Mechanical Engineering Thesis Defense

Development and Evaluation of a Laboratory Water Pump Digital Twin Simulationfor Enhanced Learning

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Abstract

Expedited by the ongoing effects of the Covid-19 pandemic and the expanding portfolio of Arizona State University's online degree programs, this study undertakes the task of enriching the “Experimental Mechanical Engineering” course within ASU's online Bachelor of Mechanical Engineering curriculum. This thesis outlines the development of simulations accurately mirroring the characteristics and functionalities of water pump laboratory experiments, which previously necessitated on-site, group-based participation. The goal is for these simulations to serve as digital twins of the original equipment, allowing students to examine fundamental mechanical principles like the Bernoulli equation and Affinity Laws in a virtual, yet realistic setting. Furthermore, the simulations are designed to accommodate uncertainty calculations, replicating the instrument error inherent in the original water pump units. The methodology of this simulation design predominantly involves the use of MATLAB SimScape, chosen for its configurability and simplicity, with modifications made to match the original experiment data. Then, subsequent analysis of results between the simulation and experiment is conducted to facilitate the validation process. After executing the full laboratory procedure using the simulations, they display rapid operation and produce results that remained within boundaries of experimental uncertainty. Although they faces several challenges, such as the inability to simulate the pump cavitation effect and the lack of animation, potential solutions and extensions are also discussed to improve simulation precision and validation.

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