Proceedings of the Eighteenth (2008) International Offshore and Polar Engineering Conference
Vancouver, BC, Canada, July 6-11, 2008

ISBN 978-1-880653-70-8 (Set); ISBN 1-880653-68-0 (Set)

Automatic Pipeline Welding System Equipped with Six Welding Carriages, Laser Vision Sensor and Arc Sensor for Offshore Pipeline Laying

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ABSTRACT

This application-oriented paper introduces new automatic welding equipment for pipeline construction. The automatic welding equipment developed consists of six welding carriages, three for starboard and three for portside. Each welding carriage has a unique laser vision sensor and arc sensor and two welding torches to maximize productivity. The laser vision sensor and the arc sensor were designed to locate the welding torch into the center of the welding groove before welding and to track the weld seam center during welding respectively. This paper also describes the control system which was designed and implemented for the automatic welding equipment. The system has the self diagnostic function which facilitates maintenance and repairs, and also has the network function via which the welding task data can be transmitted and the welding process data can be monitored.

KEY WORDS: Pipeline welding, Laser vision sensor, Arc sensor, Pulse welding

INTRODUCTION

Automatic welding has been used frequently on offshore pipeline projects. The productivity and reliability are most essential features of the automatic welding system. It has been proved that the carriage-and-band system is most effective on pipeline lay barges. Currently, many pipe laying contractors rely on automatic welding by using their own proprietary equipment or renting it at a high cost.

The aim of this study is to develop a new generation automatic pipeline welding system based on cutting-edge design and practical welding physics. The developed system has been improved in three respects.

First, multiple welding carriage system with pulse process has been applied to the pipeline welding. Pulse welding process becomes increasingly common because it characterizes less heat input than that of standard arc welding, stable arc and superior weld quality. In order to increase weld productivity, the developed system has been applied with six welding carriages. Second, an arc sensor has been developed for automatic seam tracking. Since the system adopts multiple welding carriages, it has more arcs than conventional systems have. Adding to arcs makes it difficult for machine operators to trace on weld seam. Thus automatic seam tracking system is required.

In this study, arc sensor is used for automatic seam tracking. Arc-based signal sensing with a weaving welding torch is now widely used for seam tracking in automated GMAW pipeline application [Hur, JW, 1990]. Key factors in performance of through arc sensing approaches are welding process, welding conditions and welding speed. However, the reliability of an arc sensor dominantly depends on the groove geometry, welding positions and arc sensor algorithm. The groove shape of the pipeline is mostly narrow “U” shape. It means that the tip-to-work piece distance(CTWD) is dramatically changed at the edge of groove, whereas the CTWD is constant during the oscillation motion except the position of the end of groove. This makes it difficult to develop the reliable arc seam tracking sensor in pipeline welding. This study focuses on the development of signal processing algorithm which enables stable tracking in pipeline welding applications featuring out-of-position welding and narrow U grooves. The laser vision sensor was also specially designed to locate the welding torch into the center of the welding groove before welding. After locating the welding torch into the center of the groove, the arc sensor is enabled to track the weld seam center.

Finally, the developed system has various features to make a weld effectively. To minimize downtime caused by the machine faults, the self-diagnostic function has been developed so that the system can automatically detect faults status for each control board and cable connection. A wireless remote pendant and a database downloading system have been developed for easy use of operators. Process monitoring and job data transfer are possible using a delicate software running on a windows system via wireless network. Also, the mechanized carriage has been designed to have a slim, ergonomic design and less weight so that the operator can handle easily.

The developed system has realized remarkable increase of weld productivity. Detailed descriptions will follow in next section.