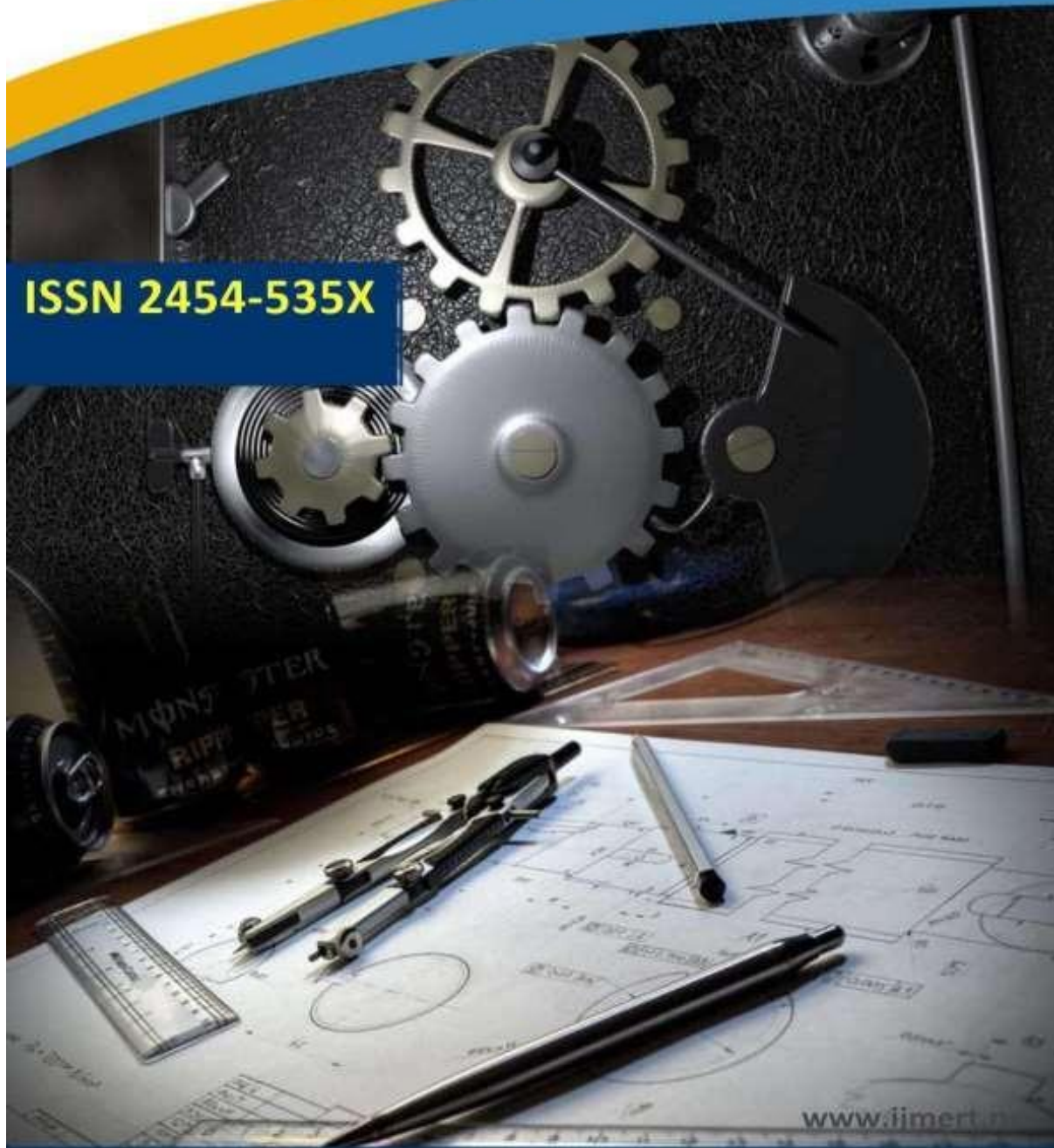




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Effect of Using Different Welding Currents and Distributed Heat Fluxes on the Geometrical Weld Bead Characteristics

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ABSTRACT:

The goal of the current work is to experimentally investigate how various currents and dispersed heat fluxes affect the geometrical weld bead form characteristic of low carbon steel that has been fused utilizing a particular kind of fusion welding method. Designs for butt welded joints were created by welding a sheet of 4 mm thickness in a single pass at various input parameters (welding voltage and welding current). In order to ascertain its thermal influence on the welded bead joint geometry in terms of bead geometric characteristics (weld penetration, weld bead width, weld bead height, and reinforcement) and shape factors (weld penetration shape factor and Weld reinforcement shape factor), distributed heat flux and welding velocity were computed based on these factors. Increasing the welding current was discovered to

KEYWORDS: Welding parameter; heat Flux; welding velocity; shape factor.

INTRODUCTION

The penetration shape factor (W/P), reinforcement shape factor (W/R), distributed heat flux, and depth of penetration (P), width of bead (W), height of reinforcement (R), which are considered the output variables of the CO₂ - MAG welding, are all examined in this work for the thermal influence of welding variables.

Fusion welding processes are widely used in the fabrication of numerous engineering applications, including the building of nuclear reactors, the routine maintenance of boiler accessories, the shipbuilding and marine industries, and the automotive and naval sectors. One type of fusion welding is shielded metal arc welding, which creates a junction between two base metals by heating, melting, and solidifying the parent metals using a transitory heating source movement [1]. In this study, the welding process is an important part of several The welding

input parameters play a crucial role in achieving the quality of the weld joint. It is possible to describe a joint's quality in terms of its mechanical qualities, distortion, and weld bead shape. Generally speaking, the goal of the entire welding process is to produce a welded junction with the necessary weld bead characteristics and sufficient mechanical qualities with minimal deformation [5]. Welding is a general process that joins two materials to create. The impact of welding parameters on penetration depth, such as current, voltage, and welding velocity, was taken into account. Low carbon steel (LCS) with a temperature of 0.14%C and dimensions of 75 x 50 x 6 mm was welded at a voltage of 18 volts.

METHODOLOGY

The welded bead joint geometry is regarded in the present work. The sheets have 4 mm thickness and, the joint is 60 mm long in the direction of welding; they are welded via a single pass butt weld. The distributed heat flux (q'') was calculated by the equation below depending on the welding parameters, like welding voltage, welding current voltage and the MAG welding process efficiency, respectively [9-12].

$q'' = \eta I V$ (1) Where:



V is the welding voltage (Volt).

I is the welding current (ampere).

η is the efficiency of MAG welding process, which is equal to 0.8.

The weld bead width is the peak weld metal deposited width. This affects the rate flux of consumption. The width of bead is in the direct proportion to the voltage of welding, current of welding and the electrode diameter. It's inversely proportional to the velocity of welding [13]. Penetration is the peak distance between the base metal sheet top and the fusion depth. It's affected via the welding velocity and current. Also, it is directly proportional to current and inversely proportional to velocity and electrode diameter. A stable arc raises the penetration, since the wanders of arc is minimized which permits more effective heat transfer [14-16]. The reinforcement is the maximum height between the top of weld metal and the top of the base metal surface. It affects the weld strength and feed rate of wire feed. Raising the rate of wire raises the reinforcement without taking into account the current of welding. It's inversely proportional to welding velocity, welding voltage and electrode diameter. [17]. The penetration (P) of weld, the width (W) of bead and the reinforcement (R) height of weld were measured by using an optical microscope equipped with scales in the x and y directions, see Fig. 1. The weld penetration shape factor (W/P) is the ratio of the width of weld bead to the penetration height of weld is calculated from equation [18-19]:

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Weld penetration shape factor = (W/P) (2)

ratio of the weld bead width to the weld height of reinforcement, is calculated from equations:

Weld reinforcement shape factor = (W/R) (3)

The welding velocity is the rate of electrode travel along the seam, or the rate of work travel under the electrode along the seam. It is calculated for each welded specimen by the equation below [20]: $U = S / t$ (4)

Where,

t is the arc time of the welding in second.

S is the constant line welding in (mm).

U is the welding velocity (U) in (mm/sec).

Figure 1 depicts the shape of the weld bead of the butt welded joint with the main weld bead geometrical characteristics.

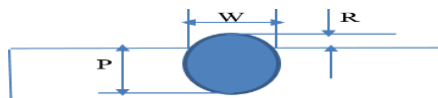


Figure 1. Weld Bead Shape of Butt Welded Joint.

MATERIAL AND METHODS

LCS (AISI 1015) material and wire electrode

(ER70S-4) of (1.2 mm) diameter was used in shape of sheet with 4 mm thickness. Firstly, 22 pieces



with dimensions 30 mm× 60 mm× 4 mm were prepared to be welded in closed Square butt weld bead joint design, see Fig. 2 for one weldment. Single side single pass was applied with welding machine type BEAM-350 South Korean made by MAG welding process see Fig. 3, the chemical composition of the used materials standard type wire electrode are given in Table (1) indicates that the used material matches to the standard base metal [21]. Having finished the welding processes

using the welding conditions shown in Table (2), eleven welded specimens were cut normal to the welding direction using a power hacksaw machine. After that, with the aid of a measuring instrument, the penetration depth, bead width and bead reinforcement of the welded specimens were measured. Additionally, penetration shape factor (W/P), reinforcement shape factor (W/R), welding velocity (U) and distributed heat flux ($q\bullet$) were calculated and also given in Table (2).

Table 1. The Chemical Composition Of Base Metal (LCS) With Its Standard Alloy And Wire Electrode

Material	C	Mn	P	S	Si	Cr	Ni	AL	Mo	Cu	Co	V	Fe
Experiment al Material Base metal	0.13	0.450	0.003	0.003	0.015	0.001	0.043	0.036	0.002	0.001	0.007	0.001	Bal.
Standard AISI 1015[17]	0.13-0.18	0.3-0.6	0.04 max	0.05 max	-----	-----	---	-----	-----	-----	-----	-----	---
ER70S-4	0.07-0.15	1-1.5	0.035	0.025	0.65 - 0.85	-----	---	-----	-----	0.5	-----	-----	---

**Table 2.** Used Input Welding Parameters with the Output Values.

S.No	I(Amp.)	Volt)V	t(min)	(mm/min.)U	q•(J/sec)	P(mm)	W(mm)	R(mm)	W/P	W/R
1	39	20	1.052	63.12	624	1.69	6.51	3.84	3.85	1.69
2	47	21	1.333	79.98	789.6	2.01	8.76	2.83	4.36	3.09
3	51	21	1.2	72	856.8	1.41	9.53	3.01	6.76	3.17
4	54	20	1.666	99.96	864	1.89	11.04	2.98	5.84	3.7
5	56	19	1.132	67.92	851.2	2.77	7.11	3.99	2.57	1.78
6	60	19	1.304	78.24	912	1.94	7.19	3.88	3.71	1.85
7	78	20	1.578	94.68	1248	2.63	11.79	3.04	4.48	3.88
8	86	19	1.276	76.56	1307.2	2.02	9.75	3.21	4.82	3.04
9	88	20	1.237	74.22	1408	2.33	11.3	3.18	4.84	3.55
10	90	20	1.224	73.5	1440	2.35	11.25	3.2	4.78	3.52
11	92	20	1.25	75	1472	2.36	11.3	3.15	4.79	3.58

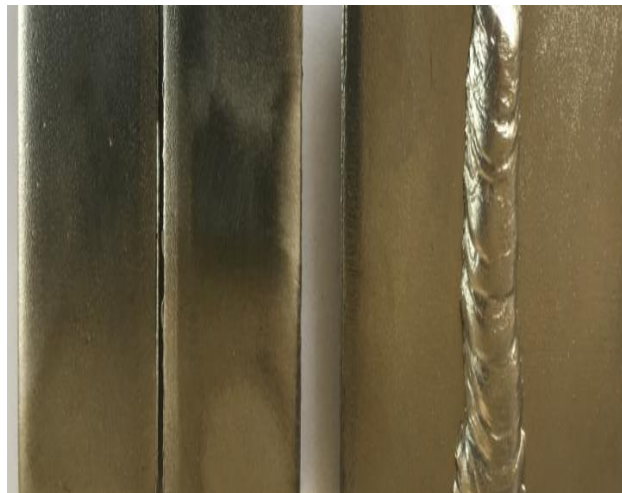
**Figure 2.** Specimens before(left) and after (right)welding process.



Figure 3. MAG Welding Machine Used for the Experiment

RESULTS AND DISCUSSION

Effects of welding current on the thermal and geometrical weld bead characteristics

Figure 4 depicts the influence of welding current on the weld penetration (fusion depth), it can be observed that the penetration first increased slightly and finally stayed stable except that the penetration increased and decreased sharply a slight variation on the welding current because of the less weld reinforcement and increasing thermal the effect on region of the welding joint.

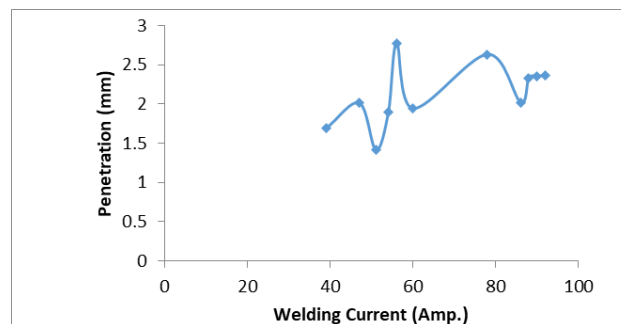


Figure 4. Welding Current Influence on the Weld Penetration

Figure 5 reveals the welding current influence on the width of the bead, it can be noted that the width of the bead increased first slightly and then remained constant due to less weld reinforcement and more thermal effect on the weld bead joint.

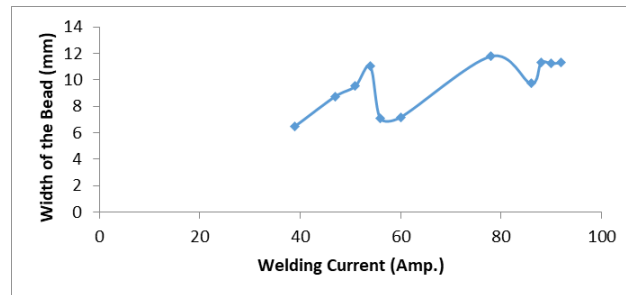


Figure 5. Effect of Welding Current on the Width of the Bead

Figure 6 depicts the effect of the welding current on the reinforcement, it can be noticed that the reinforcement first decreased slightly and eventually kept stable due to less weld reinforcement and more thermal influence on the weld bead joint.

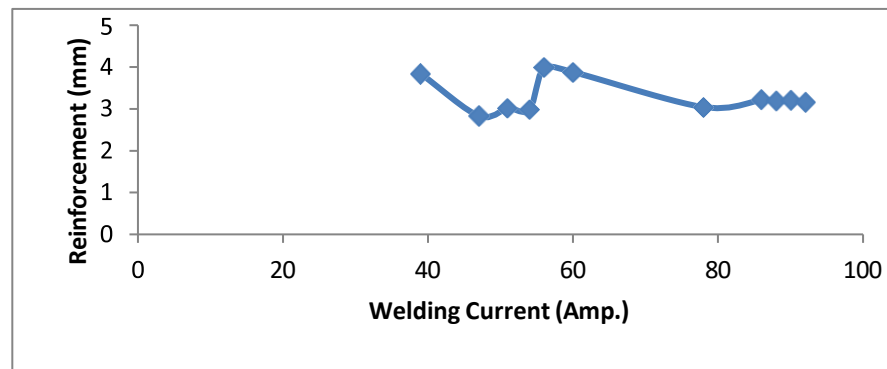


Figure 6. Welding Current Influence on the Reinforcement

Figure 7 manifests the welding current influence on the penetration shape factors, it can be seen that except the current value 51 amp the penetration has small a value but at the current value 56 amp, it increased.

The (W/P) increase is due to the less penetration at the weld bead and owing to less thermal effect (less melting) and then remained constant due to less weld reinforcement and more thermal effect on the weld bead joint.

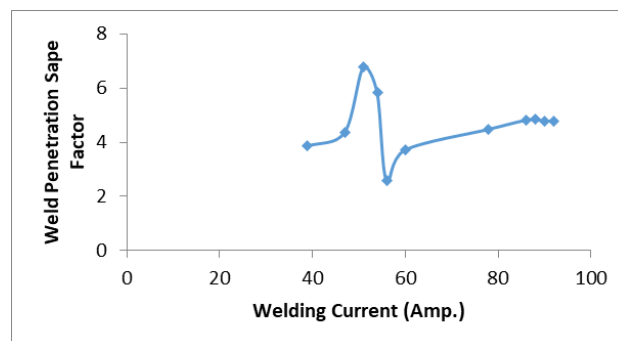


Figure 7. Welding Current Influence on the Weld Penetration Shape Factors

Figure 8 illustrates the welding current influence on the reinforcement shape factor, it can be seen that except the current value 54 amp, the reinforcement small value but at the current value 56 amp. The reinforcement becomes more. The (W/R) first increased due to the less reinforcement at the weld bead and owing to the less thermal effect (less melting) and then became stable due to the more thermal effect on the weld bead joint.

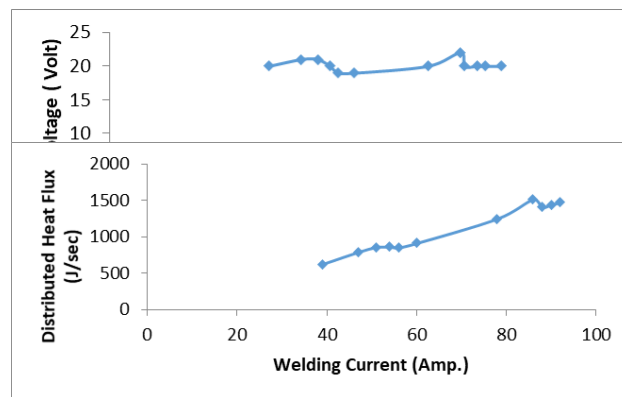


Figure 10. Welding Current Influence on the Arc Voltage

Figure 11 demonstrates the welding current influence on the distributed heat flux, it can be noted that as the welding currents was increased, distributed heat flux increased due to more heat generation at the weld joint.

Figure 11. Welding Current Influence on the Distributed Heat Flux

Weld Reinforcement Shape Factor

Figure 8. Welding Current Influence on the Weld Reinforcement Shape Factors

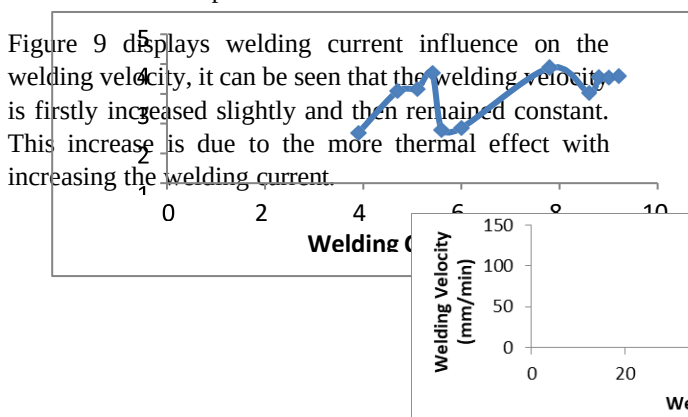


Figure 9. Welding Current Influence on the Welding Velocity

Figure 10 clarifies the welding current influence on the arc voltage, it can be seen that the arc voltage almost remained with increasing welding current, and this behavior naturally occurs in MAG welding.

Distributed Heat Flux Effect on the Thermal and Geometrical Weld Bead Characteristics

Figure 12 reveals the influence of the distributed heat flux on the welding velocity, it can be seen that welding velocity increased slightly and then remain stable except that the welding velocity increased and decreased sharply with the a little

change in the distributed heat flux due to thermal effect by the heat accumulation in the welding joint as well as sluggish of welding process.

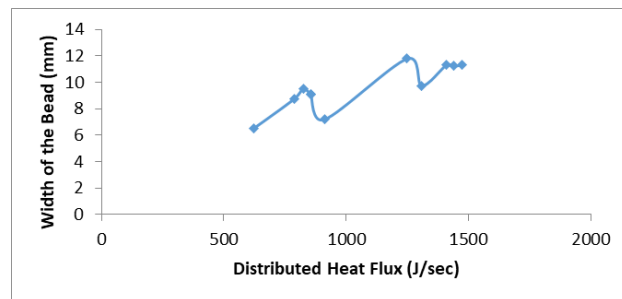


Figure 12. Effect of Distributed Heat Flux on the Welding Velocity

flux that lead to increase the penetration.

Figure 13 depicts the effect of the distributed heat flux on the weld penetration (fusion depth), it can be noted that the penetration increased first slightly and then stayed stable except that the penetration first increased and then decreased sharply at constant distributed heat flux because of thermal effect by heat accumulation in the welding joint as well as sluggish of welding process.

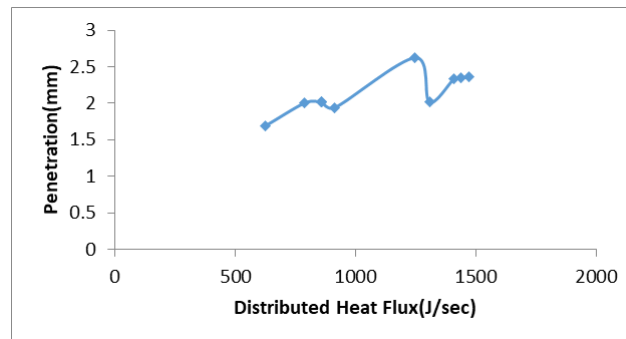


Figure 13. Effect of Distributed Heat Flux on the Penetration

Figure 14 reveals the effect of distributed heat flux on width of the bead, it can be noticed that the width of the bead first increased slightly and then remained constant owing to more distribution above the weld joint due to the distributed heat flux increased that caused more homogeneity between the melted base metal and filler.

Figure 14. Effect of Distributed Heat Flux on the Width of the Bead

Figure 15 displays the effect of distributed heat flux on the reinforcement, it can be seen that the reinforcement first reduced slightly and then stayed stable due to increase the distributed heat

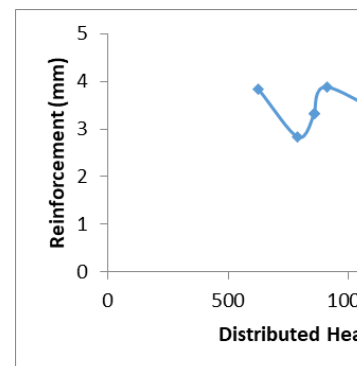


Figure 15. Effect of Distributed Heat Flux on the Reinforcement

Figure 16 views the effect of distributed heat flux on the weld penetration shape factor, it can be noted that at the weld penetration shape factor



remained stable except that the weld penetration shape factor first increased and then decreased remarkably with a little change because of thermal effect by heat accumulation in the welding joint as well as sluggish of welding process.

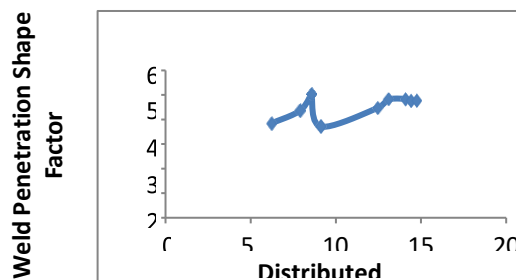


Figure 16. Effect of Distributed Heat Flux on the Weld Penetration Shape Factor

Figure 17 depicts the distributed heat flux influence on the weld reinforcement shape factor, it can be noticed that the weld reinforcement shape factor first increased and then remained stable.

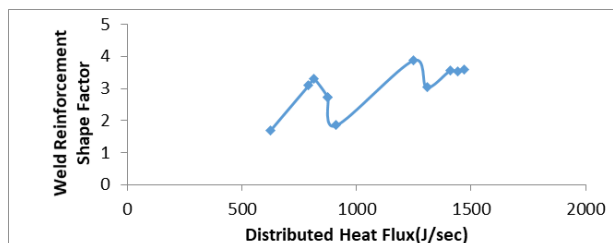


Figure 17. Effect of Distributed Heat Flux on the Weld Reinforcement Shape Factor

CONCLUSION AND POLICY SUGGESTIONS

The conclusions that can be deduced from the present results: The distributed heat flux and the current were found to be more effective on the Geometrical Weld Bead Characteristics (P, W, R, W/R and W/P) of the weld joint of low carbon steel.

1. Increasing the welding current caused an increase in weld penetration, width of the bead, weld reinforcement shape factor and distributed heat flux, while reinforcement, (W/R), welding velocity and welding voltage remained a quasi-steady.

2. As the distributed heat flux increased, the penetration slightly increased, the width of the bead significantly increased and the weld reinforcement shape factor was also increased, whereas the welding velocity, reinforcement and weld penetration shape factor stayed almost constant.

3. For future studies, the need for new research investigations the effect of the used present welding parameters and thermal fluxes on the geometrical characteristics of welded joint made by various welding techniques, such as TIG, submerge, etc.

4. Study influence of using other welding input on the weld bead shape factor that have been not considered in the present manuscript, like temperature distribution and profile, velocity distribution and profile.

5. Modeling and optimization of welding parameters for obtaining mathematical models describing relation between these parameters and the welding response.

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