Study on Automatic Hyperbaric Welding Applied in Sub-sea Pipelines Repair

Canfeng Zhou, Xiangdong Jiao, Long Xue, Jiaqing Chen
Beijing Institute of Petro-chemical Technology
Beijing, China
Xiaoming Huang
CNOOC Gas & Power,Ltd
Beijing, China

ABSTRACT

Air diving are widely used in many shallow water areas, if applicable welding technology adaptive to such a condition developed, then operation cost of offshore structure repairs can be largely saved. In order to meet such a special requirement, an automatic GTAW welding process under high air pressures was researched. Firstly, the hyperbaric welding test chamber was designed and constructed in laboratory, and the welding machine was manufactured. Secondly, experiments under 1-7 bar air pressures were studied including linear welds and pipe butt welds, and high weld quality was obtained. Lastly, the hyperbaric welding sea-trial was carried out, and perfect 5G girth weld of sub-sea pipelines was produced.

KEY WORDS: Hyperbaric welding; sub-sea pipeline; GTAW; high air pressures; test chamber; automatic welding machine

INTRODUCTION

Because high quality joint can be obtained, hyperbaric welding is often used in offshore structures repair, such as pipelines and platforms, or pipelines hot tapping, especially in the North Sea. The effects of pressure on electrical performance and weld bead geometry at pressures up to 250bar, equivalent to water depths of 2500m (8,200ft), was investigated, and overall process stability of GMAW has been shown [P. Hart et al., 2001]. Also under the same high pressure, acceptable butt joints include positional linear welds and orbital welds on API 5L X65, API 5L X70 and supermartensitic pipeline steels were produced [Ian M. Richardson et al., 2002], and later a fillet welded sleeve on API 5L X65 pipeline also were obtained successfully [N J Woodward et al., 2004], which will play a key role in driverless underwater repair system.

In fact, in order to develop driverless underwater repair system applied in tie-in and hot tapping needed in many cases such as the Langeled pipeline in the North Sea, hyperbaric welding invesGTAWation were still carried out continually in the past few years. The development of hyperbaric GMAW of X65 steel with low alloyed steel and Inconel 625 wires was carried out at 12-35 bars, and all welds showed excellent mechanical properties [Odd M. Akselsen et al., 2008]. In addition, hyperbaric GTAW of X70 Pipeline also invesGTAWated, and produced weld with outstanding mechanical properties [Odd M. Akselsen et al., 2006].

But the Bohai Sea of China is very different from the North Sea, because of shallow water depth within 60m, air diving is usually used in underwater repair. Air diving is a type of diving in which the diver's breathing medium is a normal atmospheric mixture of oxygen and nitrogen. Although air diving operations can be limited to depths of less than 100 meters, but in modern offshore diving practice, because of the long duration of divers and because divers work every day, an air diving limit of 50 meters is currently enforced. In the research of the sub-sea pipeline hyperbaric repair programme, to save cost and increase flexibility of repair operation, compressed air is selected as chamber gases to drive water. But on the other hand, the selection brings two problems, one is the flammability of objects increases greatly, another is the weld pool protection becomes difficult [John H Nixon, 2000]. The present investigation concerns hyperbaric GTAW process on 16Mn steel pipe under high air pressures. The hyperbaric welding test chamber was built, the orbital welding machine was manufactured, and successful experiment was carried out.

WELDING REPAIR UNDER HIGH AIR PRESSURES

Flammability and Weld Pool Protection

When welding is applied in sub-sea pipelines repair, the damaged region is cut and then plugs are inserted into pipe ends to prevent residual oil or gas into the chamber. Besides compressed air has the feature of increasing flammability of objects, more seriously, residual oil and gas will explode when concentration is enough high.

Fig.1. Flammability and explosion test device