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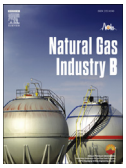

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Research article

Automatic welding technologies for long-distance pipelines by use of all-position self-shielded flux cored wires

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Abstract

In order to realize the automatic welding of pipes in a complex operation environment, an automatic welding system has been developed by use of all-position self-shielded flux cored wires due to their advantages, such as all-position weldability, good detachability, arc's stability, low incomplete fusion, no need for welding protective gas or protection against wind when the wind speed is < 8 m/s. This system consists of a welding carrier, a guide rail, an auto-control system, a welding source, a wire feeder, and so on. Welding experiments with this system were performed on the X-80 pipeline steel to determine proper welding parameters. The welding technique comprises root welding, filling welding and cover welding and their welding parameters were obtained from experimental analysis. On this basis, the mechanical properties tests were carried out on welded joints in this case. Results show that this system can help improve the continuity and stability of the whole welding process and the welded joints' inherent quality, appearance shape, and mechanical performance can all meet the welding criteria for X-80 pipeline steel; with no need for windbreak fences, the overall welding cost will be sharply reduced. Meanwhile, more positive proposals were presented herein for the further research and development of this self-shielded flux core wires.

Keywords: Natural gas; Pipeline; Self-shielded flux core wire; Automatic welding; Welding system; Welding technique; Welding efficiency; Mechanical property

In recent years, automatic welding, high in automatic degree, low in labor intensity, good in welded joint appearance shape, fast in welding speed, high in first-time welding pass rate, has been widely applied [1−6] in on-site welding of long-distance oil/gas pipelines intensity etc. Limited by the pipeline routes, welding techniques, equipment volumes, etc., the pipeline automatic welding technology is mostly applied in a flat operation environment rather than a complex operation environment. The self-shielded flux cored wire has been the hotspot [7−14] due to its advantages, such as excellent all-position operability, sound welding performance, high wind resistance, arc's flexibility and good directivity, sound fusion with base metal, low crack tendency, wide welding operation window, good detachability, no need for protective gas for welding nor windbreak fence against wind when the wind speed is below 8 m/s, low possibility of welding defects like incomplete fusion, etc.

In view of the significant advantages of the automatic pipe welding technology and self-shielded flux cored wires, PetroChina Natural Gas Pipeline Scientific Research Institute took the lead in research on the development of an automatic welding system by use of all-position self-shielded flux cored wires and welding techniques, carried out welding test for X-80 pipeline steel of West-East Natural Gas Transmission Line 3 on the basis of the existing finished self-shielded flux cored wires to explore proper automatic welding parameters, and put forward proper proposals for further research on the special self-shielded flux cored wires applicable to automatic welding, thus to guide actual project application and continual and in-depth research on automatic welding technology by use of self-shielded flux cored wires.

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1. All-position welding of pipes and automatic welding technology

1.1. Characteristics of all-position welding of pipes

A long-distance oil/gas pipeline is connected by joints of steel pipes with an average length of 12 m upon pipe joint welding. The whole joint welding procedure is composed of pipe end grooving, joint matching, root welding, hot welding, filling welding and cover welding with steel pipe fixed during welding, and manual arc welding. Semi-automatic welding or automatic welding can also be used to weld pipe jointS at all positions. Full-position welding of pipes generally takes downward welding at present. Compared with the single welding state of plane welding, the whole all-position welding process of pipes is a complex changing process from a plane welding state to a vertical welding state and then to an overhead welding state, and welding parameters also change in real-time with different welding positions.

1.2. Principles of automatic welding of pipes

Pipe automatic welding is a kind of technique realizing automatic welding of girth welded joints with pipes relatively fixed by automatic welding equipment. An automatic control system controls a welding carrier on a guide rail fixed near the pipe joint to be welded and further to control the welding speed, arc voltage, wire feeding speed, welding torch amplitude, frequency and change of other welding parameters, thus to realize the all-position automatic welding of pipe girth welded joints.

2. The automatic welding system of pipes by use of all-position self-shielded flux cored wires

An automatic welding system of pipes by use of all-position self-shielded flux cored wires (hereinafter referred to as an automatic welding system by use of self-shielded flux cored wires) mainly consists of a welding carrier, a guide rail, an auto-control system, a welding source, a wire feeder, and so on (Fig. 1).

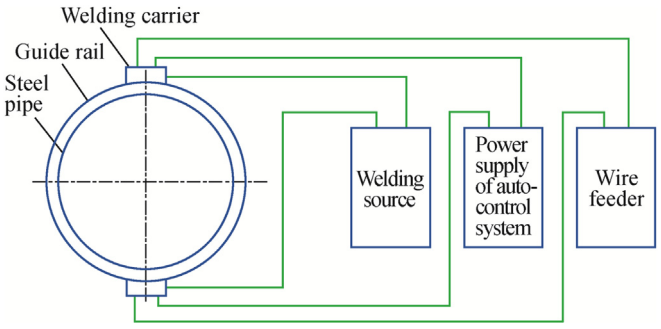

Fig. 1. Compositions of an automatic welding system by use of self-shielded flux cored wires.

2.1. Working principles

The welding torch of a self-shielded flux core wire is mounted on a welding carrier on the guide rail fixed near a pipe joint to be welded. Welding parameters are preset in the auto-control system to accurately control the spatial position of welding torch, welding speed, wire feeding speed, welding voltage, amplitude, swing trace, swing rate, etc., thus to realize an efficient and all-position automatic welding of pipe girth welded joints. Arc striking starts from a 12 o'clock position by a welding carrier at first during welding, and welding is toward a 6 o'clock position along one side of a girth welded joint, then another welding carrier is moved to the 12 o'clock position afterwards for arc striking, and welding is conducted at the 6 o'clock position along the other side of the girth welded joint (Fig. 2). The minimum time interval of arc striking is maintained on the premise of no interference between the space of the two welding carriers to ensure a basic symmetrical stress on both sides of the welded joint during welding, thus to realize hot welding, filling welding and cover welding of a girth welded joint in sequence. It should be noted that deslagging is required for the previous welding layer before the welding of the next layer.

2.2. Mechanical parts

The mechanical parts of an automatic welding system by use of self-shielded flux cored wires is mainly composed of a welding carrier and a driving mechanism.

2.2.1. The welding carrier

The welding carrier mainly consists of the angle swing mechanism and the cross adjustment mechanism of a welding torch (Fig. 3). The angle swing mechanism of the welding torch therein can realize optimal swing angles and the swing frequency of the welding torch to avoid incomplete fusion during welding; the cross adjustment mechanism of the welding torch can realize upward/downward adjustment and

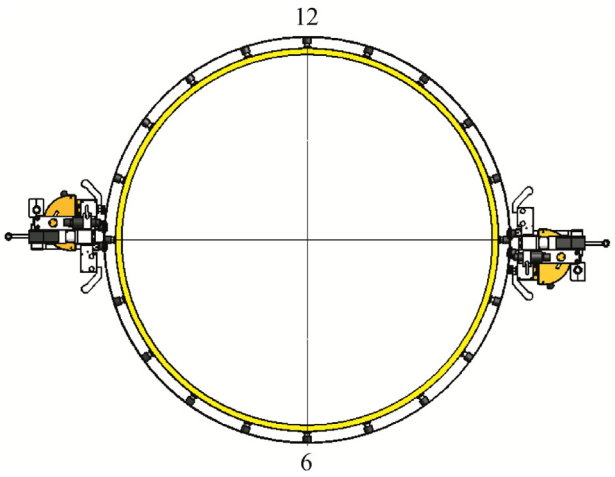

Fig. 2. Working principles of an automatic welding by use of self-shielded flux cored wires.