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Engineering process for the injection of carbon black in suspension applied directly to the polymer to obtain pigmented acrylic fiber

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Abstract

It is defined as a acrylic fiber a polymer consisting of linear macromolecules whose chain contains at least 85 mass% acrylonitrile structural corresponding. Some acrylic fibers are spun dry and wet spun other. Acrylic fibers, in producing fabrics and yarn can be dyed in different colors according to market needs. Dyeing is applied to the fabric by different methods. These methods include direct dyeing; yarn dyeing; Part dyeing; pigment or dye solution for the polymer; Garment dyed etc. In this research we will discuss the importance of knowing the behavior of one of the pigments used for dyeing acrylic fiber black smoke named. Produce acrylic pigmented with carbon black is indeed complicated. The lack of technology to apply specific carbon black pigment resulted in the yields obtained were not optimal in terms of color quality, operability.

Pigment, dyeability, Acrylic Fiber

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Introduction

A polymer consisting of linear macromolecules whose chain contains at least 85% by mass of structural unit corresponding to acrylonitrile is defined as acrylic fiber.

The properties of the acrylic fibers recommend its use as an alternative of the wool in the field of the dress and the textiles for interiors. Among these properties we can mention the high voluminousness with warm touch similar to wool, its excellent resilience, its low density and its pleasant touch.

Some acrylic fibers are spun dry, with solvents and others wet spun. In solvent spinning, the polymers are dissolved in a suitable material, such as dimethylformamide, the extraction is done in hot air and solidified by evaporation of the solvent.

After spinning, the fibers are drawn hot three to ten times their original length, rippled, cut and marketed as short fiber or filament. In wet spinning the polymer is dissolved in a solvent, the extrusion is carried out in a coagulating bath, dried, undulating and collected as a filament to be voluminized or cut into fibers and packed.

Acrylonitrile is relatively inexpensive, but the solvents are expensive, so the spinning process is more expensive than the other synthetic fibers.

Wet Spinning

1. The polymer is dissolved in an organic solvent such as dimethylformamide to obtain a spinable solution containing 25 to 40% of the polymer.
2. The solution is filtered and heated to the boiling point and then extruded (similar to acetate rayon) through the die.
3. When leaving the holes in the die, the filaments pass through the spinning chamber in which a stream of hot air circulates (400 ° C), resulting in the evaporation of the solvent which solidifies the filaments.
4. The filaments are driven together and undergo a 10 to 3 stretch of their Long. Original, by means of the draw rolls.
5. If continuous filament yarns are required.

The filaments are lubricated, twisted and finally wound, if on the contrary the production is like short fiber, the filaments are mechanically crimped and cut. The spinning solution is pumped (by extrusion) through the die die (matrix die) which is submerged in a coagulant bath having a liquid which dissolves the solvent of the polymer, for its recovery.

The filaments obtained are stretched, the solvent is extracted by careful washing. They are then dried, stabilized, curled and finally cut into suitable lengths. In its absence the filaments are deposited in the form of tape.

Acrylic fibers, for use by the textile industry in the production of fabrics and threads, can usually be dyed in different colors according to the needs of the market. Manufacturers of acrylic fibers have seen the need to incorporate into the manufacturing process an intermediate step to be able to dye various colors and various types of dyes before finishing the fiber manufacturing process. Textile dyes including acid dyes, mainly used to dye wool, silk and nylon, which has a strong affinity for cellulose fibers. Unrelated dyes require the addition of chemicals, such as salts, to give them an affinity for the material to be dyed. These dyes are applied to the fibers of cellulose, wool or silk after having been treated with metal salts. The reactive dyes combine directly with the fiber resulting in excellent color setting. The first reactive dyes for cellulose fibers were introduced in 1950. At present there is a wide variety of them.

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Methods of dyeing

The color is applied to the fabric by different dyeing methods for the different types of fiber and in different stages of the textile production process. These methods include direct dyeing; Dyeing the threads; Piece dyeing; Pigmentation or solution for the dyeing of the polymer; Clothing dyeing etc. Of these methods of direct dyeing and dyeing of threads are the most popular.

Direct staining.

When a dye is applied directly to the fabric without the aid of a fixing agent, it is called direct dyeing. In this method the dye is either fermented (by natural dye) or chemically reduced (for synthetic dye and sulfur dyes) before it is applied.

Direct dyes, which are widely used for cotton dyeing, are water soluble and can be applied directly to the fiber of an aqueous solution. Most other types of synthetic dyes, such as vat and sulfur dyes, are also applied in this way.

Figure 1 Direct Dyeing. *Source: http://www.teonline.com/knowledge-centre/dyeing.html*

Dyeing the Threads

Dyeing of yarns is used in stock dyeing which is used to dye fibers. In this process, the staple fibers are packed in a container and then liquid dye is forced through them. Although the dye solution is pumped in large quantities, the dye cannot fully penetrate the fibers and some areas may be left untouched. However, in the following mixing and spinning processes the fibers are thoroughly blended resulting in a uniform overall color.

When the dyeing is performed after the fiber has become the yarn, it is called yarn dyeing. In this method, the dye penetrates into the fibers at the core of the yarn. There are many forms of yarn dyeing like: dyed hank, dyed package, dyeing and dyeing space.

Figure 2 Dyeing the Threads. *Source: http://www.teonline.com/knowledge-centre/dyeing.html*

Pigment dyes

Color pigments, although pigments, are not coloring in a certain sense, are widely used to color fabrics such as cotton, wool and other man-made fibers because of their excellent resistance to light. They have no affinity to the fibers and are fixed to the fabric with the help of resins. After dyeing, the fabrics are subjected to high temperatures.

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Pigmentation or solution for polymer dyeing

This is a method that is applied for the dyeing of synthetic fibers. The dye is added to the solution before it is extruded through the spinning nozzles for the manufacture of synthetic filaments. This gives a fiber apparently faded by the pigments that are used.

Figure 3 Solution for polymer dyeing. *Source: http://www.teonline.com/knowledge-centre/dyeing.html*

In this research we will talk about the importance of knowing the behavior of one of the pigments used for the dyeing of acrylic fiber of black carbon name. This pigment by its characteristics is applied in an intermediate step of the manufacturing process of wet spinning acrylic fiber.

Currently in Mexico exists a plant of acrylic fiber of wet spinning that produces among others pigmented fiber with black dye of smoke to satisfy the national and export market.

The market for pigmented fiber with carbon black is moderate and appreciated mainly by the domestic market. However the production runs of this product have been affected mainly by the behavior of the pigment in the process of preparation, preparation, storage and application of the same.

The objective of this research is to make known how they were solving the different problems derived from the behavior of the pigment causing interruptions in the production runs or batches of incomplete productions. On the other hand it is also objective to show the methodology used and that resulted in the substantial improvement of the behavior of the pigment once the correct actions were given to be able to carry out the runs without mishaps.

Problem Statement

Producing acrylic fiber pigmented with carbon black is indeed complicated considering that the design of the process of manufacturing acrylic fiber in the Mexico plant was created to produce unpigmented fiber. The incorporation of the infrastructure and / or equipment necessary to prepare, store and meter the solution of the carbon black pigment in the polymer prior to extrusion was done taking into account the experience gained from other similar and proven processes such as the dosage of Additives to give gloss or opacity to the acrylic fiber.

The lack of specific technology to apply carbon black pigment in the wet spinning resulted in that the obtained productions were not the optimal ones in terms of color quality, processability of the fiber, interruptions of runs, operability to dosage, quality of the Polymer blended with the pigment, etc. As a result of the need to raise the problem that prevented the production of pigmented fiber runs with good results of quality, productivity and operability.

Methodology

Given the lack of experience in the handling, use, preparation, storage and application of the black pigment of smoke, it was necessary to use the experience obtained in other similar additions as starting base.

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In this way, we tried to reach the best operating conditions to experience live racing tests and generate knowledge and information that allowed us to develop specifications, procedures and reengineering in facilities, equipment and vessels. Additionally as part of or complement to the methodology used, it was basically based on some tools applied in the industry such as:

- Test and Error Methodology.
- Brainstorming.
- Cause and effect analysis.

Finally, we investigated the relative technical information regarding the black carbon pigment which was very scarce since no articles or publications with results of behavior of the pigment with the acrylic polymer with wet spinning were found.

Results

The results achieved in general terms were quite satisfactory. There were very remarkable advances in some parameters and there were not very good results in other points of the product.

The achievements of the most important characteristics of acrylic fiber pigmented with carbon black as well as the carbon black solution prepared to inject the polymer prior to extrusion.

Black Smoke Preparation

The first preparations that were made had very variable results basically in two of its indicators such as humidity and filterability. This latter indicator shows the ability of the pigment to integrate with the polymer. Analyzing the causes of low filterability, several actions were taken:

- Modification of the formulation mainly in the amount of polymer as a dispersant.
- Increase in stirring speeds and grinding times in carbon black preparations
- Increasing the storage times and agitation speed in the turbomixer.

With these actions the results in filtrability improved significantly the pigment integration capacity in the polymer increased up to 100% more.

Operativity

Oerativity was essentially affected in the filtration of the solution of the carbon black preparation and in the filtration of the suspension of the polymer being both in the reduction of the life cycle of the filter elements.

Improvement of the filterability of the carbon black in the preparations resulted in an increase in the life cycle of the filter elements by up to 50% more of the typical time. Which allowed higher volumes of product per run.

Product quality

Two important quality parameters stand out from the rest in the production of pigmented acrylic fiber. These are dyeing and parching. Both are grounds for customer complaint so they were corrected as follows:

Dyeing.- To give the right tone, different dyeing tests were done with different dosing flows of the pigment to give different concentrations until finding the tone accepted by the customer. Once the flow rate of the pigment was defined with the polymer flow, the ratio of% carbon black /% polymer was established and a master flow controller was installed in the dosing to always ensure the same flow rate during the run production.

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During extrusion of the pigmented polymer, the fiber exhibited breakage of filaments. This defilamentation to some extent normal in the untanned fiber was increased in the runs of acrylic fiber pigmented with carbon black up to 200%.

The reduction of the fiber defilamentation was achieved with actions such as cleaning in the extrusion vats, uniformity in the speed of the extruder dosing pumps and the improvement in the filtrability of the carbon black in the preparation slurry.

Conclusions

The obtained results reflect correctness in the methodology used which allowed to be able to continue making runs of pigmented acrylic fiber for the customers who so requested. The tools used were the appropriate ones to solve the problems that were presented, analyzing the causes and the actions that were taken to achieve the results obtained in the quality and operability of the product.

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