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Effect of Heat Treatment on Anisotropic Tensile Behavior of CLAM Steel Fabricated by Additive Manufacturing

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Fusion reactor blanket needs to withstand the 14.06 MeV high energy neutron irradiation, high heat flux, high nuclear thermal deposition and complex electromagnetic and mechanical loading and so on, which put forward a high requirement for the structural materials and the quality of components manufacturing. Reduced-activation ferritic/martensitic (RAFM) steel has been developed as the structure materials for future fusion reactors due to its excellent thermophysical and mechanical properties. China low activation martensitic (CLAM) steel, a kind of RAFM steel, has been chosen as the primary structure material of China ITER TBM and China fusion engineering test reactor (CFETR) blanket. In the harsh service environment of fusion reactor, the blanket is generally designed with high density and complex embedded cooling channels, which is a challenge to the traditional manufacturing technology.
Additive manufacturing (also named 3D printing) is an advanced precision manufacturing technology, which can be used to manufacture the parts that are difficult for traditional methods. It has the advantages of near net forming, high forming efficiency of complex structural components and good integrated. It is a new exploration to apply the additive manufacturing technology to the complex structure manufacturing of fusion reactor blanket, which is of great significance to the development of the preparation technology of the components with complex structures. The mechanical properties of the parts, which were fabricated layer by layer with additive manufacturing, are anisotropic in the directions of the parallel layers direction and the vertical layers direction. Therefore, it is important to research the anisotropic mechanical behavior of CLAM steel and to explore the technique.
In this study, the selective laser melting (SLM) was adopted for the additive manufacturing of CLAM steel. The hot isostatic pressing (HIP) and quenching and tempering heat treatments (HT) were performed. The effect of HT on microstructures and tensile properties at different status were investigated. The results showed that tensile strength at parallel layers direction and the vertical layers directions were 966 MPa and 880 MPa at SLM status. After the HIP quenching and tempering HT, the tensile strength were reached to 694MPa and 684MPa, and then the tensile strength of two directions were so closed due to the recrystallization of grain during the HT conditions. The results of this research were of great scientific research significance and engineering application value for the techniques application in the key components manufacturing of the fusion reactor blanket.

Eligible for student paper award?

No

Author: Dr ZHAI, Yutao (Institute of Nuclear Energy Safety Technology, Chinese Academy of Sciences)

Co-authors: Dr HUANG, Bo (Institute of Nuclear Energy Safety Technology, Chinese Academy of Sciences); Dr ZHU, Zhiqiang (Institute of Nuclear Energy Safety Technology, Chinese Academy of Sciences); Dr MAO, Xiaodong (Institute of Nuclear Energy Safety Technology, Chinese Academy of Sciences); Dr LIU, Shaojun (Institute of Nuclear Energy Safety Technology, Chinese Academy of Sciences); Prof. HUANG, Qunying (Institute of Nuclear

Energy Safety Technology, Chinese Academy of Sciences)

Presenter: Dr ZHAI, Yutao (Institute of Nuclear Energy Safety Technology, Chinese Academy of Sciences)

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