A New Approach to the Boom Welding Technique by Determining Seam Profile Tracking

Muciz ÖZCAN, Mustafa Sacid ENDİZ, and Veysel ALVER

***Abstract*—**In this paper we present a new approach to the boom welding related to the mobile cranes manufacturing, implementing a new method in order to get homogenous welding quality and reduced energy usage during booms production. We aim to get the realization of the same welding quality carried out on the boom in every region during the manufacturing process and to detect the possible welding errors whether they could be eliminated using laser sensors. We determine the position of the welding region directly through our system and with the help of the welding oscillator we are able to perform a proper boom welding. The major modification in the production of the crane booms will be their form of the booms. Although conventionally, more than one welding is required to perform this process, with the suggested concept, only one particular welding is sufficient, which will be more energy and environment-friendly. As a way to satisfy the welding quality, a welding manipulator was made and fabricated. By using this welding manipulator, the risks of involving dangerous gases formed during the welding process for the operator and the surroundings are diminished as much as possible.

***Keywords*—**Boom welding, Seam tracking, Energy saving, Global warming.

I. INTRODUCTION

THE actual global warming, which is among the most important environmental problems in our time is closely related to the production of dangerous gases [1 - 4]. Global warming is increasing and on account of this the energy consumption increases [5, 6]. Approximately 1 kg involving CO_2 gas is actually released to the atmosphere for each 1 kWh of energy generated by a coal power station. Likewise burning propane or water heating system for power production creates circa ½ kg of CO_2 for every 1 kWh of energy generation [7]. Therefore it is of great importance to utilize energy in the most useful way and to diminish the particular production of these harmful gases for the protection of the environment. Today to minimize the energy consumption is a very crucial research topic along with the production of this kind of harmful gases by generating alternative solutions [8, 9]. In this paper to minimize of power consumption and preventing of the dangerous gases throughout the production process regarding mobile cranes will be investigated. In order to perform high quality operation a special welding manipulator was fabricated. With the help of this manipulator high sensitive and automated welding has been achieved.

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II. A NEW ALTERNATIVE WAY FOR BOOM DESIGNING

Conventionally, booms for mobile cranes and other vehicles are produced by jointing two steel pieces with at least two welding operations fulfilled by an operator. The steps for the boom operation are described as follows: First of all, two steel pieces with right dimensions are taken from the steel plate by using automatic oxygen plasma cutting machine. As two steel pieces are cut in order to form the boom, the values should be doubled to determine the total energy usage. The steel pieces are then bent by means of press brake to form the boom shape. In order to joint these two steel plates using by welding machine, two corner joints for every metal plate must be created at the boundaries. These corner joints are created by using oxygen-acetylene cutting torch shown in Figure 1 (a). The shape and angle of the corner joints are the factors affecting the quality of the welding operations. The opening angle of each corner joint is set to 45□ to get the best welding quality [10]. After the forming of corner joints, two steel pieces are welded together by an operator using gas metal arc welding in Figure 1(b).

The welding process performed in this way takes very long time and the required shape and size of the booms are not easy to get the end product properly since we use two steel pieces and due to the excessive deformation occurred during manual welding.

(a) (b)

Fig. 1: Traditional boom production (a) corner joints, (b) welded boom shape

Since the average length of the booms is long (3m), excessive deformations such as overlaps, roughness after the welding progress are inevitable. As a result we have undesired poor welding qualities which makes necessary additional correction processes.

In the proposed alternative boom design way explained in this study, lots of energy consuming steps caused by the traditional boom manufacturing are eliminated. The details of the alternative design and the way to manufacture it are as follows: Firstly a single steel piece is cut from the steel plate which is sufficient to create the boom when the alternative method is applied. This single piece is again bent in the size of the boom in the press brake which is shown in Figure 2 (a). However, after bending this single piece in the boom shape, the corner joints are formed automatically shown in Figure 2 (b), which eliminates the corner joint creation steps. The final step is to weld this single piece to itself with a single welding operation using the welding manipulator designed for the purpose of this study.

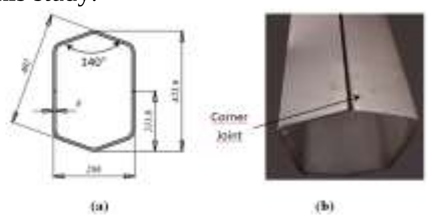

Fig. 2: Shows the bending of the single steel piece to form the boom shape and (b) shows the automatic formation of the corner joints

As it can be understand from the related figures, the new alternative design has two main advantages compared to the traditional methods. Firstly, as a single welding step will be enough for the alternative method, the welding operation time and consumed energy for the welding processes are reduced considerably. Additionally, cutting the steel pieces from the steel plate will consume less energy and time. Secondly, the corner joint creation steps are completely eliminated so the total energy consumption for the production of the booms is diminished significantly.

III. The Design Details of the Used Welding Manipulator

A specific welding manipulator was designed and produced for our study. There are two main reasons why we need to design this welding manipulator. Firstly, since the booms will have a single welded line (the boom shape will not be 100 % symmetric due to this welded side), this line should have as high quality as possible. The quality of the welding performed by an operator will have less quality compared to the welding done by an automatic manipulator. Secondly, operators will not be exposed to the hazardous gases emerge from the welding operation. Moreover, these dangerous gases can be filtered as well to keep the environment clean.

The boom welding manipulator designed and generated for this purpose, includes a MIG (Metal Inert Gas) welding machine, a biaxial stepper motor-controlled manipulator to control the position of the welding torch, a mechanism to move the stepper control mechanism, a speed control unit to set the welding speed, a Programmable Logic Controller (PLC) to control and command the system and a 3 phase motor to move the torch mechanism throughout the x-axis. The block diagram of the designed system is shown in Figure 3.

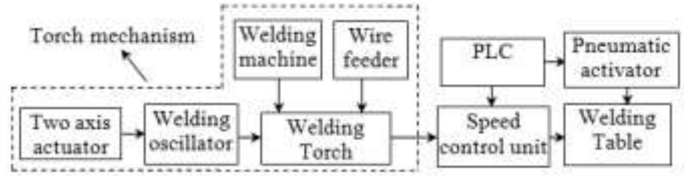

Fig. 3: Block diagram of the welding manipulator

MIG method is one of the most suitable and common used arc welding methods, and therefore it has been chosen for the boom welding of our study [11-14]. The Block diagram of the system operation is shown in Figure 4.

The operation of the system can be summarized briefly as follows: First, the boom which is to be welded is placed in the manipulator and fixed. The torch is brought to the center of the corner joints manually by an operator where the welding process will start. This movement is performed with the help of two axis actuators which can move the welding torch along y and z axes. To achieve a high quality welding, the welding should be done in constant speed. Welding current, welding wire, and wire feed speed should be also chosen according to the welding process requirements. Using a protective gas during the welding process is of great importance for a high welding quality. In the welding process, the flow of the protective gas is fixed, as well. The parameter of wire feeder speed is also adjusted on the speed of control unit. Figure 5 shows the designed and generated welding manipulator. Figure 6 demonstrates a sample welded boom by using the designed welding manipulator.

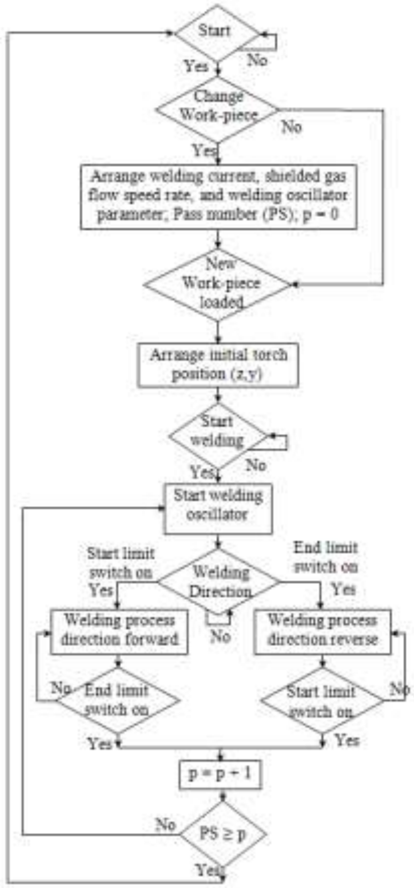

Fig. 4: Flow chart of welding manipulator

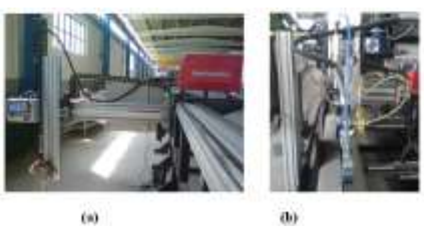

Fig. 5: The designed welding manipulator a) initial version b) final version

Fig. 6: Two samples of welded booms using designed welding manipulator a) high speed welding b) low speed welding

These booms are welded using 20 psi argon gas and CO2 as the protective gases. 8 mm thick pieces are welded using 390 A current and 10 mm thick pieces are welded using 410 A current with 3 passes. The welding operation is performed in a closed and air filtered chamber to minimize the effects of the dangerous gases occurred in the course of the operation on the operators and the environment. The selected welding parameters depending on the thickness of the boom to be weld and the material used are given in Table I.

TABLE I:
BOOM WELDING PARAMETERS DEPENDING ON THE THICKNESS OF THE WORK-PIECE

Item	Specifications	
Thickness of the work-piece (mm)	10	8
Wire feeder speed (mm / s)	19	17
Welding speed (mm / s)	5.5	8
Diameter of welding wire (mm)	1.2	1.2
Welding current (A)	410	390
Shielded gas mix with CO_2-ARGON (L / min)	15	15

IV. RESULTS AND DISCUSSIONS

As we have seen from the test results shown in Table II, the performance of the alternative boom design and manufacturing method proposed in this study is superior and innovative compared to the traditional boom design and manufacturing methods. Thus, in addition to the energy saving benefits and reducing the risks of the dangerous gases on operators and the environment, the presented alternative design and manufacturing method ensures a higher performance booms for mobile cranes and other vehicles where booms are needed.

Below in Table II the two boom welding methods, the conventional method and the proposed alternative method have been summarized. As it can be seen from the Table below, cutting the boom plates in plasma as a single piece instead of two-pieces results in an average of about 41% less energy consumption. Additionally, there is also a huge saving from the consumed materials, such as cutting and welding gases and welding wires. About 53% of saving gain from welding energy, welding time, and welding wire are obtained. As corner joint creation steps are eliminated completely, energy and material losses are overcome. Eventually; manpower, energy and material usage to design and manufacture of the booms for mobile cranes are minimized in relation with the improving the boom performance thanks to the alternative method proposed in this work.

By using this method that is explained in this study, new yields have been achieved such as energy consumption, labour force and efficient material usage during the process of mobile crane manufacturing. In addition to this, better and more durable cranes are manufactured compared to those which manufactured by conventional methods. It is shown that more than 50% energy saving is possible when this method is applied.

It is believed and hoped that this study provides an example to the industry to consider their production way in order to get more gains in different areas of boom welding as mentioned above. This type of production is a significant muster to the sector of mobile crane manufacturing. With the help of this method, about 50MWh energy saving could be achieved in Konya which is an important place in mobile crane manufacturing in Turkey. Besides the savings from energy, material and labour force, the releasing of carbon dioxide (CO2) to the atmosphere is significantly reduced during the crane manufacturing process. This has become an essential step today and is very important gain for a clean environment with the purpose of controlling and minimizing global warming. The experiments that we performed give evidence that the precision of the system can cover the need of quality requirements of welding operation.

TABLE II: COMPARISON OF THE TRADITIONAL AND THE ALTERNATIVE BOOM MANUFACTURING METHODS

Welded Booms	Traditional boom manufacturing method			Alternative boom manufacturing method		
	Welding time (s)	Welding Energy consumption (Kwh)	Used welding wire (m)	Welding time (s)	Welding Energy consumption (Kwh)	Used welding wire (m)
Knuckle Boom	1930	9.65	185	900	4.500	92
1.extension	2010	10.0503	196	940	4.700	95
2.extension	2080	10.4004	206	975	4.875	98
3.extension	2150	10.7502	209	1005	5.025	102
4.extension	1526	7.2061	115	713	3.3669	65
5.extension	1576	7.4422	147	735	3.4708	67
6.extension	1630	7.6972	145	762	3.5983	70
Total	12902	63.1964	1223	6030	29.5361	589

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