Journal of Manufacturing Processes 19 (2015) 67–72

Contents lists available at ScienceDirect

Journal of Manufacturing Processes

journal homepage: www.elsevier.com/locate/manpro

Technical Paper

Characterisation of transient out-of-plane distortion of nipple welding with header component

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ARTICLE INFO

Article history:
Received 20 November 2014
Received in revised form 28 April 2015
Accepted 3 May 2015
Available online 29 May 2015

Keywords:
Out-of-plane distortion
Header
Nipple
Multipass welding
Welding sequence
Welding direction
Weld start/stop points

ABSTRACT

Welding distortions are experienced during the manufacture of boiler components using welding processes. Header is one of the significant boiler components currently fabricated using shielded metal arc welding (SMAW) process. Header is fabricated by welding tubes called nipple with thick-walled pipe called header using SMAW multipass circumferential fillet welding with T-joint orientation. The transient out-of-plane distortion of nipple experienced during welding with header is investigated in this paper. The analysis is carried out using the transient displacement and thermal cycle data obtained for two weld sequences.

The thermal cycle and transient displacement data obtained during the investigation is having correlation with each other. The transient analysis reveals the influence of weld start/stop points. The out-of-plane distortion in X and Y directions is quantified. The distortion in X direction is influenced by weld start/stop points. The distortion in Y direction is influenced by welding direction. The influence of weld start/stop points over welding direction on distortion is quantified from the analysis. The transient analysis details are presented.

1. Introduction

Welding-induced distortion is a common problem in all the welded components. The type of distortion induced primarily depends on the orientation of the component to be welded, shape and size of groove, thickness of component and weld metal deposition. Pipes and tubes are often welded with different orientation for different applications. This involves groove and fillet welding of tubes with pipes in circumferential and longitudinal orientation. The out-of-plane distortion of plates with T-joint configuration due to longitudinal welding was reported by few researchers [1,2]. The distortion mechanism due to circumferential welding is different from longitudinal welding.

When components are subjected to circumferential welding with butt joint orientation, (specifically in shell component) it leads to axis shift distortion as reported by Ravichandran et al. [3]. Distortion due to butt joints of pipes with different thickness and with different welding processes is manifested in different ways and individual studies in such cases are reported widely as can be inferred from [4–8]. Transient analysis in these studies is done using finite element method (FEM) analysis. In analysing transient distortion behaviour of components during welding, FEM studies are useful otherwise it requires transient experimental data. However, it is found that very few FEM studies have been carried out on circumferential welding with T-joint orientation of pipe components [9–11]. The results however could not be used to a header to nipple welding due to constraints in dimensional values used for simulation.

Studies have also been conducted to understand the distortion of pipe components without FEM analysis and in such cases, they depend on steady state distortion measured after welding [12]. In few illustrative cases alone, the transient experimental data have been captured in butt joint studies on pipe components, such as the one analysed by Jianxun et al. [13].

It is inferred from the literature survey that the data of transient distortion induced due to circumferential fillet welding of pipe components is not available either experimentally or by other modes such as simulation. This data, when made available, is of vital importance for industrial applications like nipple to header

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http://dx.doi.org/10.1016/j.jmapro.2015.05.001
1526-6125/

welding as it could reduce cycle time and improve weld quality. A study combining the availability of experimental data on the header to nipple joint configuration will lead to reducing distortion in welding.

As a specific case study, a typical header of boiler component experiencing similar problem is considered. Here, multiple tubes called nipples are fillet welded with thick-walled pipe called header in perpendicular (T-joint) orientation. Holes are drilled on the header, and nipples are inserted into them and fillet welded by SMAW. Distortion of nipples is experienced during welding due to the multipass fillet welding involved in the process. Controlling of nipple misalignment during welding requires experimental transient distortion measurement. To quantify distortion, there are different measurement techniques available including contact, non-contact, point, full field, stationary and transient which have been studied through [14–19].

The amount of displacement experienced by the nipple during welding is large enough to make it possible to use displacement sensor. For localised measurement, linear velocity displacement transducer (LVDT) sensor is used, and the measurement arrangements are similar to studies reported [20] elsewhere. It is therefore the objective of the present study to analyse transient distortion experienced during header to nipple welding by using LVDT with thermal cycle data on a mock-up specimen for different weld sequences.

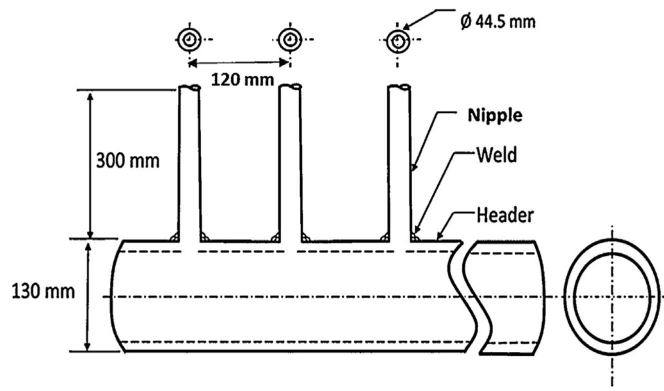

Fig. 1. Dimensional details of nipple to header T-joint considered for the study.

2. Experimental procedure

In order to understand the transient distortion behaviour of nipple during welding with header the mock-up welding is carried out on a typical header. Actual header consists of many number of nipples welded along the length of header. The nipple distortion is not affected by length of header. Hence, the mock-up specimen consists of few nipples with short length of header. The typical nipple

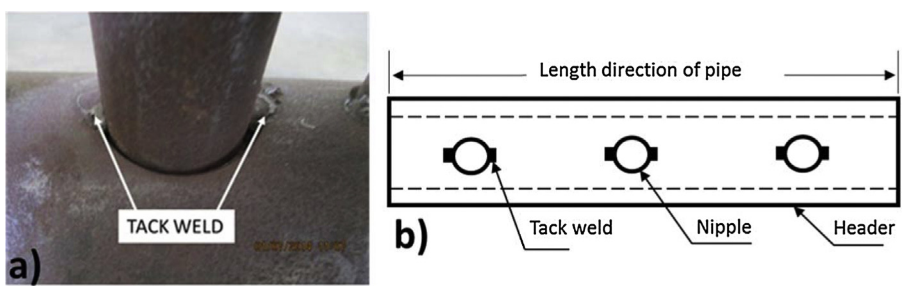

Fig. 2. Tack welding position of nipple with header.

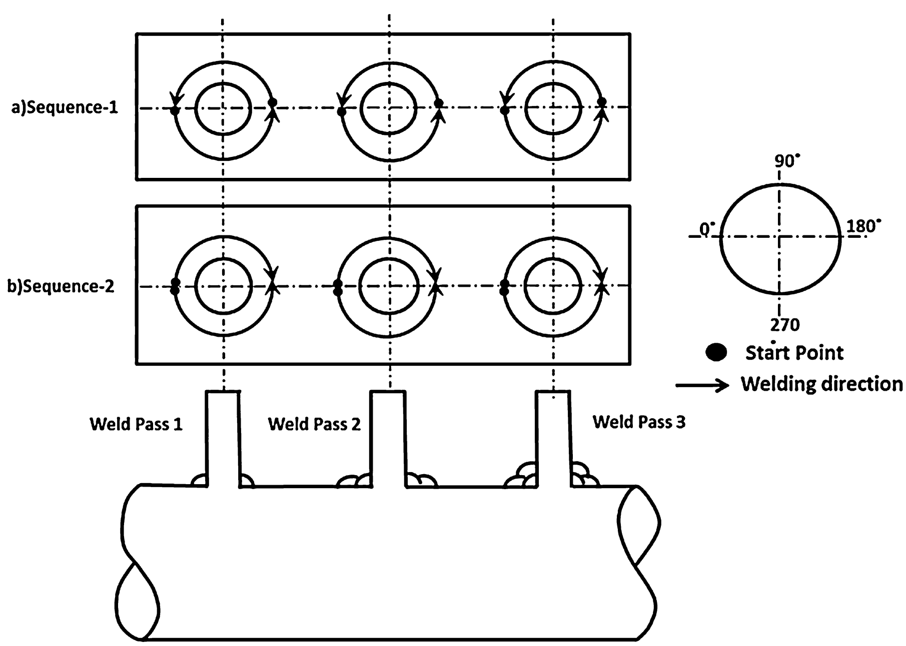

Fig. 3. Schematic view of two welding sequences between nipple and header.