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Y. Myhovych, S. Klymenko, I. Karpovych, O. Hurko

ADVANCES IN EFFECTIVE TENSION CONTROL AND OPTIMIZATION TECHNIQUES IN FILAMENT WINDING OF POLYMER COMPOSITE MATERIALS

Effective tension control in the process of filament winding of axisymmetric products made of polymer composite materials plays a key role in ensuring not only the quality but also the strength and stability properties of the final product. This process poses a complex engineering challenge, as it requires precise control of fiber tension during winding, taking into account various factors such as material type, winding speed, product geometry, and more.

An overview of existing methods for controlling fiber tension encompasses a wide range of approaches, from traditional mechanical systems with manual control to modern automated systems that utilize advanced technologies such as computer vision systems, tension sensors, and artificial intelligence algorithms for automatic regulation [1, p. 535].

The application of modern control technologies and algorithms opens up new possibilities for optimizing the filament winding process. For example, [2, p. 119] the use of machine learning systems allows for the adaptation of control parameters in real-time, considering the variable production conditions and properties of the materials used.

Optimization of fiber tension control methods involves searching for the most effective and accurate solutions that will ensure optimal preservation of fiber structural characteristics and minimize potential defects in the final product [3, p. 596].

The most popular real-life examples of equipment for automating fiber tension control include integrated control systems from leading equipment manufacturers in the production of composite materials, such as "Siemens," "ABB," "KUKA," and others, which utilize cutting-edge technologies to ensure the highest quality and productivity of the winding process [4, p. 102].

In conclusion, the research has demonstrated significant potential for improving filament winding processes of polymer composite materials through the utilization of advanced control and optimization technologies. Moving forward, emphasis should be placed on the development of innovative materials and their interaction with winding processes to achieve further progress. These avenues of development have the potential to pave the way for the creation of new high-performance products for various industries.

The prospects for continued exploration of advanced control technologies, such as artificial intelligence and machine learning, hold promise for further enhancing filament winding processes. Additionally, innovations in materials science and engineering will play a crucial role in driving future advancements. Together, these developments are poised to revolutionize the production of polymer composite materials, offering new possibilities for high-performance products across various industries.

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