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A Comparison between FSW, MIG and TIG based on Total Cost Estimation for Aluminum Pipes

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ABSTRACT

In this Work, a comprehensive practical study in total cost estimation of welded Aluminum 6061 pipes using three different types of welds, Metal Inert Gas (MIG), Tungsten Inert Gas (TIG) and Friction Stir Welding (FSW) . The cost component of joining Al 6061 aluminum pipe welding was each component cost (labor cost, Power cost, Machine cost, shield gas cost(MIG,TIG), filler metal cost(MIG,TIG) and Tool cost(FSW)) has been closely analyzed and major cost components have been included in the cost model. We used these cost models to predict the cost of Metal Inert Gas (MIG), Tungsten Inert Gas (TIG) and friction stir welded pipe joints. Initial results show that MIG and TIG welding were less cost effective compared to FS welding, but it is possible that the cost of reduced friction stirs welding with quantitative prediction.

Keywords: FSW, MIG, TIG, Aluminium pipe, cost analysis

INTRODUCTION

Aluminum can't successfully be arc welded in an air environment, due to the affinity for oxygen. If fusion welded in normal atmosphere oxidizes readily happens and this outcome in both slag inclusion and porosity in the weld, greatly reducing its mechanical properties. In modern years, there has been a potential demand for lightweight transport equipment. The use of aluminum alloys to substitution ferrous alloys in transport equipment is most effective in reducing the weight of automobiles and aerospace vehicles. Considerable tonnages of aluminum alloys are used in the transport manufacture. In that esteem, the strength to weight ratios of aluminum alloys has thus been a predominant design consideration. Several strengthening mechanisms have been used in the else 30 years to incubate new aluminum alloys with high strength to weight ratios. Stampede hardening, precipitation hardening, and improvement of grain structure provide active strengthening mechanisms [1-2].

Fusion welding of mercantile aluminum alloys is mostly hard and not bespoke for some aluminum alloy groups. The existence of protective tenacious oxide film on aluminum alloys is accountable for such difficulties. Extensive surface planning to take off the oxide film is needful before welding of some aluminum alloys. Fusion welding of Al-alloys, whilst, faces some other problems, such as, generation of welding defects such as blowholes, cracks, welding distortion, and angular distortion, which reduced the mechanical properties of weldments. Fusion welding of high strength Al-alloys caused significant changes in the microstructure of cold worked and age hardened alloys, which drastically decrease the mechanical properties of welded alloys [3-4].

In this work study effective material thickness and addition Aluminium Oxide powder on mechanical properties of friction stir welding pipes. The advantage of Hydroforming of FSW tubes is the tailoring of the starting materials that can vary in thickness and/or composition to optimize weight or performance. This tailoring is typically carried out in stamping by welding sheets of different thickness together. The blank is then stretched, formed and drawn, resulting in a part with optimized weight [5-10]. More recently, attempts have been made to weld dissimilar aluminum alloys, which ultimately could provide flexibility in design as well as optimize strength, weight, and corrosion resistance [11-15]. To date, no work has been reported on the welding of tailor welded tubes for Hydroforming. The study shows the preliminary results on Friction Stir Welding (FSW) of 2024-T3 aluminum alloy tubes and the impact of the welding process on weld quality. Welding was performed on tubes with similar thickness. The mechanical properties of the welds were assessed by hardness and tensile measurements on as-welded and heat treated tubes [16-17]. So in recent years has spread the use of friction stir welding alloys, aluminium has been used successfully in welding plate In 2013 appeared to use this method in the pipe welding aluminium has been successfully stunning and we began to develop and improve the mechanical properties of the pipes, welded by the addition Aluminium Oxide (Al_2O_3) powder during the welding process [15].

A large number of research papers are available in the literature on various aspects of FS welded aluminium alloy such material flow, development of microstructure and mechanical properties in friction stir welding for plates and sheets, but the research papers that done in pipe parts by using friction stir technique are quite rare and also there is no research in the field of determining the cost of friction stir welding It was alleged that we are one of the first researchers worked in this field in order to implement the Code cost estimation of friction stir welding.

In this Work, a comprehensive practical study in total cost estimation of welded Aluminum 6061 pipe using three different types of welds, Metal Inert Gas (MIG), Tungsten Inert Gas (TIG) and Friction Stir Welding (FSW) with rotation speed (1800 RPM) and travel speed 4mm/min. Each cost component of joining Al 6061 aluminum pipe welding was each component cost (labor cost, Power cost, Machine cost, shield gas cost(MIG,TIG), filler metal cost(MIG,TIG) and Tool cost(FSW)) has been closely analyzed and major cost components have been included in the cost model. We used these cost models to predict the cost of friction stir welded pipe joints.

EXPERIMENTAL WORK

In this work, the present optimum welding parameters are volt, 20 V and ampere 170A (TIG), 180 A (MIG), travel speed 194 mm/min (MIG), 100 mm/min (TIG) and filler size 1.2 mm. The optimum friction stir welding parameters are spindle speed 1800 RPM, travel speed 4 mm/min and material thickness 2 mm.

The cost estimate of friction stir welding, metal inert gas, and tungsten inert gas for aluminum pipes 6061 is calculated using special software. The pipe sections, 30mm, and relatively thin walled 2 mm. Wire welded at similar alloy joints using (FSW, MIG, and TIG) process. All process parameters are taken from a theoretical study in this work [18].

Cost Analysis of Aluminum 6061 Pipes Welded Joints

Welding costs may be divided into two categories; the fixed costs and variable cost. The choice of a particular joining process is usually based on cost issues. Therefore, it is necessary to develop a model for cost estimation. Various cost components are available for cost estimation. The commonly occurring components are discussed below. Other cost components critical for special products and processes must be included during cost estimation on a case-specific basis. The typical components of a cost estimate are as follows [19-20]:

- Labor cost (weld preparation time + actual weld time) (FSW, MIG, TIG)
- Power cost (FSW, MIG, TIG)
- Machine cost (FSW, MIG, TIG)
- Tool cost (FSW)
- Shielding gas cost (MIG, TIG)
- Filler material (MIG, TIG)

Weld Time

The weld time equation for calculating is given below: -

$$\text{Weld time } (W_T)\ (\text{FSW, MIG, TIG}) = \frac{L}{F} + \frac{d}{F_d} + T_d \tag{1}$$

This is one of the most expensive elements contributing to the total weld cost. It should be accounted for properly because careful attention could suggest ways and means to increase productivity by any change that permits a reduction of the total workforce for the job. Because this process is applied semi-automatically and automatically, the operator factor can vary widely. Operator factors for semiautomatic welding usually range from 25% to as high as 60%. The cost of labor estimation is based on weld preparation time, a number of weld runs and lengths of welds. The rate of production determines the number of working hours and the product of the hourly labor rate and the number of labor hours determines the cost of labor. The model also includes the break time for which the laborers are paid. The labor cost estimation equation for calculating is given below Eq.2 and Eq.3 [19-20].

$$\text{Labor cost (MIG, TIG)} = [3.471 \times L] \times \frac{C_l}{0.5} \tag{2}$$

$$\text{Labor cost (FSW)} = \frac{W_T \times C_L}{54} \tag{3}$$

Machine Cost

Machine cost includes the cost of welding equipment, weld preparation equipment, and special handling equipment. The hourly cost of the equipment is calculated from the costs for depreciation, interest, and maintenance, together with an estimate of the annual usage time. The machine cost estimation equation for calculating friction stir welding is given the Eq.3 and the machine cost estimation equation for calculating MIG and TIG welding is given the Eq.4 [18-20].

$$\text{Machine cost(FSW)} = \frac{[W_T + T_S + T_{ch}] \times C_M}{57} \tag{4}$$

$$\text{Machinery cost(MIG, TIG)} = 8.772 \times 10^{-4} \times C_M \times L \tag{5}$$

Power Cost

The cost of power includes the number of working hours of the welding machine and its power consumption. The power consumed depends on the power rating of each machine. Heavy machines usually tend to higher rates of power consumption. Hence, the power rating of each FSW, MIG and TIG machine is used to calculate the cost of power. The power cost estimation equation for calculating friction stir welding is given Eq.6 and Eq.7. The power cost estimation equation for calculating MIG and TIG welding is given the Eq.8 [19-20].

$$\text{Power cost(FSW)} = 0.014 \times P_R \times W_T \times C_P \tag{6}$$

$$\text{Power rating } P_R \text{ (FSW)} = 16.7 \times F_x \times w \times r_s \tag{7}$$

$$\text{Power cost (MIG, TIG)} = \frac{I \times V \times C_P}{57000} \times W_T \tag{8}$$

Shielding Gas Cost

Gas-shielded, tungsten inert gas and metal inert gas is a very communal and multilateral welding process. The two most common (but not exclusive) shielding gasses used with the tungsten inert gas and metal inert gas process are carbon dioxide (CO_2) and a binary blend of 85% argon (Ar) / 15% CO2. The equation for calculating the cost of the shielding gas is given Eq.8 [20-23]:

$$\text{Shield gas cost(MIG, TIG)} = 4.167 \times 10^{-3} \times C_g \times L \tag{9}$$

Filler Material

The filler metal selection should be closely identified with the base material being welded. In metal inert gas welding, the filler metal not only conducts current to the arc zone, but collect reinforcement in the completed weld joint. In tungsten inert gas and metal inert gas welding, the filler rod is fed into the molten puddle by hand. The choice of filler rod is very important as the rod must correctly match the material and allow you will be welding. The material thickness of pipes to be welded determines the diameter of the electrode selection. Tungsten inert gas welding, there's a lot going on. Generally, argon is running out of the torch. You have an electrode that's made of tungsten. You have an electrode that's made of tungsten. Too high heat. The equation for calculating the cost of the filler metal is given Eq.10

$$\text{Cost of electrode(MIG, TIG)} = 0.0487 \times Z^2 \times L \tag{10}$$

Tool Cost

The design of the tool is a critical factor as a good tool can improve both the quality of the weld and the maximum possible welding speed. It is desirable that the tool material is high carbon steel, sufficiently strong, tough and hardwearing, at the welding temperature. [8]. The tool pin penetration depth was suggested to be at least about 90% of the work piece thickness. The tooling cost provides the cost incurred in using a particular tool for making a joint. It also takes into consideration the life of the tool. The tool cost estimation equation for calculating is given Eq.11.

$$\text{Tool cost(FSW)} = \frac{C_T \times Q \times W_T}{T} \tag{11}$$

Experimental studies the total cost of Friction stir welded joints can be calculated as follows. This suggestion model considers various cost components involved in the cost estimation of an FSW and MIG, TIG joint see Eq.12 and Eq.13.

$$\text{Total cost}_{\text{(FSW)}} = L_C + M_C + P_C + T_C \tag{12}$$

$$\text{Total cost}_{\text{(MIG,TIG)}} = L_C + P_C + M_C + F_C + S_C \tag{13}$$

RESULT AND DISCUSSION

The contribution of Cost Component on Total Cost Fig. 1 illustrates the cost distribution for the example, friction stir welding without considering material cost which includes a large portion (92%) of the total cost. In Fig.2 illustrates the cost distribution for the example MIG and TIG process without considering material cost which includes a large portion (95%) of the total cost. It has been found that the cost of labor is the major contributor towards the total cost of a joint. The second major of machine cost account in calculating the total cost the results of a case study using this model were reasonable. Simultaneously, a set of cost estimates is generated based on welder's experience.

Action has been compared between friction stir welding (FSW) pipes, metal inert gas (MIG) for pipes, and tungsten inert gas (TIG) for pipes in terms of the total cost of the welding line. Calculation suggestion models developed for comparison of direct welding costs of virtually any three welding methods. The cost elements are machine cost, labor cost, power cost, tool cost (FSW), filler cost (MIG, TIG) and shielding gas cost (MIG, TIG). Welding duty cycles were taken from the measurements in the factories military training sector. Welding costs were calculated per joint of the fabricated weld. Generally, MIG and TIG welding was more cost effective in this case study see Fig.3.

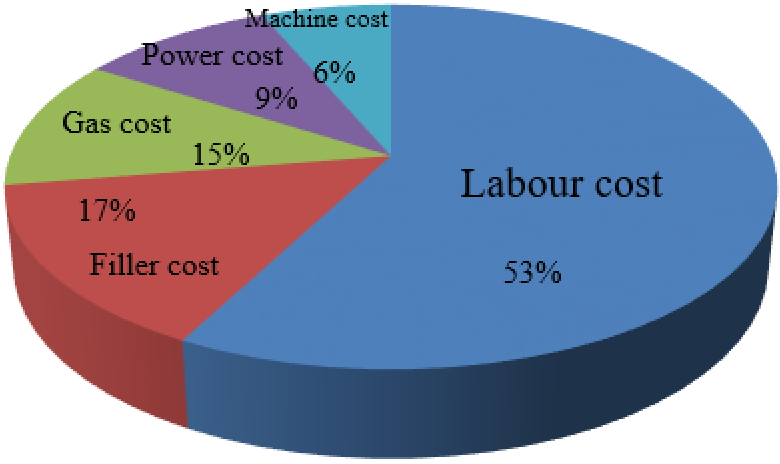

Fig. 1 The cost distribution for weld joint fabricated using MIG and TIG process

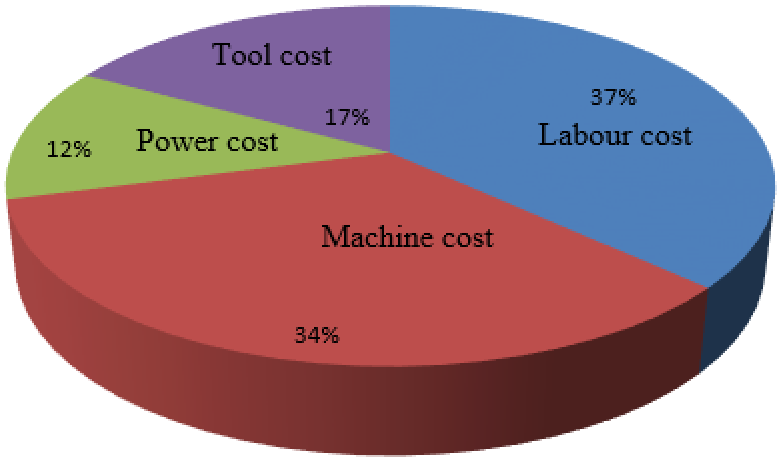

Fig. 2 The cost distribution for weld joint fabricated using FSW process

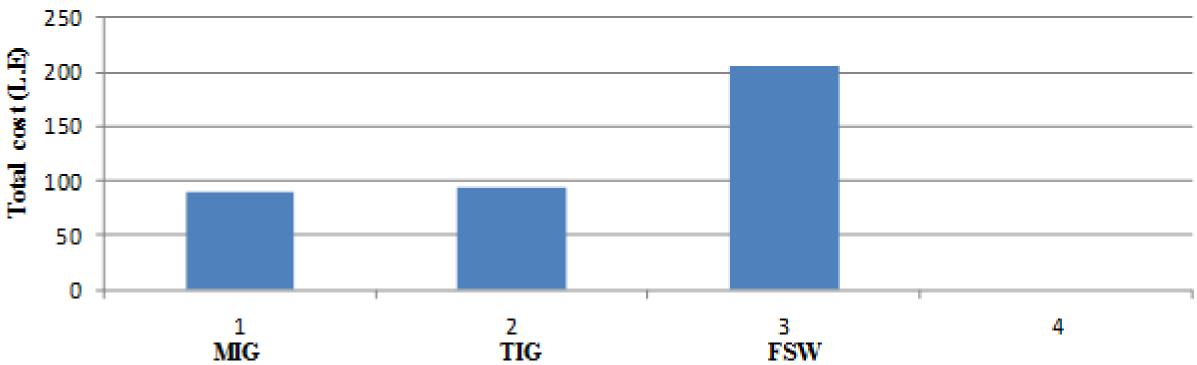

Fig. 3 Relation between total cost and type of welded (FSW, MIG and TIG)

Through that, a cost comparison with lots of information shows the order of volume and the share of costs in the different group for good overview information. It should also be stressed that none of the FSW process advantages, such as low distortion, high strength, regular quality and improved occupational health issues, have been taken into computation in the calculations due to the fact that no general estimate can be made for these issues.

CONCLUSIONS

It has been found that the cost of labor is the major contributor towards the total cost of a joint. MIG and TIG welding was less cost effective comparative FS welding, but it is possible that the cost of reduced friction stirs welding with quantitative prediction. We are currently working on building a software model for friction stir welding for welding cost estimate.

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Nomenclature

CL	Unit labor cost (L.E/HR)
CM	Unit machine cost (L.E /HR)
CP	Unit cost of power (L.E /kWh)
CT	Unit cost of tool (L.E /tool)
Cpc	Variable power cost per joint (L.E)
Clc	Labor cost per joint (L.E)
Cmc	Machine cost per joint (L.E)
Ct	Tool cost per joint (L.E)
Ctotal	Total cost of the joint (L.E)
F	Tool feed rate (mm/min)
Fp	Tool plunge feed rate (mm/min)
L	Length of the weld (mm)
n	Number of weld passes
S	Travel speed (mm/min)
T_{Ch}	Tool change-over time (min)
Td	Dwell time (min)
TS	Setup time (min)
TW	Weld preparation time (min)
Z	Thickness of the base material (mm)
CL	Labor rate (L.E/hr)
Mc	Machine cost (L.E /hr)
I	Current (amps)
V	Voltage (volts)
Cp	Power cost (L.E /kWh)
Cg	Gas cost (L.E /ft3)