Implementation of Robotic Welding for the Improvement of Production Systems

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Abstract *Implementing the robotic welding leads to increase in efficiency of the production system. To achieve this modern concept for implementing robotic welding was used in industrial environment. The multi-level industries use the main part of the production process in welding. The welding was carried out manually by the employees. At this process, many problems occurred in this method. So, it was decided to eliminate manual welding by introducing robotic welding. The robotic function was done in all the welding process. The manual welding is not suitable for the higher level industrial environment. Generally, industries preferred robotic welding. Robotic welding leads to the betterment for higher level industrial systems and a large amount of production welding process. Plan step by step process interconnected in welding. In this production system, finding out how to minimize the welding cost and to produce good quality welding and finally compare the manual welding with the robotic welding process. In many of the industrial cases, the improvement is achieved through the usage of robotic welding that leads to many cases to follow for improving higher level production in this robotic welding*

Keywords — *Robotic welding, production process, manual welding, cost analysis.*

I. INTRODUCTION (SIZE 10 & BOLD)

(Size 10 & Normal)This document is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the conference publications committee as indicated on the conference website. Information about final paper submission is available from the conference website. Welding has been a large part of the materials joining process for the production of various consumer products. The robotic welding industry has become more important and allows rapid production and higher quality parts to be produced while reducing labour costs and operator exposure to hazardous bio-products of the welding process. In order be able to use robotic welding for production, a fixture must be designed that will locate, hold, and support the part during the welding process. Fixture design will have a drastic impact on the quality of part produced from the process. The objectives of this work are to design a useful part that can be robotically welded, design a fixture to allow the automatic welding of the component and to analyse the cost of the robotic welding process compared to other methods. The research includes the type of welding the machine does, defects and how to avoid them, fixtures for welding, programming the robot, and the reasons for automating welding. This paper focuses and used for the design of the part and final fixture. The next step after research is designing the part and fixture. The part is designed with machine capabilities and part weldability in mind. The part will need a fixture so that robotic welding is possible. The fixture is designed using basic fixture design principles as well as weld specific guidelines. Determining the success of the fixture requires running a program and evaluating the quality of the parts produced. Testing the fixture first requires setting up a program for the robot to run. This is done using Fanuc machines. The part is then welded and can be inspected. The inspection of the part is a visual check of the weld and measuring key dimensional requirements of the final part. This may lead to a re-design of the fixture in order to meet requirements. The main objective was to allow the robotic welder used in the materials joining process. It will also provide a cost analysis of robotic welding compared to manual welding to determine whether robotic welding is a realistic solution to production problems. The theme of this paper will cover the research that was done, the design of the part and fixture, the methodology for fabrication and testing of the fixture, and the results of the project.

II. LITERATURE REVIEW

This section of the paper summarizes the research that was done for this work. Yan [1] stated that this paper proposes an optimization method with the objective to maximize the section area of the weld bead so that the number of passes can be minimized. The welding passes of a deep groove are planned using the proposed method. Dong Hong Ding et al [2] stated that the study focuses on developing a fully automated system using robotic gas metal arc welding to additively manufacture metal components. The system contains several modules, including bead modelling, slicing, deposition path planning, weld setting, and post-process machining. Among these modules, bead modelling provides the essential database for process control, and an innovative path planning strategy fulfils the requirements of the automated system. Qiang Zhang and Ming-Yong Zhao [3] stated that a minimum time path planning strategy is proposed for multi-points manufacturing problems in drilling/spot welding tasks. By optimizing the travelling schedule of the set points and the detailed transfer path between points, the minimum time manufacturing task is realized by fully utilizing the dynamic performance of robotic manipulator. N. Mendes [4] stated that the aim of this study is to examine the main factors affecting friction stir welding (FSW) of acrylonitrile butadiene styrene (ABS) plates, performed by a robotic system developed for this purpose. A comparison between welds produced in the robotic FSW system and in a dedicated FSW machine is presented. Mitchell Dinham and Gu Fang [5] stated that a novel method that can autonomously identify fillet weld joints regardless of the base material, surface finish and surface imperfections such as scratches, mill scale, and rust. The new method introduces an adaptive line growing algorithm for robust identification of weld joints regardless of the shape of the seam. The proposed method is validated through experiments using an industrial welding robot in a workshop environment. T.S. Hong et al [6] Robots are quite versatile and hence have been used for a variety of welding types such as resistance welding and arc welding. This work describes the development and progress of robotization in welding over the years and also discusses many advantages and disadvantages of different robotic welding technologies. Mitchell Dinham and Gu Fang [7] stated that the methods developed to enable the robust identification of narrow weld seams for ferrous materials combined with reliable image matching and triangulation through the use of 2D homography. The proposed algorithms are validated through experiments using an industrial welding robot in a workshop environment. Wang et al [8] experimental studies have been carried out on a robot-based FSW system in order to identify the proposed models based on the least squares (LS) method. The results error of the identified models has been systematically analysed, showing good performance of the identification. Edward F. Shultz[9] shared control strategy presented that allows a skilled operator to identify irregularities that occur during robotic friction stir welding (FSW) and assist the robotic system in producing an appropriate response. Human operators are adept at identifying disturbances; however, the complexity of the friction stir welding process makes it difficult for the operator to respond. De Graaf and Aarts [10] describes how seam-tracking sensors can be integrated into a robotic laser welding system for automatic teaching of the seam trajectory as well as for correcting small errors from a pre-defined seam trajectory. Calibration procedures are required to derive accurate transformations of laser and sensor tool frames relative to each other or relative to the robot flange. Jair Carlos Dutra et al[11] stated that small worn areas are coated inside the boiler itself, while in the workshop, panels are coated so that they can either be used in the boiler's most affected regions or to produce new walls with higher wear resistance. Mechanized welding produces better results than manual welding; however, in current systems, the oscillating movement of the torch is generated by a single axis. This limitation renders the welding process unstable if the aim is to reduce bead reinforcement and the number of weld beads by increasing the amplitude of the torch oscillation. This instability produces high spattering and excess penetration due to the change in the contact tip to work distance (CTWD). Ming Tsai et al [12] stated that A path planning method based on machine vision techniques is constructed for a golf-club head robotic welding system. This system uses 3D machine vision techniques to recognize the weld seam and generates a welding path for the robot. The location of the weld seam is discovered by applying a Sobel mask to the captured data. Zhen Zhou Wang [13] stated that for automated robotic gas metal arc welding, automatic and efficient image processing algorithms are required to extract the metal transfer robustly. In addition, the machine vision apparatus in real welding environments should be compact and easy to handle. To this end, a simplified laser back-lighting based monitoring system is proposed to measure the metal transfer in this research. Yuehai Feng [14] stated that a novel robotic double-sided coaxial GTAW process has been applied to the welding of Al7A52. The microstructure and mechanical properties of the thick weld joints both welded by robotic self-fluxing double sided coaxial GTAW (RSF-DSC-GTAW) and robotic wire-feed double sided coaxial GTAW (RWF-DSC-GTAW) has been investigated. Menno de Graaf et al [15] stated that a real-time seam tracking algorithm is proposed that can cope with the accuracy demands of robotic laser welding. A trajectory-based control architecture is used, which had to be developed for this seam tracking algorithm. Cartesian locations (position and orientation) are added to the robot trajectory during the robot motion. Shijia Chen et al [16] stated that direct simulation of grain structure at industrial scale is yet rarely reported in the literature and remains a challenge. A three-dimensional (3D) coupled Cellular Automaton (CA) – Finite Element (FE) model is presented that predicts the grain structure formation during multiple passes Gas Tungsten Arc Welding (GTAW) and Gas Metal Arc Welding (GMAW). The FE model is established in a level set (LS) approach that tracks the evolution of the metal-shielding gas interface due to the addition of metal.

III. PROCEDURE FOR ROBOTIC WELDING

A. *Fixture Fabrication locator part*

The locator part is the nearest piece of the fixture to the welded spot. It will be subject to high temperatures and needs to be able to withstand them. The material that is used for this part is a low carbon steel. This part was made from 3.5 inch round bar stock that was processed on a CNC mill. The mill was used to cut the face of the part, pocket the centres and drill the holes. The pins that would be put into the holes were cut using a lathe. A lathe was used to ensure that the pin was at the correct diameter for the holes. The pins were then pressed into the holes resulting in a finished part. The remaining part of the fixture is also made from low carbon steel. This material was chosen so that the fixture would be able to resist wear from the operation. The base plate and two supporting beams were cut from steel sheet using a shear. The V was also sheared into the top beam using the press. The notch was cut using a vertical band saw. These parts were then welded together by the welding. The locator part was position so that when a part was inserted it would be vertical. This part was then welded to the base plate of the fixture.

B. *Programming*

In order to test the fixture design, a program had to be written for the robot to weld the part. This was done using the teach pendant. The teach pendant works by allowing the operator to control each of the six axes of the robot to move to the necessary weld points. Several points were chosen along the weld seam of the flange and pipe that formed an arc around the pipe. This program was written so that the robot would follow the same path each time the run button was pressed. As long as the fixture was placed in the correct location the program would run and make a satisfactory arc around the part. The program that was used to weld this part is seen in figure 8. After the basic motion of the welder was set up the weld parameters needed to be input to create a high-quality weld. The initial weld parameters of wire feed speed and voltage were set up using the Miller Welds mobile application for initial settings. The weld travel speed was calculated using the desired weld volume and calculating travel speed based on wire feed speed. The initial wire feed speed was 300 inches per minute, the voltage was 21, and travel speed was 6 feet per minute. These parameters were tested using steel stock of similar thickness and orientation. The fillet weld was repeated and parameters were adjusted until the weld was satisfactory. The wire feed and voltage were satisfactory, but the travel speed was adjusted to 12 feet per minute. These settings were input into the welding program and the fixture was ready to be tested.

IV. WELD QUALITY

The quality of the weld is determined by visual inspection. It would be ideal to test the weld by placing it in a system to see if can withstand the desired pressure, but that was unable to be accomplished in this work. It is difficult to analyse if the quality of the welding process due to a small number of parts that were able to be created. This limitation is mostly due to the cost of the flanges. More substantial testing would be required before this was implemented in a large manufacturing capacity. The quality of the part as a whole is determined by whether it meets the specifications for the part. The specification that has to do with the welding process is the parallelism of the flanges to each other and the perpendicularity of the pipe to each flange.

A. *Economic Analysis For Robot And Manual Welding*

After creating a small number of parts hardly any defects were present in the weld. The only defect that was present was due to an error by the operator. This defect was the improper fusion of the part and flange because the welding gas was not turned on before the program was started. This mistake was caught early in the weld and the part was able to be reworked. This is an issue that could come up again if the gas runs out during a weld or is not properly set up before the welding begins. The weld is remarkably consistent because all of the parameters are so tightly controlled and this process is capable of producing high-quality welds. A separate issue is that the part did not meet the perpendicularity and parallelism requirements. The reason for this is a poorly aligned fixture as well as the war page that was not fully accounted for. This issue requires a rework of the fixture to ensure that the parts are aligned properly. This is a simple rework that requires re-welding the locator part to the plate. The problem occurred when the locator warped while it was being welded to the base plate. This can be solved either attaching the locator part mechanically or bending the plate to each side of the locator is welded on.

B. *Manual Welding Cost Estimation*

The manual welding operated in industries result in the problem such as economic cost increase to a higher level. It's a component for manually weld estimation gases, filler rod, pipe, flange, safety wear and electrode all component using in the manual welding operation. In this operation concluding intermediate process for starting position to annual level to predict with the some level of the cost. Its process maximum error occurred level of the economic system. The result of the economic analysis of this process compared to manual welding to robotic welding. In this function should be arranging systematically plan for step by step process.

C. *Robotic Welding Cost Estimation*

The initial cost of the robotic welding used in the industries is high. The comparison of manual work using MIG and TIG welding and its life is not long in the industrial systems. But in the robotic welding life duration is 18 years, So many benefits obtaining in this level. The robotic welding using gases for same of the manual process. so many economic features of the robots using in this welding. It analyses all the function to make for a different view in this process. The payoff period rapidly changes if the number of parts is increased. The payoff period is also highly dependent on the labour rate. The labour rate was determined using pay scale and is a national average for welders. The number that was given was adjusted by 1.5 times to account for other expenses like workers compensation, social security, etc. These costs include factors of setup time, welding time and material usage. The robotic welder is more cost effective in each of these areas but requires a large initial investment making it a less attractive option in the short term.

V. OTHER IMPLICATION

There are reasons why a company shouldn't use this process other than economic reasons. One reason is the impact on current employees. This is an issue that is common when automating a process. Robotic welding is more efficient and would require fewer employees than a manual process. This means that welders could potentially lose their jobs and would negatively impact them and their families. Another reason why a company may not want to implement this system is that it would require the training of an employee on how to use this system. This is not as much of an issue because the training would only take a few days before the operator would be proficient. There are also some positive impacts that implementing this automation would have. Robotic welding is less hazardous for employees because they do not have to breathe the toxic fumes that are produced during welding. The operator is able to stand clear of the fumes which will have a positive impact on their physical health. Another benefit automation has is a reduction in material usage. This means that fewer natural resources are needed to produce each part. The reason for this reduction in material is that the robot performs the weld more consistently than a manual welder. This means less welding gas and wire is lost because the weld is closer to ideal every time. These factors should be considered when deciding whether or not to implement a robotic system.

A. *Implementation*

The implementation of this idea in a manufacturing environment would be simple to complete. The biggest obstacle would be training an operator for the robot. This is a relatively simple robotic system to operate and finding someone capable of learning it should not be difficult. The implementation also requires more extensive testing of this fixture. It is not possible to determine the actual quality of the parts produced with such a limited sample size. Another issue that should be considered before implementing this system is the small market for this specific size of pipe. Assuming this process is capable of producing high-quality parts this fixture could easily be modified to accommodate other pipe sizes that are more commonly used. This would increase the number of parts that could be produced and sold to decrease the idle time the welder would likely face.

VI. RESULT AND DISCUSSION

The main advantage is to use a robotic welding system is to lower the labor and overhead involved with the welding process. Since the requirement of a single technician is to operate a robotic welding cell and since his only function is to load and unload the system, the welding process becomes much more efficient. On the other hand, with a manual robotic welding cell, the technician has to do all the part setup at which time no welding is being accomplished. Therefore, this is considered wasted time since no arc is active. be in single-column format and must be centered.

A. *Welding Material and Process Costs*

The main advantage is to use a robotic welding system is to lower the labour and overhead involved with the welding process. Since the requirement of a single technician is to operate a robotic welding cell and since his only function is to load and unload the system, the welding process becomes much more efficient. On the other hand, with a manual robotic welding cell, the technician has to do all the part setup at which time no welding is being accomplished. Therefore, this is considered wasted time since no arc is active. For a robotic welding cell, once the system has been started, it will continually weld, while the technician loads the 2nd table, which is not in use by the robotic welding system. This allows the systems to work continuously and reduce time when there is no welding occurring. Secondly, the amount of gas and electrode used by a robotic welding system is lower compared to a human welder. This is due to the welding systems automated controls that know exactly when to start the gas and when to shut it off. With a human welder, there is a little more uncertainty and therefore a little more waste. Also, the welding cell automatically trims the wire in the welder the same every time to reduce waste. Again, this is a waste of product and adds up over time. The below table shows how the efficiencies increase in every category (Labour, Electrode use, and Gas) when the welding is being done by a robot instead of a human. Therefore, this shows that over time the robotic welding system will save the customer money. Manual welding operation to make one escalator to be arranging the different type of process obtained. Basically, one escalator to make for 410 hours need in this function.

The 410 hours converting 8 hours per working day.

So, = (410÷8hrs) means,

=51.25 days.

Especially 52 working days need for to make one escalator and cost analysis for in the function.

=410* Rs120

=Rs 49,200/.(one escalators)

B. ***Monthly Cost Of One Escalators***

This type of welding to be operating for 12 or 13 experienced employee only does for in this work. Especially the labour salary per month near Rs 26000 to 28000/.The monthly manual welding for

=28000*12 employee

=Rs 3,36,000/. (Employee income for per month)

Need a maximum level of hard work, investing human resources. Employees work for allocated period only, Labour having some personal work, Safety is very important for employee (wearing safety clothes). All employee to follow the welding instruction diagram. so, in this diagram figure to follow to do for in this welding. at this time some technical problem occurred. At this time the material is not reused for at the similar process. So, we are sometimes spent for at this company to do this research many problems induced for manual welding. This type of problem to be removed and again to again not occurred in the main function for manual welding replace to robotic welding.

C. ***Robotic Welding Estimation***

The robotic welding is chosen for good stability and increases accuracy precision also. The initial cost of the robotic welding is 80 lakhs. It is a one-time investment only. In this process to be the operation for to compare manual welding is to make for one escalators duration for120 hours.

=120hours÷8hours

=15 days.

The work to be finished for just 15 working days. The robotic welding to be all work to finished for robots. Especially only need for a helper.

=120hours*Rs 80

=Rs 9600/.

The robotic welding cost for 80 Lakhs. These are an only one-time investment. In this robotic welding lifetime for 15years. To comparing for MIG welding and TIG welding only for 2 years only. Electric current common for robotic welding gas all are same using the manual welding process.

Robotic welding working for input program. In this program, all are a similar way of the process. In this type of welding all not follow instruction diagram. It's only accepted for programming system. In this robotic welding process not wastage of material and sequence mass production of a big level of industry only. In this robotic welding decreasing the labour cost and increasing productivity. One time investment of robotic welding on this robotic welding process not wastage for material and sequence mass production of a big level of industry only. In this robotic welding decreasing for the labour cost and increasing productivity. One time investment of robotic welding only for a fixed cost. So, customer expecting for good surface finish and accuracy all are obtaining robotic welding. Robotic welding requires maximum 3 helpers.

The maximum salary per helper

=Rs 16000*3 helper

=Rs48000/.

The robotic welding is used only for the high level of industry, why because at this industries having mass production and line production. So, robotic welding only for the multi level of industries. The robotic welding process working for 24 hours continuous operation will not require for freeness and safety. The robotic welding having for only for maintenance work. In this separate for maintenance employee. All the type of company having Research Development department, quality department, and maintenance department. So, no use for the external employee in maintenance work. There is external employee for this type of company to focus on to do development for the company work.

VII. CONCLUSION

This paper mainly focus on the economic analysis view of the manual welding into robotic welding. In this final view to seen by the, what are problem occurred in the manual welding in the same way to a concept of what is better process implementing a plan for robotic welding. Designed a useful part that can be robotically welded. Designed a fixture to allow the automatic welding of the part. Analysed the developed cost of the robotic welding process compared to other methods. A demonstration for the robotic welding has been carried out. In this robotic welding having all companies huge benefits and lot of problem in reducing the concept. It's a system to operate economic rate, development process, quality of the welding all of the problem easily done by the robotic welding. It's the highest level lower level to get more information about in this concept. In this paper has been provided a solution to the existing problem. The approach to this project involved designing a part, fixture, and process for welding the part. The part was designed keeping in mind the requirements that it should be useful, the components should be easily attainable, and automatic welding was a valid method for the part to be assembled.

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