HEAT TRANSFER ANALYSIS OF A PLASMA ARC WELDING TORCH AND DESIGN

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ABSTRACT

Recently, Plasma arc welding（PAW）was widely applied in the industry. The main reason is that it can produce high energy density arc which reduces the rate of porosity and residual stresses. Also, it is cheaper than electron beam and laser beam welding machines. Therefore, PAW processes are utilized in the aviation and the nuclear equipment manufacturing. According to the literature, the central temperature of a plasma arc can be as high as 16650°C~27770°C. The excessively high temperature may cause damage to the welding torch . It is difficult to directly measure the temperature distribution in the welding torch by experiments. Therefore a computational fluid dynamics （CFD）package is used as the main research tool in this study. The flow and temperature fields of the commercially available " Nippon Steel PAW torch " are analyzed first. Then computation analysis on an improved cooling design is conducted. Computational results show that smoothing the plasma gas channel can rise the friction coefficient on the channel surface. Due to non-axisymmetric inlet and outlet arrangement of the cooling water channel in the Nippon Steel PAW torch, a hot spot on the nozzle surface can occur. In the improved cooling design, slant guide walls cause the flow to swirl, while a U-shaped channel causes flow redistribution so that the fluid velocity near the outer wall is increased. A thinner wall design can shorten the heat transfer path. These factors cause the averaged torch surface temperatures in the improved design to be lower than those of the Nippon steel PAW torch.

Keywords : plasma arc welding ; plasma gas ; swirling flow ; curved channel ; CFD

Table of Contents

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