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## **Review report on Doctoral Dissertation**

of **Tsegaye Shume Lemmi**

entitled „**INFLUENCE OF VULCANIZATION PROCESS PARAMETERS ON THE PHYSIO-MECHANICAL PROPERTIES OF TEXTILE MATERIALS USED FOR THE REINFORCEMENT OF RUBBER GOODS**“

(scientific supervisor Prof. Dr. Hab.Eng. Marcin Barburski)

prepared based on the invitation in accordance with Resolution no. 38/5/I/K/2023 of the Council for Academic Degrees dated May 12, 2023

The review was performed on the basis of the Doctoral Dissertation in English. The doctoral dissertation consists of an introduction and six chapters, including overview of the state-of-the-art related to the Dissertation topic, presentation of materials used in the research, implemented methodology, presentation of scientific experimental results, in-depth analysis of the results, conclusion and recommendations, and a list of references. In addition, an abstract in English and Polish languages, acknowledgement a list of papers published by the author, conferences attended, a list of abbreviations, and a short Curriculum Vitae are included. The doctoral dissertation contains 115 pages, 67 figures, and 7 tables.

The first chapter “Introduction” presents the research problem, the aim and objectives of the dissertation, justification of the choice of the research study, hypothesis, and description of the structure of the dissertation.

The second chapter “Literature Review” presents an overview of the current state of the problem and a review of the scientific literature. It includes basic information about construction and categories of conveyor belts, textile reinforced conveyor belts, structure and properties of yarns and woven fabrics used for conveyor belts, requirements and processes used in manufacturing of textile reinforced conveyor belts, and conveyor belts’ application areas. At the end of the chapter, short summary of the performed review is presented. The Literature Review is based on 111 literature sources, 60% of which are scientific papers published during the last 10 years.

In the third chapter “Materials”, high tenacity polyester yarns (5 variants), woven fabrics (4 variants) and styrene butadiene rubber, used in the research work, are presented.

In the fourth chapter “Methodology”, there are presented Experimental design from the yarn to conveyor belt, methodologies of thermal aging of polyester yarns and woven fabrics (at different temperatures and durations), and model and vulcanization parameters of the textile-reinforced conveyor belts.

In the fifth chapter “Experimental tests”, methods and equipment used to perform experimental tests are presented and illustrated by images. However, not for all tests standardized methods were used (or the description of the test is not followed by standards). Also, very important subchapter about statistical analysis is missing in the Dissertation.

In the sixth chapter "Results and Discussion", experimental tests and obtained results are clearly and in detail presented. Figures, and tables are correct and support the analysis of the findings. Obtained results are commented, explained and compared with results obtained by other researchers.

In Conclusions, the main findings and summarizing statements as well as recommendations for the future work are presented. Direct and precise answers to the Dissertation objectives would be preferred in this part.

In the list of references, 135 sources are presented, more than 50% of which are scientific papers, published during the last 10 years. However, 2 of them are articles published by the author of the Dissertation and based on the results presented in the Dissertation.

In the dissertation, the author has analysed the demand for textile-reinforced conveyor belts, their structure and influence of vulcanization process parameters, such as vulcanization temperature and duration, on the carcass of the properties of textile-reinforced conveyor belts. The topic is very important and relevant as the conveyor belts must be high-quality to fulfil market demand. Even more, the experimental work was carried out in cooperation with industrial company Sempertrans Bełchatów Ltd. Presented doctoral research aimed to investigate the influence of vulcanization process parameters on the mechanical and physical properties of yarns and woven fabrics used to reinforce conveyor belts, and to narrow the knowledge gap in the area. The determination of thermal aging and duration of the aging on physical and mechanical properties of industrial polyester yarns and woven fabrics as well as on physical and mechanical properties of the textile-reinforced conveyor belts during the process of vulcanization, the analysis of the effect of Resorcinol-Formaldehyde-Latex adhesive on the mechanical properties of industrial woven fabrics as well as the influence of vulcanization parameters on the adhesion of conveyor belt components and optimization of vulcanization parameters and improving the quality and process for the textile-reinforced conveyor belt was implemented in the research work. The dissertation fully corresponds to the problems of the field of materials engineering. The is finished scientific work presenting original results, it has clear and logic description and meets requirements of doctoral dissertations. Conclusions are based on the research results. Results of the scientific research are published in four articles in scientific journals with IF from the list of CA WoS and in three international conferences.

#### Questions and remarks:

- It is not recommended to divide a chapter into smaller parts if there is only one subchapter (2.2 Chapter has only one subchapter – 2.2.1, which volume is only 1 page; the volume of 2.2 chapter also is only 3 pages). Subchapter 2.6.7 and chapter 2.9 are extremely short – only 1 sentence. In my opinion, such short chapters may be combined together or there can be presented more information related to the sub-topic.
- Abbreviations of the most often used definitions are presented at the beginning of the Dissertation, however, these abbreviations are randomly used in the text.
- Division of polyester yarns into two groups: "apparel-grade yarns" and "industrial-grade yarns" is a bit confusing, as apparel manufacturing also is "industrial". Probably it would be clearer to name these yarns as "technical yarns".
- In the experimental part, it should be specified which SEM working mode (high, low, or lowest vacuum) was used to investigate PET yarns.
- *What statistical analysis methods were used for the analysis and evaluation of the obtained results? How many elementary tests were performed to get one experimental point?*

- How much the used twist of polyester yarns (of higher linear density) may influence braking characteristics of the yarn?
- Why did you decide to "skip" one variant of the thermal aging temperature (200 °C), which was used for PET yarns?
- Why for the high tenacity PET yarns shrinkage test the temperature of 177.7 °C was used (it was not used in another experiments and therefore this decision should be explained in the experimental part)?
- In Page 65, it is mentioned that for samples of PET yarns aged for 12 min at 200 °C "only on average  $\pm 0.55$  cN/tex tenacity loss was registered in comparison to the unaged yarn', but from the Figure 42 it is visible that this change is up to 5 cN/tex, depending on the linear density.
- It is not explained, why results of PET yarns aging for 12 min and 35 min at 220 °C are presented only for linear densities of 110 tex and 660 tex.
- Elongation at break of PET yarns dipped in adhesive chemicals and undergone weaving process significantly increased when compared to the initial property of PET yarns. *Is this positive or negative change for yarns which are used for textile-based conveyor belts?*
- How can you explain that correlation of adhesion strength between different plies of the conveyor belt after 6 min and 35 min duration of vulcanization is absolutely different (Figures 63 - 64)?
- In conclusions, some statements are taken not from the research work (for instance, "High conveyor belt elongation leads to power fluctuation on the drive-sharing rollers, causes burning out of the driving motor, and reduces the service life of the belt". Also, use of abbreviations in conclusions is not recommended.
- Determination of the conveyor belt properties (especially of elongation) changes after cyclic deformation or fatigue tests and long-lasting relaxation, depending on the vulcanization parameters, would help to increase the importance of this research work even more, as these are important factors on conveyor belt quality.

**Conclusion:** The presented dissertation makes a significant contribution to the development of the scientific discipline of materials engineering at the same time, fulfils all formal requirements set forth in Article 187 of the Law on Higher Education and Science dated July 20, 2018, and conforms to principles and requests to the structure of scientific research for the degree of doctor. In my opinion, the Dissertation submitted by Tsegaye Shume Lemmi is ready to be defended orally in front of the respective committee. Therefore, I recommend the Dissertation for the next procedure at the Lodz University of Technology. In case of positive results of the defense of the Dissertation, I recommend awarding T. S. Lemmi the title of Ph.D.

*Daiva Mikėlionienė* 