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Topology optimization of cryogenic heat transfer in stressed rods for large liquid hydrogen tanks

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The heat leakage of cryogenic equipment is primarily attributed to multilayer insulation and solid heat conduction at a macroscopic level. However, there has been limited research on optimizing solid heat transfer. Traditionally, the design criterion for materials subjected to cryogenic temperatures has been based on their yield strength or ultimate tensile strength at room temperature due to considerations for room temperature loading. In reality, the strength of materials generally increases at cryogenic temperatures. Additionally, thermal conductivity at cryogenic temperatures can be several times or even orders of magnitude smaller than that at room temperatures. This provides ample opportunities for optimizing heat transfer in applications with cryogenic temperature loading, such as large-scale liquid hydrogen storage tanks. Based on the topology optimization algorithm, this paper optimizes rods with different temperatures, forces and materials and obtains the minimum heat transfer profile while meeting strength requirements. The applicable scope of topological optimization in stressed rods at cryogenic temperature is also analyzed. This research is of great significance for optimizing heavy-duty structural components at cryogenic temperatures.

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