Design and Development of an Automated Venturi-Based Foam Fire Suppression System for Oil Storage Applications

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Abstract

Oil storage tank fires pose significant industrial hazards, requiring rapid and effective suppression. This study presents the design and validation of an automated foam fire suppression system tailored for hydrocarbon-based Class B fires. The system features a Venturi-based proportioning unit, custom foam nozzle, centrifugal pump, and Arduino-controlled automation with thermal imaging for early detection and activation. Designed per NFPA 11 and 20 standards, the system delivers a foam flow density of 20.4 lpm/m² for a scaled 1,000-liter tank. Hydraulic design used the Hazen-Williams equation and Bernoulli's principle, while CFD optimized mixing and spray coverage. FEA confirmed nozzle durability in PA6 and stainless steel. Achieving 50 lpm flow at 2.75 bar and a 5.5% foam induction ratio, the system ensured fast, autonomous response with minimal foam wastage. The solution is scalable, efficient, and ideal for high-risk sectors like oil, gas, and power.

Keywords

Fire suppression, venturi injector, Arduino automation, Oil tank fire safety, Eco-friendly foam systems.