Investigating Hydraulic Equipment Disassembly and Assembly Practice in Education through AMESim Virtual Simulation

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Abstract: Hydraulic equipment disassembly and assembly stand as pivotal practical components within the realm of marine engineering. This educational segment pertains to the dismantling and reassembly training focused on typical hydraulic pumps, motors, and control valve components present in deck machinery and specialized operational equipment. Currently, students are limited to static learning environments where they acquire foundational knowledge regarding disassembly and assembly methods, working principles, and structural composition of hydraulic equipment. Regrettably, opportunities for performance parameter testing and dynamic characteristic analysis are absent. To counter this educational gap, a novel practical teaching paradigm based on AMESim virtual simulation appears. This innovative model integrates a virtual simulation platform into physical teaching sessions, empowering students to autonomously construct simulation systems and delve into the analysis of equipment's dynamic characteristics through hydraulic simulation circuits. This pioneering practical teaching approach not only enriches the educational spectrum regarding hydraulic equipment disassembly and assembly but also elevates students' overall proficiency in hydraulic practical skills.

Keywords: Hydraulic Equipment; Disassembly and Assembly Practice; AMESim; Virtual Simulation; Teaching Model

1. Introduction

In the maritime industry, hydraulic transmission systems, with their advantages of high power-to-weight ratios, ease of overload protection, and convenient control, have found widespread application due to their exceptional performance[1-5]. To enhance the operational and maintenance skills of marine engineering students in the field of ship hydraulic systems, the significance of hydraulic technology-related teaching content in the curriculum has been steadily increasing. Among these components, *Hydraulic Equipment Disassembly and Assembly* stands out as a crucial practical course within marine engineering. However, in traditional teaching models, students are limited to understanding and mastering the working principles, structural composition, and disassembly and assembly techniques of hydraulic equipment and components. They lack the opportunity to delve deeper into performance parameter testing and dynamic characteristic analysis, aspects crucial for students to acquire the technical skills necessary for prospective job applications.

Amid the rapid evolution of technology, certain scholars have ingeniously integrated virtual simulation technology into practical education, effectively compensating for the deficiencies of traditional hands-on teaching methods and significantly enhancing the pedagogical outcomes of practical learning sessions. Researchers like Luo Yi and colleagues have devised a novel blended teaching approach for virtual simulation laboratory instruction. By structuring activities across pre-class, in-class, and post-class phases, they have successfully cultivated a cutting-edge model that amalgamates online and offline components, thereby notably augmenting the overall quality of experimental teaching [6]. Furthermore, Wang Dongcheng and his team have revolutionized hydraulic and pneumatic experimental education by incorporating CATIA and AMESim virtual simulation software. This inclusion has revolutionized the learning experience, offering students immediate access to dynamic learning environments and enabling a diverse array of hydraulic virtual simulation experiments[7]. In a similar vein, Yang Xiuping and associates have broadened the educational landscape by developing virtual simulation experiments using AMESim and Automation Studio software. This initiative not only enriches the breadth of experimental teaching resources and instructional formats but also synergistically complements the strengths of physical experiments through mutual validation[8]. Finally, the pioneering work of Han Guangdong and colleagues in integrating AMESim simulation software into valve and crane instructional contexts has yielded multifaceted benefits. Beyond expanding students' proficiency in software application, this innovative approach serves to cultivate essential practical hydraulic skills, thereby equipping learners with a comprehensive skill set essential for navigating modern technological landscapes [9-10].

Building upon traditional physical disassembly and assembly classroom instruction, this study introduces the AMESim simulation platform into the hydraulic equipment and component performance testing phase. By engaging students in hands-on creation of hydraulic simulation circuits and analyzing relevant performance parameter curves, the initiative seeks to deepen understanding of the varying parameters and dynamic characteristics of hydraulic equipment and components.

2. Practical Teaching of Hydraulic Disassembly and Assembly

The practical teaching of hydraulic disassembly and assembly is typically confined to imparting knowledge of the working principles, structural composition, and disassembly methods of hydraulic equipment and components within the limitations of static teaching apparatus that lack dynamic testing conditions. In response to this constraint, the integration of the AMESim simulation platform into both classroom and post-class learning activities allows students to delve further into understanding the performance of hydraulic equipment and components in operational states through hydraulic simulation circuits.

AMESim, developed by the German company Siemens, stands as a multidisciplinary modeling and simulation platform, enabling users to construct intricate system simulation models spanning various disciplines and study the steady-state and dynamic performance of any component or system[11-12]. Concurrently, AMESim incorporates a plethora of component libraries, including the hydraulic library (comprising pipeline models), hydraulic component design library (HCD), power transmission library, electromagnetic library, among others. These diverse library components within AMESim find practical application in hydraulic equipment and component teaching, facilitating the visualization of performance parameters through intuitive graphical representations.

3. Teaching Methodology

Within the realm of virtual hydraulic disassembly and assembly education facilitated by AMESim, a myriad of knowledge points are explored, covering various types of hydraulic equipment and components. This study will elucidate the teaching methodology using the axial piston pump as an illustrative example.

3.1 Educational objectives

Building upon the classroom instruction concerning axial piston pumps and leveraging the AMESim simulation software, students will construct a hydraulic test circuit centered around the axial piston pump. This approach allows students to delve deeper into understanding the flow and pressure variations of the axial piston pump under varying load pressures, complementing their grasp of the pump's structure and disassembly techniques. The physical embodiment of an axial piston pump is depicted in Figure 1.

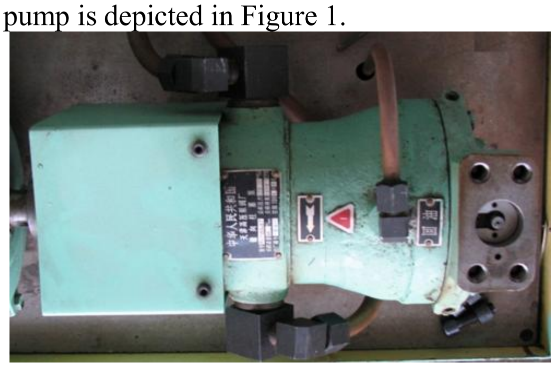

Figure 1. Physical Representation of an Axial Piston Pump

3.2 Implementation Process

Review: Before students engage in hands-on disassembly and assembly of the axial piston pump, a review session on the relevant principles is conducted to prepare them for constructing the simulated hydraulic circuit.

Introduction: Integrating discussions on the simulation software into the classroom practical instruction, students merge their knowledge of the AMESim software with the practical insights gained. They propose design concepts for the hydraulic test circuit of the axial piston pump, engage in discussions with the teacher, and are guided in building the simulation system.

Instruction: By contrasting various design approaches and adhering to a consensus between teachers and students, the final design scheme for the test circuit is formulated. This scheme is depicted in Figure 2.

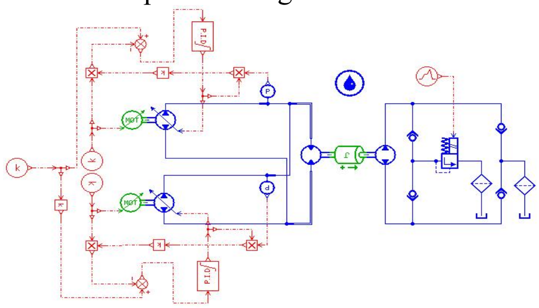

Figure 2. Hydraulic Test Simulation Circuit for the Axial Piston Pump

An elaborate elucidation on the utilization of the AMESim software encompasses the selection of individual components and the configuration of critical coefficients. Through the employment of the AMESim software, demonstrations are conducted on constructing the simulation circuit and analyzing the flow-pressure characteristics. The accuracy of the hydraulic circuit is tested post-demonstration. Following the demonstration, students are tasked with hands-on construction of the simulated circuit illustrated in Figure 2. This hands-on experience not only equips students with adeptness in software operation but also provides insights into the composition and principles of hydraulic test circuits. Throughout the simulation testing process, students manipulate various parameters, such as the rotational speed of the axial piston pump and the loading pressure of the electromagnetic relief valve. By doing so, they attain flow and pressure characteristic curves of the axial piston pump under diverse operating conditions and engage in the analysis of dynamic properties.

Self-Study After Class: Following the classroom instruction on the disassembly and assembly of axial piston pumps, the construction of hydraulic test circuits for axial piston pumps using AMESim simulation software, the derivation of flow-pressure characteristic curves for axial piston pumps through simulation calculations, and the hands-on construction of simulation systems by students, a deeper understanding of the dynamic characteristics of axial piston pumps under varying conditions is cultivated. Building upon the foundation laid in class, students can further enhance their comprehensive grasp of the dynamic properties of various hydraulic equipment and components through post-class adjustments to hydraulic circuits and elements.

Reflections on Learning: Prior to the commencement of the next session, a selection of students will be randomly chosen to share their reflections on the hybrid teaching method combining physical and virtual experiences. They will express their adaptability to this approach, the extent to which it aids in the learning of hydraulic disassembly and assembly, and other related aspects. Through the students' narratives, the effectiveness of integrating physical instruction with virtual experiments is affirmed. This method enables students to better grasp the knowledge of hydraulic disassembly and assembly while fostering interest in practical hydraulic learning. This case serves as a foundation for the enhancement of future teaching methodologies.

4. Practical Application

Guided by the formulated hydraulic testing scheme for axial piston pumps, students will engage in the hands-on construction of simulated circuits. This exercise involves the selection of suitable components, hydraulic pipelines, fittings, and control switches, fostering familiarity with the software and nurturing hydraulic modeling proficiency. Through this practical endeavor, students gain a nuanced comprehension of knowledge pertaining to hydraulic equipment and component testing.

Within the simulated circuit, students will undertake parameter modifications, encompassing adjustments to the axial piston pump's rotational speed, the loading pressure of the electromagnetic relief valve, and the resistance within hydraulic pipelines, among other variables. By altering simulation timeframes and step sizes, a spectrum of simulation results will emerge, including pressure fluctuation curves at the pump's inlet and outlet, flow variations, volumetric efficiency changes, and power dynamics. Through a meticulous analysis of these simulation outcomes, students can delve deeper into the dynamic attributes of axial piston pumps under varying operational scenarios, thereby enriching their understanding of the subject matter.

5. Conclusion

By integrating physical classroom instruction with AMESim simulations, the diversity and depth of hydraulic dismantling and assembly teaching have been enriched, offering valuable insights for future instructional enhancements. The utilization of the AMESim software to construct simulation testing circuits facilitates a comprehensive understanding of hydraulic testing circuit composition and principles among students, enabling the transformation of statically discussed hydraulic equipment in the curriculum into dynamically testable hydraulic virtual circuits. Through the analysis of simulation results, students can gain a heightened awareness of the dynamic characteristics of hydraulic equipment and components under varying operational conditions. In summary, this teaching approach not only boosts student engagement and enthusiasm for learning but also cultivates their proficiency in software comprehension and utilization, laying a robust foundation for their future academic and professional endeavors.

Acknowledgment

This work was financially supported by the Undergraduate Teaching Reform Project of Dalian Maritime University in 2022, titled "Exploration and Research on the 'Previewing-Teaching-Reviewing-Training' Teaching Model under the Background of Engineering Education Accreditation—A Case Study of 'Comprehensive Training of Auxiliary Machinery'".

The Talent Cultivation Project for Virtual Simulation Teaching Program Construction at Dalian Maritime University (Project Number: YS20226993850).

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