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Failure analysis of a plastic modular belt in-service

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ABSTRACT

In this study, an analysis of the possible causes of the failure in-service of a section of a plastic modular belt was conducted. The study begins with a reproduction of the service conditions in a traction gear. An analysis of the fracture surfaces revealed the existence of defects in the interior of the parts. With the aim of determining the origin of the imperfections and their influence on the failure, an exhaustive mechanical and rheological characterization of the material was carried out. The development of an FE Analysis established that the reduction of the tensile strength of the part due to internal defects was around 70%. Tests also showed that the most stressed area was the area where the most defects appeared. A simulation of the injection process showed that the defects are caused by the geometry of the part, leading to the conclusion that its failure was caused by bad dimensioning of thicknesses.

1. Introduction

Plastic modular belts (Fig. 1) are widely used in industry as a means of transporting material during production processes. Their niche in the market is located between metal and belt conveyors. The main advantages of this type of system are its capacity to deal with curved trajectories, its lightness, its mechanical and chemical strength and that it is ease to repair. Because of their construction, they are especially suited to humid or saline conditions, and food and chemical industries.

These types of belts are made up of a number of links that are connected by a series of pins to form the width of the belt. This width may vary from a few centimeters to several meters, and thus, in order to achieve the desired width a number of links must be used adjacently. These links act simultaneously as handling and traction elements [1].

This study shows a real case of a fracture in-service in which the fracture occurs in one of the thickest parts of the belt while carrying a load considerably lower than that recommended by the manufacturer. The belt links are made of an acetal copolymer, a material that has not been analyzed before in belt conveyors. There are several studies focused on other materials. Vaxman et al. [2], for example, worked on the void formation in thermoplastic composites; as well as Francis et al. [3], but they studied the failure analysis of a clamp hanger. Lewis [4] found that a premature fracture of a composite nylon radiator was caused by a bad quality control during injection molding, rather than being a design fault. Other authors analyzed the failures of different parts made of PVC [5], HDPE [6] and aluminum alloys [7]. All these studies follow a specific methodology that is going to be used in the present work as well.

The aim of the study is to determine the cause of the failure, if it was due to an inappropriate use of the belt, the material used in its manufacture, the manufacturing process used or the belt link design.

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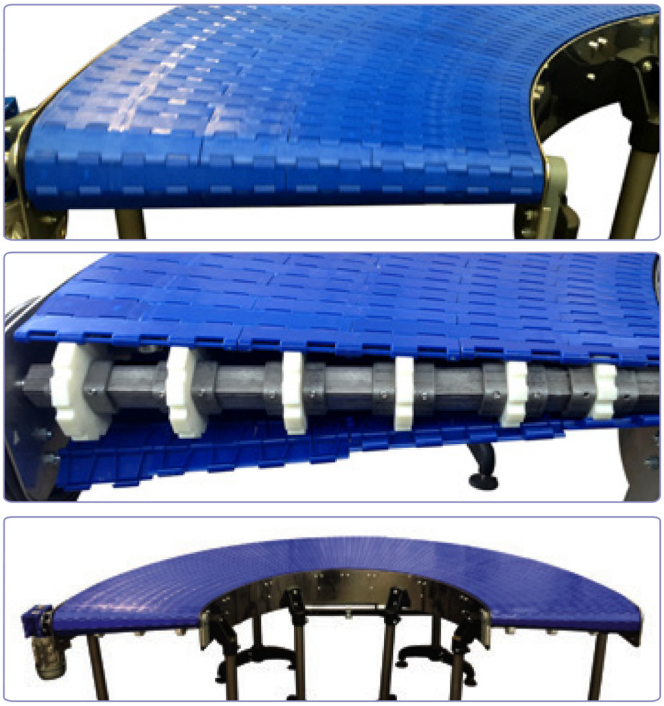

Fig. 1. Plastic modular belt.

2. Material and methods

In order to establish the cause of failure, different tensile tests were carried out on the links of the modular belt. Following this, the tests results and the fracture surfaces were analyzed. Finally, a mechanical and rheological characterization of the material was performed with the aim of establishing the influence that the material properties and the processing techniques have on the tensile strength of the belt links.

2.1. Belt link tensile test

The first step in this study was to test the links' tensile strength. For that purpose, two clamps were designed in order set up the belt link in the same way as in on duty conditions. The tests were carried out at a speed of 1.2 mm/s. The Data Acquisition System was composed of an MGCPLUS® (Hottinger Baldwin Messtechnik GmbH, Darmstadt,Germany) as DAS hardware, a 100 kN U3 load cell of the same brand, and a displacement transducer WS1.1-750-R1K-L10 (ASM GmbHb, Moosinning Germany). The time, force and movement data were acquired at a speed of 10 Hz. Fig. 2 shows one test in the tensile test machine.

2.2. Visual inspection

After the belt link tests, pictures of the fracture surfaces were obtained using a OLYMPUS SZX7 stereo microscope with a OLYMPUS C-5060 Wide Zoom Camera, lighted with a OLYMPUS KL 1500 HL halogen light.

2.3. Material tensile analysis

In order to carry out a later Finite Element Analysis to quantify the loss of tensile strength of the part due to imperfections, a characterization of the material was done beforehand. The material used in the manufacture of the belt link was YUNCON® M90 (YunNan YunTianHua CO., YunNan ShuiFu, China), an Acetal (POM) Copolymer. Following the manufacturer's instructions, pellets were first dried in a dehumidifier MDEU1/10 (Industrial y Comercial Marse S.L., Barcelona Spain) at a temperature of 90 °C for 4 h and the mold was tempered at a temperature of 70 °C. Finally, a series of specimens was injected at 200/200/180/170 °C according to temperatures indicated by the manufacturer. After the injection process, tensile tests were carried out on the specimens using a universal ELIB 30 tensile test machine supplied by S.A.E. Ibertest® (Madrid, Spain) following the guidelines of ISO 527, at a temperature of 25 °C, with a relative humidity of 50% and with a 5 kN load cell.