Influence of Vulcanization Process Parameters on the Physio-Mechanical Properties of Textile Materials Used for the Reinforcement of Rubber Goods

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ABSTRACT

Conveyor belts are mechanical rubber goods used to transport raw materials and finished products from one location to another in various manufacturing, mining, and logistics sectors. The demand for lightweight materials with high mechanical properties and affordable conveyor belt costs accelerated the use of textiles as reinforcement material for conveyor belts. In recent years, woven fabrics produced from synthetic yarns have been widely used to reinforce the conveyor belt because of their flexibility, lightweightiness, good mechanical property, and cost-effectiveness.

However, the presence of materials with distinct properties in the textile-reinforced conveyor belt's structure has created complexity in adhering the components together, determining the influence of processing parameters on the mechanical property of the belt, and achieving the necessary properties of the belt. In order to adhere the rubber with textiles, the woven fabrics were impregnated with Resorcinol Formaldehyde Latex adhesive solution, and the reinforcement was subjected to a vulcanization process. The vulcanization temperature is carried out at a high temperature under pressure depending on the type of fabric, rubber, and conveyor belt being produced.

Therefore, during the vulcanization process, woven fabrics are susceptible to high temperatures for a specific duration depending on the conveyor belt type, which leads to physio-mechanical property changes in the textile materials. Nevertheless, the change that can occur in fabrics' properties during vulcanization was never scientifically analyzed. Therefore, this thesis aimed to investigate the effect of vulcanization parameters on the mechanical and physical properties of conveyor belts, woven fabrics, and yarns used to reinforce mechanical rubber goods. Additionally, the optimum vulcanization parameter was aimed to be identified based on the investigations.

In order to achieve the goal of the thesis, the research was conducted on high-tenacity polyester yarns, polyester-polyamide woven fabrics (EP), and textile-reinforced conveyor belts. The yarn and woven fabric samples were subjected to different thermal aging with various aging duration.

The thermal aging parameters used for aging yarn and woven fabric samples were designated based on the fiber's glass transition temperature and melting temperature. Furthermore, the physio-mechanical properties of yarns, woven fabrics, and conveyor belts at various levels were investigated with a focus on the tensile properties of these materials at different stages.

The tensile, shrinkage, thermal stability, and micro-structural property analyses were conducted on the high-tenacity polyester yarn of different linear densities with the objective of analyzing the effect of temperature on the property of the yarn. Following that, a tensile property investigation was carried out on woven fabrics at the greige and dipped level pre-and post-thermal aging.

The experiments conducted on the yarns and fabrics showed that the tensile strength was significantly diminished when the yarn and fabric samples were subjected to thermal aging at a high temperature (220 °C) for thirty-five minutes. In contrast, the yarn and fabric samples' elongation were incremented with the increase in aging temperature regardless of the duration of aging. Therefore, determining vulcanization parameters that yield optimum tensile strength and elongation of the conveyor belt was compulsory for the effective functioning of the belt.

Based on the experimental results obtained from the yarns and fabrics, the vulcanization parameters were designated, and three layers of textile-reinforced conveyor belts were produced under the designated parameters. In addition, the tensile property and adhesive strength of the conveyor belt samples were investigated to determine the optimum vulcanization parameters of the belt. Based on the works carried out, a vulcanization temperature of 160 °C and a vulcanization duration of thirty-five minutes were found to be the optimum parameters to vulcanize three layers of EP 200 fabric-reinforced conveyor belts.

In general, this work contributed to the science on determining the influence of vulcanization parameters on the carcass of textile-reinforced conveyor belts. The work concluded that the vulcanization temperature and duration of vulcanization have an immense influence on the tensile strength and elongation property of the textile-reinforced conveyor belts. Vulcanizing the EP fabric reinforced conveyor belt at a high temperature (≥ 220 °C) for a longer duration (≥ 35 min) yields a lower tensile strength of the belt and increments the elongation of the belt, which can affect the proper functioning and lifespan of the conveyor belt. Moreover, the glass transition and the melting temperature of fibers in the fabric composition need to be considered to design the vulcanization parameters of textile-reinforced conveyor belts.

The experimental tests were carried out in cooperation with Sempertrans Bełchatów Ltd. Company, and the results obtained from this work was resulted in the introduction of an optimal production process for this company.