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[54] **METHOD OF PREPARING SHORT FIBERS OF FINE DIAMETERS**

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[51] **Int. Cl.²** **B26F 3/00**

[58] **Field of Search** 225/103, 93.5, 4, 3, 2, 225/1; 264/28, 143

[56] **References Cited**

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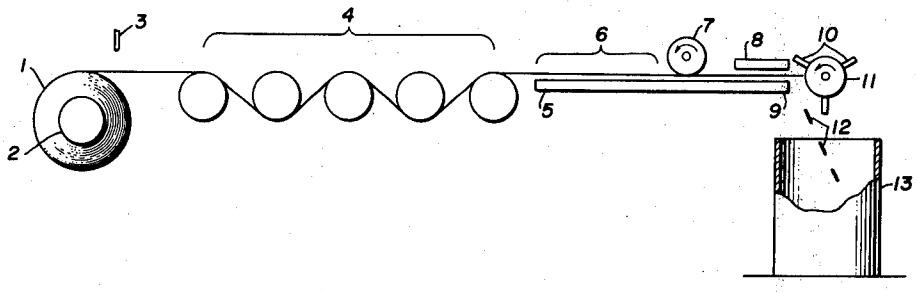
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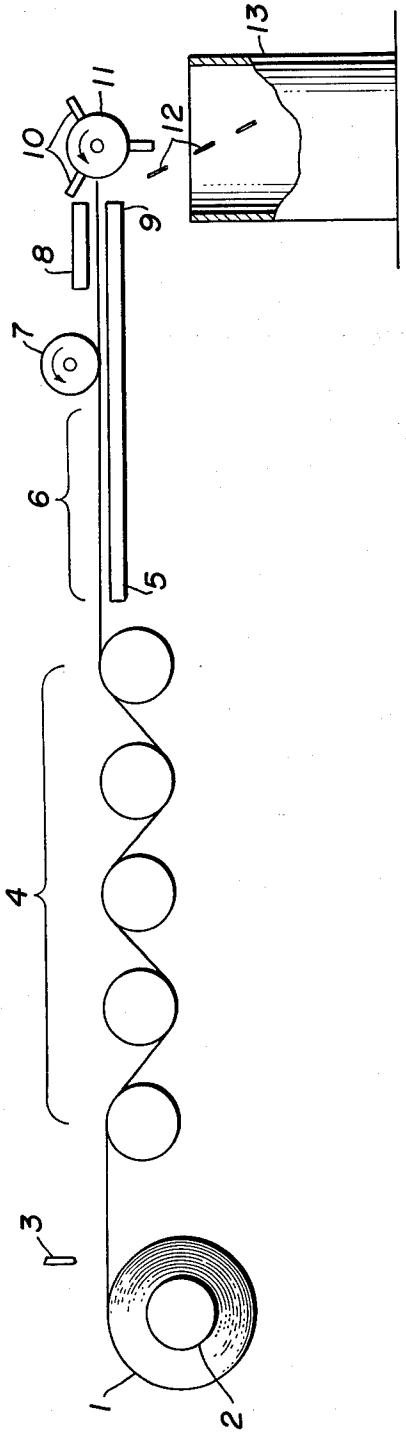
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[57] **ABSTRACT**

A method is provided for preparing short fibers of controlled lengths from continuous multifilament fiber bundles by impregnating the bundles with a liquid, tensioning the impregnated fiber bundles to obtain a high degree of fiber collimation, freezing the impregnating liquid to a solid, mechanically advancing the rigid bundle to a cutting edge, and mechanically cutting the fiber to desired lengths by mechanically driven blades. The impregnating liquid of the collected chopped short fibers is melted and the liquid subsequently removed by drying.

3 Claims, 1 Drawing Figure




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METHOD OF PREPARING SHORT FIBERS OF FINE DIAMETERS

FIELD OF THE INVENTION

The present invention relates to a method by which continuous bundles of fine diameter filaments are converted to short fibers of controllable lengths with minimized fiber entanglement.

BACKGROUND OF THE INVENTION

Short lengths of strong, stiff carbon fibers are increasing in use as a constituent of composite bodies employing a variety of matrix materials. Such fibers, in composites, provide a means to beneficially alter matrix materials as to mechanical properties, tribological properties, and physical properties. Examples of matrix materials include thermosetting and thermoplastic resins, carbon, elastomeric vulcanizates, glasses, metals and ceramics.

Minimization of the translation of carbon fiber properties to resultant composites requires: 1) a uniform dispersion of the carbon fibers in the matrix material, and 2) a minimization of deleterious fiber to fiber interactions during the reduction of long lengths of multifilament carbon fiber bundles to desired short fiber lengths and during the subsequent operations to prepare particular composite bodies.

Conventional methods of preparing short carbon fibers from long lengths of multifilament carbon bundles have involved reciprocating fiber cutters and various types of rotating cutters.

In one method of reciprocating fiber cutting, the fiber bundle is mechanically advanced a predetermined length to a cutting edge with the cutter in the up or open position, the fiber bundle is then held stationary as the close fitting cutter descends to cut the fiber bundle, and the process is continually repeated to produce short fiber lengths.

In rotary cutting, the fiber bundle is often continuously advanced to a cutting edge, and subjected to cutting by a close fitting blade or blades attached to a rotating member.

Both of these conventional techniques have several inherent disadvantages. While carbon fibers may have moduli of 75×10^6 psi or more, their small nominal fiber diameters (typically 5 to 10 microns) renders such fibers highly flexible. Thus fiber bundles and/or individual fibers can easily be skewed in mechanical advancement to the cutter, yielding major deviations from the attainment of the desired short fiber lengths. In both techniques, the primary cutting action is one of fiber shear so that wear of the cutter may be high. Particularly with rotating cutting operations, a severe and unwanted degree of fiber entanglement of a portion of the chopped short fibers is obtained. These clumped fiber entanglements are difficult to disperse without damaging individual fibers. Because of inertial considerations, the reciprocating method of fiber chopping is inherently slow.

Therefore, the objects of the present invention are to provide a rapid method wherein continuous carbon fiber bundles can be reduced to desired short fiber lengths of low fiber length variation, wherein the mechanism is primarily of fiber impact rather than wear producing fiber shear, and to minimize entanglement of the short fibers.

BRIEF STATEMENT OF THE INVENTION

In accordance with the present invention, multifilament fiber bundles of long lengths are: 1) impregnated with a liquid, 2) spread to a band by passage of the tensioned fiber bundle over a series of freely turning or mechanically driven rollers, 3) subjected to a heat removing zone which transforms the impregnating liquid to a frozen solid, 4) continuously advanced by mechanical means to an impact edge, and 5) impacted to form discrete and controlled fiber lengths by the action of a moving impacting member. In effect, a fugative matrix unidirectional composite is formed which is successively impacted to form short controlled lengths of the composite. Free, untangled fibers are subsequently attained by allowing the fugative matrix to melt and drying the fibrous mass.

This invention in especially useful when chopping carbon fibers to short lengths as conventional fiber chopping techniques may result in short carbon fibers becoming airborne. Such airborne fibers can cause malfunction of electrical and electronic devices, and can cause human discomfort on contacting the skin or by inhalation. The present invention greatly reduces the generation of airborne fibers as the carbon fibers during processing are wetted with a liquid or bound in a frozen matrix.

DESCRIPTION OF THE DRAWING

FIG. **1** is a schematic drawing of the apparatus typical of the entire present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates the general apparatus of the present invention. A supply of the long length of multifilament carbon fiber bundle **1** on a bobbin or reel is moderately restrained by a tensioning device **2.** The nominal liquid to form the subsequent solid frozen matrix is applied at **3,** by a means of convenience. A series of freely turning or driven rollers **4** provides a method of forming the tensioned mutlifilament fiber bundle into a thin band which is fed into a non-adherent flat bed plate **5.** Heat is removed by auxiliary means in a zone **6** from the liquid impregnated band to quickly freeze the liquid to a solid matrix. The fiber containing solid matrix band is passed under a driven propelling roller **7** which provides tension to the prior fiber bundle and moves the fugative matrix composite forward along the bed plate **5** under a lightly pressured non-adherent restraining block **8** to the impact edge **9.** Impacting blades **10** mounted on a rotating or other type of member **11** are synchronized with the forward movement of the fugative matrix band so as to obtain the desired impact fractured composite lengths **12** which are collected in a porous container **13.**

EXAMPLE

As an example, a 10,000 filament untwisted carbon fiber tow obtainable from Hercules, Incorporated and designated as Magnamite Type A-S may be employed. Water may be applied to the tow immediately after unwinding from the supply bobbin. Typically, the amount of water applied to the tow may be about 125 percent of the weight of the tow, although water in excess of this amount is not detrimental to the process as surplus water readily drips from the fiber band-forming rollers. The fiber band may be then immediately directed onto

a flat Teflon film coated bed plate and cooled below the freezing point of water. The now solid fiber-containing ice matrix composite may be passed under an elastomer coated driving roll which remains deformable at the temperature of the composite band, propelling the band to the impacting edge under an upper restraining block. The forward moving solid band may be then impacted by blades secured to a rotating member. Short lengths of the impact fractured composite may be collected in a porous bag. A free fibrous mass is obtained by allowing the ice matrix to melt and drying the fibers in a warm air stream.

Short fibers of about ⅛ inch lengths prepared by the process of the present invention were readily dispersed in water by simple mechanical stirring to form a non-settling dispersed fibrous mass at a concentration of 1 percent or less of the fibers in water.

In contrast, comparable ⅛ inch lengths of fiber prepared by mechanically chopping dry tow could not be readily dispersed in water by stirring. Settled fibrous mass was considerably less than that of fibers prepared by the present invention, and dense ovoid fiber clumps persisted after prolonged stirring.

It has also been found that with the collection of chopped prepared by the present invention without drying and with the addition of more water to form a more diluted concentration of fibers in water, particulate materials may be added and readily and uniformly dispersed by simple stirring. Examples of particulare materials may include fillers, such as some carbons and silicas, and polymers of various types. The bulk of the water may be removed by simple filtration, with the remaining water removed in drying by a method of convenience. If desired, the water removal may be conducted with auxiliary forming members to prepare preforms for the subsequent preparation of composite items, as, for example by compression molding.

While the foregoing has described the preparation of short carbon fibers from long lengths of multifilament carbon fiber bundles, the process is also applicable to other types of multifilament fiber bundles with individual filament diameters below 25 microns.

Matrix materials other than water may also be employed. These alternate materials include normally liquid materials which can be conveniently frozen to a solid and later removed by conventional drying techniques.

Although the description has been limited to particular embodiments of the present invention, it is thought that modifications and variations would be obvious to one skilled in the art in light of the above teachings. It is understood, therefore, that changes may be made in the features of the present invention described herein which fall within the full intended scope of the invention as defined by the following claims.

What I claim is:

1. A method for preparing short fibers of controllable lengths of multifilament bundles of fine diameter individual filaments comprising the steps of:

impregnating the multifilament fiber bundles with a fiber inert liquid material;

tensioning the impregnated multifilament fiber bundles to achieve a high degree of fiber collimation;

freezing the impregnating liquid to form a solid composite comprised of the multifilament fiber bundles and a matrix of the frozen impregnating liquid;

mechanically advancing the said solid composite beyond a cutting edge at a predetermined rate and severing the said solid composite incrementally to provide predetermined lengths of said solid composite;

thawing the frozen impregnating liquid; and

removing the impregnating liquid from the composite to provide plural fibers of desired length.

2. The process of claim **1** wherein the multifilament fiber bundle is essentially carbon.

3. The process of claim **2** wherein the matrix forming liquid is water.

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