one of the preceding claims, wherein the cutting
- 50 mechanism, when cutting the individual fibres, is operative simultaneously to sharpen ends of the fibres and accelerate the fibres by increasing their kinetic energy in their direction of travel.
8. Apparatus according to any one of the preceding claims, wherein the cutting mechanism
- 55 is drivable by compressed air and means is provided to employ exhaust air to increase the kinetic energy of the fibres.
9. Apparatus for shooting fibres, the apparatus
- 60 being substantially as herein described with reference to Figure 1 of the accompanying drawings.
10. A method of producing and bonding fibres,

- wherein the fibres are produced by means of
- 65 apparatus according to any one of claims 1 to 9 and the fibres are oriented and projected at a suitable speed towards a surface of a base, which the fibres partially enter.

11. Apparatus according to claim 10, wherein
- 70 a matrix material is applied to the surface of the base having the fibres projecting therefrom.
12. Apparatus according to claim 11, wherein the matrix material is a surface covering material.
13. Apparatus according to claim 11 or claim
- 75 12, wherein the matrix material comprises concrete or plaster.
14. Apparatus according to claim 11, claim 12 or claim 13, wherein the matrix material is applied by spraying.
- 80 15. A method according to claim 10, substantially as hereinbefore described with reference to Figure 1 or Figure 2 of the accompanying drawings.
16. A method of forming a sandwich
- 85 construction comprising two outer retaining panels separated by spacing material, wherein fibres are bonded to two bases, each in the form of a panel, by a method according to claim 10, and the spacing material is injected and foamed
- 90 between the panels, which serve as a mould for the spacing material, the panels being disposed so that fibre-coated surfaces thereof face each other.
17. A method according to claim 16,
- 95 substantially as hereinbefore described with reference to Figure 3 of the accompanying drawings.
18. A method of forming a sandwich construction comprising two outer retaining
- 100 panels separated by spacing material, wherein fibres produced by means of apparatus according to any one of claims 1 to 9 are oriented and projected at a suitable speed towards a surface of the spacing material so that they partially enter
- 105 the spacing material, and at least one of the panels is formed by applying a matrix material to the surface of the base having the fibres projecting therefrom.
19. Apparatus according to claim 18, wherein
- 110 the matrix material comprises concrete or plaster.
20. Apparatus according to claim 18 or claim 19, wherein the matrix material is applied by spraying.
21. A method according to claim 18,
- 115 substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.
22. A sandwich construction formed by a method according to any one of claims 16 to 21.
- 120 23. A method of producing and bonding fibres, wherein the fibres are produced by means of apparatus according to any one of claims 1 to 9 and the fibres are oriented and projected at a suitable speed towards a base in the form of a foil,
- 125 fabric or layer of material, which the fibres penetrate.



24. A method according to claim 23,
substantially as hereinbefore described with

reference to Figure 5 of the accompanying
drawings.

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