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MANUFACTURE OF ELECTRIC CABLE

Edwin J. Merrell, Scarsdale, N.Y., assignor to Phelps Dodge Copper Products Corporation, New York, N.Y.
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1 Claim

ABSTRACT OF THE DISCLOSURE

An electric cable conductor has a plastic insulating layer uniformly and symmetrically disposed therearound at a relatively rapid production rate. Curing and cooling of the plastic is effected by drawing the conductor and insulation through a plurality of contiguous circulating fluid zones included in a catenary chamber, with such zones being characterized by monotonically decreasing operative temperatures.

DISCLOSURE OF INVENTION

This invention relates to the manufacture of electric cable and, more specifically, to a method and apparatus for depositing insulating material about a cable conductor.

A cylindrical plastic insulating layer for coaxial cable or the like is typically formed by extruding the plastic material in a heated, molten state about a metallic cable center conductor. Continuous production of such an insulated conductor has heretofore proceeded relatively slowly in view of heat transfer limitations obtaining when the plastic material is cured and cooled. Further, the plastic insulation in prior art production methods often departs from its extruded cylindrical form symmetrically disposed about the cable center conductor when exposed to the relatively high temperatures necessary to cure, or thermoset, this material. The resulting eccentricity gives rise to undesirable changes in the electrical properties of the finished cable product.

In addition, prior art cable fabricating systems have illustratively traversed the extruded plastic through a cooling trough containing a coolant exhibiting a homogeneous, relatively low temperature. Such an organization heat shocks the plastic, thereby encouraging the formation of voids, or discontinuities in the plastic near the cable center conductor. Such discontinuities are exceedingly deleterious to the dielectric strength of the thermoset insulating layer.

It is therefore an object of the present invention to provide an improved method and apparatus for fabricating an electric cable conductor having an insulating layer thereabout.

More specifically, an object of the present invention is the provision of a method and apparatus for rapidly and continuously fabricating a cable conductor having an insulating layer therearound which exhibits a relatively high dielectric strength.

The above and other objects, features and advantages of the present invention are realized in a specific, illustrative method and apparatus described hereinafter in conjunction with the accompanying drawing which depicts a cable fabricating system arrangement which embodies the principles of the present invention.

Referring now to the system depicted in the drawing, there is included a reel 10 for supplying a metallic conductor 11 to extruding apparatus 12 of any conventional configuration. A source 15 supplies an uncured, molten plastic insulating material 13 to the extruder 12 which is operative to uniformly deposit the material 13 circumferentially around the conductor 11. The insulating material 13 may comprise, for example, polyethylene which

can be thermoset, or cured, after extrusion to effect molecular cross-linking. Other suitable plastic insulating materials are similarly well known to those skilled in the art.

From the output of the extruder 12, the conductor 11 and its associated insulating layer 13 pass through a downwardly inclined catenary chamber or pipe 14, and are drawn through a water sealing tank 70 to a take-up reel 73 which is driven by a motor 75 through any suitable linkage 77. The pipe 14 is catenary in the sense that its diameter and canted orientation (illustratively straight and downward sloping in the drawing) are such as to accommodate the catenary-like natural disposition of the insulated conductor 11-13 without significant contact between the cable and pipe.

A steam source 20 applies steam to the catenary pipe 14 near the output of the extruder 12 via an inlet tube 21. An outlet 22 completes a closed steam system. The source 20 supplies steam at a relatively high temperature and pressure to partially effect curing of the plastic layer 13 as it is drawn through the chamber 14 zone *a* shown in the drawing by the take-up reel 73. Typical operative parameters for the steam phase comprise a pressure of 600 p.s.i.a. and a corresponding temperature range at saturation of approximately 250° C.

To the right of the relatively short steam phase tube length *a* is a further plastic curing zone *b* which employs a fluid to effect heat exchanging. In particular, a heating unit 30 and a pump 32 are employed to rapidly circulate a pressurized fluid heated above the plastic thermosetting temperature, e.g. to 250° C., in the tube 14 zone *b* between an inlet pipe 34 and an outlet pipe 35.

The liquid circulated in the zone *b* (and also in the remainder of the tube 14 as described hereinafter) is selected to have a specific gravity approximately the same as that of the plastic material 13, i.e., in the approximate range of .86-1.1 for a great many polymers and specifically .93 for polyethylene. Thus water with a specific gravity of 1.0 is well suited for this purpose.

Absent a suitable liquid in the catenary tube 14, the force of gravity acting on the molten extruded plastic 13 in the pipe 14 area near the extruder 12 would produce a downward sagging of the plastic material relative to the conductor 11. Accordingly, the conductor 11 would be eccentrically fixed in the insulating layer 13. Such an insulated conductor configuration would give rise to deleterious changes in the electrical properties of the cable, i.e., a lowered breakdown voltage, and an altered iterative impedance.

However, by employing a suitable liquid in the catenary 14 of approximately the same specific gravity as the insulating material 13, a neutral buoyancy is produced by the fluid which essentially negates the undesirable gravity sagging. Accordingly, water is included throughout most (if not all as disclosed below) of the length of the catenary tube 14 to assure that the electrical insulating layer 13 will remain symmetrically disposed about the conductor 11.

To the right of the plastic curing zones *a* and *b* are a plurality of plastic insulation cooling zones *c*, *d*, . . . *i*, characterized by a monotonically decreasing temperature gradation, to cool and harden the plastic 13 while avoiding thermal shock. More specifically, the zones *c*, *d*, . . . *i* illustratively comprise pressurized closed loops fluid circulation systems having characteristic operative temperatures of 125° C., 100° C., . . . 5° C., and respectively include a pump, a cooling unit, and inlet and outlet conduits 42, 40, 44 and 45; 52, 50, 54 and 55; . . . 62, 60, 64 and 65. In accordance with one aspect of my invention, an advantageous mode of system functioning is effected when the characteristic temperatures for selected cooling zones are adjusted to correspond with