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Structural optimization of the manned pressure hull of a deep manned submersible based on a new safety standard

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Summary

The most critical component of a deep manned submersible is the manned pressure hull. It provides not only a safe living space for pilots and scientists but also provides a proper working condition for non-pressure-resisting and non-water-repellent equipments. At the same time, the weight of the pressure hull occupies a large part of the total weight of the deep manned submersible. So the pressure hull should be designed to have enough strength, water-tightness and as light as possible. As the most commonly used pressure hull type, spherical pressure hull has been used in all the existing deep manned submersibles such as Alvin of USA, Nautile of France, MIR I&II, RUS and Consul of Russia, Shinkai6500 of Japan and Jiaolong of China.

Facing the requirement of designing a new 4500m manned submersible, we have carried out a comparative study on the current available design rules from various classification societies. According to this comparison, significantly different results among these design rules have been found and many existing spherical pressure hulls are found not to be in compliance with most of the current design rules.

Based on a systematic FEM study on the effects of various parameters on the ultimate strength of spherical shells under external pressure, a new safety standard for the design of spherical pressure hull of deep manned submersibles is proposed. In this paper, the new safety standard is first introduced and then a structural optimization of the titanium alloy spherical pressure hull of a 4500m deep manned submersible is performed based on the new safety standard. Finally, the optimal solution is presented.