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论文资料

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专　　题：热结构与热防护

中文标题：点阵材料夹层结构主动冷却性能与热结构响应分析

英文标题：ACTIVE COOLING BEHAVIOR AND THERMAL-STRUCTURAL RESPONSE OF LATTICE-FRAMED MATERIAL SANDWICH PANEL

中文摘要：点阵材料具有较高的比强度、比刚度，并具有显著的多功能性的特点。本文提出一类以点阵材料为夹芯的新型轻质主动冷却壁板，研究了该壁板的主动冷却性能与热结构响应。采用三维流固耦合共轭传热数值计算方法，考虑了点阵夹层结构与冷却液动态换热过程的相互影响，以及碳氢燃料与合金材料热物理性质随温度的变化，求解获得了流体与结构的三维瞬态温度场，并通过顺序耦合求解获得了结构的应力场。探讨了胞元构型、相对密度、截面尺寸和入口流速的影响规律，并从热防护、热强度和轻量化等几个方面行了综合讨论。研究表明，胞元构型对换热能力和结构强度有较大的影响，相对密度较大、截面尺寸较小、流速较高的条件下有利于主动冷却结构的耦合传热。与槽道式主动冷却结构相比，点阵材料夹层结构的最高壁温较低，同时应力集中问题也有所缓解。

英文摘要：Lattice-framed materials (LFMs) is a class of new materials with the merits of high specific strength, stiffness and multi-functions. In this paper, light-weight actively cooled panel made of LFMs core is proposed, and the active cooling performance and thermal structure responses are studied. A numerical method of 3D coupled fluid structure for the conjugate heat transfer is employed, and the interaction and dynamic heat transfer process of some typical LFM structures with the cooling fuel is investigated. Temperature variant behavior of thermal properties of both hydrocarbon fuel and alloy material is considered in the numerical model. The 3D transient temperature field of fluid and structures is firstly computed using the conjugate heat transfer model, then the thermal stress of structures is obtained via sequential coupling method. The influence of cell configuration, relative density, core height and inlet velocity of fluid on the coupled heat transfer and structure response is discussed, and a general comparison of thermal protection, thermal strength, and light-weight performance is made between the LFMs panels and square-channel panel. The results show that in the same thermal environment, cell configuration of LFM has significant influence on the heat transfer and thermal structure behavior of the active cooling panels. A favorable cooling tendency is found for the high relative density, low core height and high fluid inlet velocity. It is found that the heat transfer property of the fluid-solid interface of high porosity LFM panels outclass that of the square channel panel, therefore the maximum temperature of the structure is reduced and the stress concentration problem is mitigated.

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