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DEVELOPMENT APPROACH TOWARDS THE IN-HOUSE DESIGN, MANUFACTURING, AND TESTING OF AN E-PUMP FOR A STUDENT-LED LIQUID FUELLED REUSABLE SOUNDING ROCKET.

Abstract

Over the course of two years, Delft Aerospace Rocket Engineering's (DARE) turbomachinery department has worked on the development, manufacturing, and testing of a novel cost-effective electric-powered pump. The custom e-pump is sized to be integrated with the team's flagship 10kN liquid-fueled engine "Firebolt", powered by ethanol and cryogenic oxygen. Given the complexity and novelty of e-pump design, especially within the resource constraints of student-teams, the development approach had to be redefined from the ground up. A few key organizational challenges make this pump development project intrinsically different from current industry ones, requiring the process to be reconsidered within the domain of student-teams. This paper highlights the strategy and critical steps needed to tackle the complexity of rocketry turbomachines at a student level. This implies being heavily constrained by the lack of practical and theoretical experience joint with a limited budget, and no access to high-end machining and industrial facilities. Within these constraints, the turbomachinery department has designed, reviewed, and manufactured an ethanol e-pump to validate the presented formalized design approach. Following a thorough systems engineering approach, functional requirements for the system were determined based on the Firebolt engine specifications. With a required pressure rise of around 25 bar, the hydraulic components were modelled assisted by CFD and surface modelling software tools. A radial closed impeller and a single-stage, single-outlet volute were custom designed and additively manufactured out of titanium through industry partnerships. The hydraulic components were then machined and post-processed by DARE to be prepared for integration. The mechanical sealing solution was fully custom designed, primarily trying to balance the limitations of available machining equipment and the tight tolerances dictated by the high required performance metrics. With an impeller diameter below 10 cm, and a shaft power and rotational speed of around 10 kW and 30,000 RPM respectively, sealing the high-pressure flammable working fluid required a lengthy development process. Except for the ceramic seal contact rings, the final sealing solution and bulkheads were machined entirely in-house. With a completed and manufactured e-pump, the test setup and procedures are then drafted. These are then used to begin testing and validating the system's performance together with its formalized development strategy. The team has hence successfully designed, manufactured and assembled one of the world's first high-power student-built e-pumps paving the way for the technology to be adopted at a student-team level.