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STRUCTURAL DESIGN OF COMBUSTION CHAMBER NOZZLE FOR A BULGING PROCESS

Abstract

A bulging process is required to manufacture converging-diverging nozzle section of a regeneratively cooled thrust chamber with milled cooling channels on a copper-base alloyed inner structure. This process is essential for reducing the weight of a thrust chamber. This paper deals with the structural design of a thrust chamber which has to be deformed to a diverging nozzle shape by a bulging of the inner structure. Mechanical properties of the material which are necessary for a structural analysis were obtained experimentally by tension tests. Forming limit curve of the material has also been obtained experimentally to evaluate whether a necking or fracture of the structure is expected to occur during the bulging process. A finite element elastic-plastic analysis was conducted to predict the strain states and wall thickness of the inner structure after the bulging deformation process. There are two important factors necessary to be considered in the design of thrust chamber nozzle for a bulging. The one is that the material should have sufficient formability to avoid an occurrence of necking or fracture of the structure during the forming process. The other is that the wall thickness of the inner structure after the bulging deformation has to be in good agreement with designed value within an allowable tolerance for structural integrity and stability during the operation. Two bulging test specimens were designed and tested for a validation of the structural design methodology. The bulging was successfully performed without an occurrence of necking or fracture, and the wall thickness of the bulged specimens was measured to be in good agreement with the simulation result. It is concluded that the present structural design methodology for a bulging process can be applied successfully to the bulging of regeneratively cooled thrust chamber nozzle with milled cooling channels.