PATENT SPECIFICATION (11) 1 570 240

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(21) Application No. 46217/77 (22) Filed 7 Nov. 1977 (19)
(23) Complete Specification filed 30 May 1978
(44) Complete Specification published 25 June 1980
(51) INT. CL.³ C08K 7/06 7/28 F16L 9/12
(52) Index at acceptance
C3B 1C33A 1C5B1 1C6X 1C8R 1D2C 1L2CX 1L6B N
F2P 1A12 1A16A 1B3 1B7 1B8 2A3 2C10 2C11
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(54) ELECTRICALLY CONDUCTING RESINOUS COMPOSITION

(71) We, BTR INDUSTRIES LIMITED, a British Company, of Silvertown House, Vincent Square, London SW1P 2PL, 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 present invention relates to an electrically conducting resinous composition and more particularly to electrically conducting reinforced resin compositions and to articles, e.g. tubes, pipes and sheets made therefrom.

In areas such as coalmines and other places where fire and explosion hazards exist the use of plastics which are highly electrically insulating is potentially dangerous due to the build up of static electricity.

In some cases this problem is overcome by coating the surfaces of the plastics concerned with metallic paints or other conductive coatings, but frequently this is unacceptable and other ways of making the plastic item conductive have to be employed, for example, by the inclusion of conducting fillers such as powdered metals, carbon or graphite. With this material the filler loading required is high, typically 20% or more by weight. This high loading may adversely affect other properties of the plastics and the ease with which they can be processed.

In the case of filament winding which typically uses thermosetting resins, such as epoxides, unsaturated polyesters, phenolic and furanes the incorporation of high filler loadings gives rise to unacceptably high increases in the resin viscosity such as to make it extremely difficult to maintain the correct resin to glass ratio in the finished product.

The present invention provides an electrically conducting reinforced resin composition comprising a solid resin containing a fibrous reinforcing material and from 0·15 to 2% preferably 0·25 to 2% by weight of resin of carbon fibres, the carbon fibres being aligned with one another.

Preferably there are at least two adjacent layers of aligned carbon fibres, the carbon fibres in one layer crossing over those in the adjacent layer.

The reinforcing material may be any textile fibre and may be in the form of a web or a plurality of elongate strands.

The reinforcing material may be asbestos. Preferably, however, the reinforcing material is glass fibre, preferably in the form of elongate filaments.

The resin which is preferred to be thermosetting may be a polyester resin, a phenolic resin, an acrylic resin or a polyurethane resin but is preferably an epoxy resin.

The carbon fibres may suitably have a length of from 1 to 12 mm, preferably about 4 mm and are preferably present to the extent of from 0·3 to 1% more preferably 0·3 to 0·5% by weight of the resin.

The percentage of reinforcing material used is preferably 75% by weight based on the combined weight of resin and reinforcing material.

The use of carbon fibres in accordance with the invention allows the total free carbon content of the composition to be 2·0% or less by weight based on the weight of resin, without loss of conductive properties.

The present invention includes a method for producing an electrically conducting reinforced resin composition which method comprises impregnating a fibrous reinforcing material with a liquid resin containing carbon fibres in such a manner that the carbon fibres are aligned with one another on the impregnated reinforcing material, and setting the resin.

Alignment of the carbon fibres may be brought about by producing shear forces in the liquid resin, e.g. by causing the liquid resin to flow relative to a surface.

Alignment of carbon fibres may also be brought about by a process of "pultrusion" in which a mass of fibrous material is pulled

through a die in which resin is extruded onto the fibres. Solid rods and other sections may be formed in this manner having axially aligned fibres.

Preferably a web of reinforcing material or a plurality of strands of reinforcing material is impregnated with resin containing carbon fibres from a bath by contact with a transfer roller rotating with its lower portion in the resin bath.

Alternatively, but less desirably, reinforcing material as described above is passed through a resin bath. This method can cause uneven pick up of carbon fibres by the reinforcing material.

It is thought that the alignment of the carbon fibres is caused by the relative movement of the transfer roller or the reinforcing material respectively with respect to the liquid resin in the bath.

The impregnated reinforcing material may be wound on a mandrel where the resin solidifies, thus forming a tube or pipe when the mandrel is removed.

Before setting, the winding of impregnated material may be slit, removed from the mandrel and flattened to form a sheet which is then set.

The winding on the mandrel may be circumferential or helical. In circumferential winding impregnated material is fed to the rotating mandrel in such a way that the mandrel surface is progressively covered with circumferential windings positioned at an angle of approximately 90° with the rotating axis of the mandrel, thus giving only hoop strength. The surface of the mandrel is therefore covered in a single pass.

Axial strength may be obtained by incorporating a layer of unidirectional rovings or roving fabric between the circumferential layers.

Preferably however the winding is helical, that is to say the ratio of traverse speed to mandrel speed is such that the winding is deposited at an angle substantially less than 90° with the mandrel axis, the angle depending on the required ratio of hoop strength to axial strength. Several passes are necessary to cover the mandrel.

A plurality of layers may be applied to the mandrel and a mixture of circumferential and helical winding may be employed for the different layers.

The invention includes compositions made by the methods described above and articles comprising or consisting of compositions of the invention.

Examples of articles made of compositions of the invention are pipes, tubes and sheets. Pipes and tubes in accordance with this invention may have a core or an outer sheath of a suitable material, e.g. a non-conducting plastics material.

Compositions of the present invention may be used to form a wide variety of articles in which anti-static properties are desired, e.g. pipework, mandrels or rollers for plastics materials (including man made fibre textiles, and plastics films), storage tanks and other vessels.

The materials of the invention are conductive, i.e. they have a relatively low resistivity, e.g. below 10^3 ohm cm.

The resistivity of the materials of the invention is typically from 20 to 500, e.g. 30 to 70 ohm cm.

The invention will be illustrated by the following Examples and an embodiment of the method of the invention will be described with reference to the accompanying drawings in which:

Figure 1 is a top view of apparatus in use in forming a filament wound article in accordance with the invention; and

Figure 2 is a side view of the same apparatus.

Figure 1 shows glass fibre roving 13 containing many fine glass filaments being drawn from a tensioning device (not shown), impregnated with a resin 12 containing carbon fibres and helically wound on a mandrel 7.

The roving is combed by guide pins 1 to maximise subsequent impregnation; passes over a guide roller 2, under an adjustable bar 3, and over the surface of a transfer roller 4. The transfer roller 4 rotates in a bath 14 containing the resin 12, the lower part only of roller 4 being immersed in the resin. The dwell angle of the roving on the roller is adjustable by vertical adjustment of bar 3. Excess resin is removed from the roving by wiper bars 5 and falls back into the bath 14. The roving is then passed over a guide roller 6, combed by pins 11, and fed through an eye 8 to the mandrel. The pins 11 and the eye 8 are carried on a bar 9 and traverse the mandrel from end to end forming a helical winding with a winding angle of 55°.

In the following Examples, tubes are made using the apparatus described above.

EXAMPLE 1

An epoxy resin containing 0·3% by weight of carbon fibres, 4 mm long was placed in the bath and impregnated on to glass filaments to produce a loading of 25% resin, 75% glass by weight. The impregnated resin was helically wound on a 2″ diameter mandrel and set to form a tube having an outer diameter of $2\frac{3}{8}$″. A section of the tube was cut and colloidal graphite was painted on the cut ends to form an electrical contact. The resistivity was found to be 65 ohm cm.

EXAMPLE 2

Example 1 was repeated with 0·5% by weight of carbon fibres in the bath. The mandrel was replaced by an 8″ mandrel and the outer diameter of the finished tube was 8⅜″. The resistivity was found to be 40 ohm cm.

EXAMPLE 3

Example 1 was repeated with 0·15% by weight of carbon fibre in the bath. The resistivity was found to be 100 ohm cm.

As specifically exemplified, the present invention allows the production of plastics materials having a high conductivity without the use of high loadings of conductive material. Fillers including conductive fillers may of course be included in the compositions of the invention if desired. The compositions and articles of the invention may also include additives such as fire retardents.

The invention includes apparatus, e.g. pipes, of the type described, provided with electrical contacts for direct heating by passage of electric current.

WHAT WE CLAIM IS:—

1. An electrically conducting reinforced resin composition comprising a solid resin containing a fibrous reinforcing material and from 0·15 to 2% by weight of resin of carbon fibres, the carbon fibres being aligned with one another.

2. A resin composition as claimed in claim 1 wherein the carbon fibre content is from 0·3 to 0·5% by weight of resin.

3. A composition as claimed in claim 1 or claim 2 wherein there are at least two adjacent layers of aligned carbon fibres, those in one layer crossing over those in the adjacent layer.

4. A composition as claimed in any preceding claim wherein the reinforcing materials in the form of a web or a multitude of elongate strands.

5. A composition as claimed in any preceding claim wherein the reinforcing material is of textile fibre or glass fibre.

6. A composition as claimed in any preceding claim wherein the resin is a thermosetting polyester resin, phenolic resin, acrylic resin, polyurethane resin or epoxy resin.

7. A composition as claimed in any preceding claim wherein the carbon fibres are from 1 to 12 mm long.

8. A composition as claimed in claim 7 wherein the carbon fibres are about 4 mm long.

9. A composition as claimed in any preceding claim wherein the content of reinforcing material is about 75% by weight based on the combined weight of resin and reinforcing material.

10. An electrically conducting reinforced resin composition substantially as hereinbefore described in any one of the specific Examples.

11. A composition as claimed in any preceding claim in the form of a pipe, tube or sheet.

12. A method for producing an electrically conducting reinforced resin composition which method comprises impregnating a fibrous reinforcing material with a liquid resin containing carbon fibres in such a manner that the carbon fibres are aligned with one another on the impregnated reinforcing material, and setting the resin.

13. A method as claimed in claim 12 wherein alignment of the carbon fibres is brought about by producing shear forces in the liquid resin.

14. A method as claimed in claim 11 wherein a multitude of strands of reinforcing material is impregnated with resin containing carbon fibres from a bath by contact with a transfer roller rotating with its lower portion in the bath.

15. A method as claimed in any one of claims 12 to 14 wherein the impregnated reinforcing material is wound on a mandrel and the resin is set to form a hollow body or is slit and removed from the mandrel before setting, formed into a sheet and set.

16. A method as claimed in claim 15 wherein layers of impregnated reinforcing material are helically wound on the mandrel.

17. A method for producing an electrically conducting reinforced resin composition substantially as hereinbefore described in any one of the specific Examples.

18. A composition as claimed in claim 1 when produced by a method claimed in any one of claims 12 to 17.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1980.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG. 1.

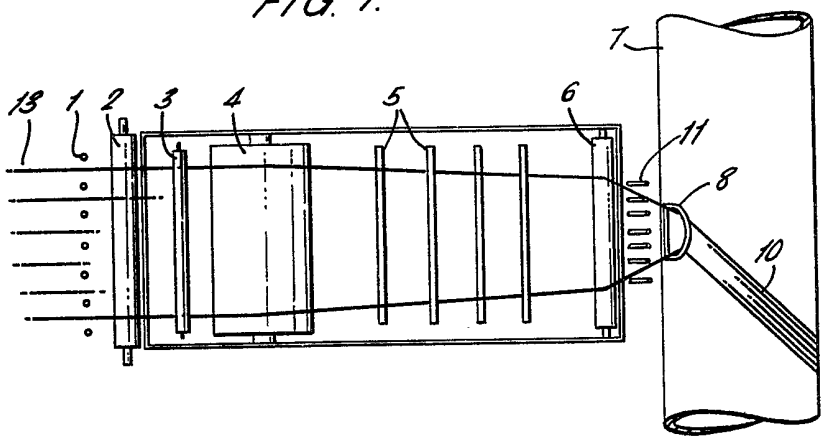

FIG. 2.