

Study on Mini-cap Local Dry Underwater Flux-Cored Arc Welding and Online Control of Weld Penetration

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ABSTRACT

A new type local dry underwater flux-cored arc welding system based on a mini-cap was developed. This paper describes the details about the design of the mini-cap underwater welding system. Underwater welding based on the mini-cap is carried out using a variety of self-shielded and gas-shielded flux-cored wires in a pressure cabin. Microstructure, hardness, diffusible hydrogen content and toughness of the mini-cap underwater welds have been studied. The results show that the weld quality carried out by this novel system is better than the quality of wet welding. To guarantee the underwater welding penetration, an online penetration control system was also developed. This system uses a laser stripe to detect the weld width and can recognize the welding penetration based on a support vector machine (SVM) model. It then controls the welding current so as to adjust the welding penetration. Because the size of the mini-cap is very small, the underwater welding system is suitable to most conditions of offshore structure building and underwater repairing.

KEY WORDS: Underwater welding; local dry welding; flux-cored wires; weld penetration.

INTRODUCTION

Underwater welding has been one of the most important repair techniques for offshore structure fabrication. As the number of offshore oil and gas structures grows, and those in existence are continuously exposed to fatigue, corrosion and accidental damage, the demand for underwater structural repair increases (Grubbs and Reynolds, 1998). Underwater welding techniques can be divided into three types: wet welding, dry hyperbaric welding and local dry welding (Labanowski, 2008). Wet welding is carried out directly at ambient water pressure with the welder/diver in the water and without any physical barrier between water and welding arc. Dry hyperbaric welding is done at ambient pressure in a custom built chamber from which the water has been displaced with air or other gas mixture, depending on water depth (Shi et al, 2006). Simplicity of the wet welding process makes it possible to weld on even the most geometrically complex node sections (Majumdar, 2006). Commercial use of wet welding has now been done

to depths of 101m meeting the requirements of AWS D3.6 for type B welds, but it is not suitable for welding on base metals with carbon equivalents (CE) greater than 0.4 wt% due to hydrogen induced underbead cracking in the heat affected zone (HAZ) (Rowe and Liu, 2001). Dry welds meet all the requirements for welds made above water and several dry welded pipeline tie-ins have been made down 220m. However, repair costs and time for dry welded repairs are usually at least double that for wet welded repairs, and furthermore under some conditions, installation of a dry weld chamber can impose unacceptable loads on the structure (Shi and Wang, 2006).

Traditional local dry welding systems use a “water curtain nozzle” or water drain cover to create a water-free environment surrounding the welding arc, as shown in Fig. 1. There are two disadvantages for these devices. The first one is that the size of the nozzle or the cover is too big, and the second one is that they need supply shielded gas to drain the water out of the cavity or the drain cover, which is not convenient and danger under deep sea.

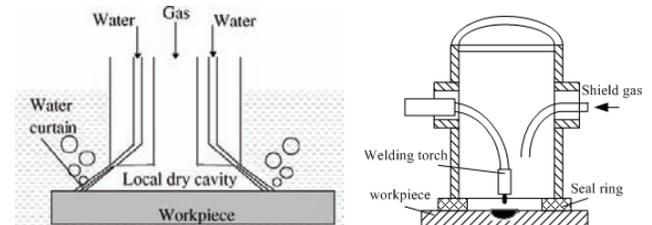


Fig. 1 Diagram of local dry cavity formed by a “water curtain nozzle” or a drain cover.

The purpose of this work was to develop a local dry underwater welding system, which can produce a better quality weld than wet welding with less cost than dry welding. As the system is working, the welding arc is covered with a mini-cap, and the water in the mini-cap is drained by the gas produced by the melting of the wire and the gasification of the water surrounding the welding arc.

PRINCIPLES OF THE WELDING SYSTEM