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Opportunities and challenges on composite pressure vessels (CPVs) from advanced filament winding machinery: A short communication

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ABSTRACT

This short communication article critically reviews the modern trends in advanced filament winding machinery and filament wound composite pressure vessels (CPVs) and their potential applications. Firstly, it explores the historical development and advancements in filament winding machinery, which is essential to understand and assess the future state-of-the-art filament winding technique. Secondly, the classification of CPVs is further elucidated concentrating on composition, operating pressure, liner material, and load-bearing capability. It is classified that Type I, II, III, IV, and V of CPVs have been introduced and developed from all-metal to all-composite construction, which significantly reduces the weight of 75% to all-metallic pressure vessels. Thirdly, commercial and potential applications of CPVs have been introduced. Finally, this article provides an outlook on opportunities and challenges of advanced filament winding machinery and CPVs, which gains new insights into integrated design, manufacturing, and performance evaluation on CPVs with artificial intelligence (AI), digitalization, and visualization techniques.

1. State-of-the-art filament winding machinery

The filament winding process is a well-known and one of the traditional composite fabrication methods to manufacture filament-wound composite products in mass production [1]. Fiber strands/filaments are continuously wound on the mandrel in the winding process, which is generally used for symmetric components, such as high-pressure vessels, rocket engine cases, launch tubes, fishing rods, and shafts [2,3]. Filament winding has three winding patterns: hoop, helical, and polar winding, which provide a considerable and optimizable fabrication method [4]. Moreover, filament winding can wind the different types of fibers (e.g., carbon, glass, aramid, etc.) with the resin system to strengthen the filament-wound structural performance. The manufacturing capability of the filament winding technique mainly depends on the degree of freedom (axis) of the filament winding machinery [5]. In addition, filament-wound composite structures have the potential for ideal wide-ranging applications due to outstanding energy-absorbing characteristics and strength performance [6].

It was announced that the first computer-controlled winding machinery was developed in the early 1980s and collaborated with Bosch, Fanuc, NUM, and Siemens companies. In the 1990s, the electronic control system was developed for filament winding machines with different motions, which accurately performed position and speed. The computerized numerical control system is developed to control the fiber trajectory precisely. Therefore, traditional winding machinery has developed with different axes (2–6 axes motion) and machinery design

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