Reduction of carbon black content due to nouvelle compounding technique

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ABSTRACT

There have been several attempts reducing the carbon black content in semi-conductive compounds and keeping a good surface finish.

Modern semi-conductive compounds are based on clean furnace blacks with an ethylene copolymer, antioxidant and peroxide that are mixed together. The structure of the carbon black should not be destroyed in order to keep the conductive, however the dispersion of the carbon black should be excellent in order to fulfil the requirements of the conductor-screen in a power cable.

The carbon black content is determined by the percolation of this in a specific polymer and is depending on the compounding process, the processing of the compound, the temperature and the temperature history of the compound.. The requirements are outlined with a maximum value in several cable standards which are then translated into compounding requirements.

We have now developed a process, using a planetary roller extruder, in order to reduce the carbon black content that is needed in other compounding processes by still keeping the same electrical performance of the compound.

We did several measurements and studies in order to prove that the material is equivalent to conventional compounds. Due to the reduction in carbon black content, we naturally had better mechanical properties and also better process-ability of the material in terms of viscosity and pre-cross-linking (scorch).

KEYWORDS

Carbon black, Compounding, Semi-conductive compounds, Conductivity

INTRODUCTION

Currently cross-linkable semi-conductive compounds are based on an ethylene – copolymer, like ethylene-butyl acrylate (EBA), ethylene-ethyl-acrylate (EEA) or ethylene-vinyl-acetate EVA. There are also other polymers used but in this paper we will focus on the classical fully bonded compound for general purpose applications up the high voltage range.
To achieve a specified conductivity of the screens a certain amount of a clean furnace type carbon black is added. This carbon black is commonly described as a P-type. Additional a suitable antioxidant and a cross-linker like a peroxide is added to ensure the stability and the performance of the cables in service.
The amount of carbon black that is used is depending on the polymer, the type of carbon black itself and the shear rate during production of the compound and during the production of the cable.
We have made now tests adapting the shear rate during production of the compound in order to reduce the amount of carbon black in the compound.

DESCRIPTION OF THE COMPOUNDING PROCESS

The compounding process is designed following the idea of balancing the mechanical and thermal energy input into the compound. The target is to achieve the best compromise between sufficient mixing without having agglomerates in the compound and overstressing the carbon black, which would lead to the destruction of secondary structures and loss of conductivity.

The extruder setup is based on a short standard compounding design, see schematic depiction below. It is a three-modular setup with a single screw feed section upstream of the first roller cylinder. Sidefeeders are attached to roller cylinder two and three.

The compounder is being starve-fed using loss in weight feeders for all components. The matrix compound is fed via the main feed opening. The single screw conveys the material into roller cylinder one, where melting, homogenisation and heating to the desired melt temperature takes place. To achieve this, cylinder one is configured with and aggressive spindle design and a small diameter dispersion ring.

Carbon black is added via the Sidefeeder in cylinder two, so it meets with the before plasticised material. The cylinder is configured with a rather gentle planetary spindle and dispersion ring setup, giving room to adjust the mechanical energy input via melt temperature, ergo viscosity.

The third roller cylinder finalises the compounding task with a degassing and pressure build-up configuration since the gentle setup of the previous cylinder is prone to leave air into the compound due to low compression. To enhance the degassing performance, a vacuum pump is connected to the sidefeeder. Also, the setup targets the dispersion of residual agglomerates whilst adjusting the compound temperature and pressure for the granulation step following