IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Effect of Welding Voltage on the Dimensions of Bead in Tungsten Inert Gas Welding Process

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Abstract

Welding is a powerful method of joining two or more structural parts. The industries use machines which are constructed of several parts. These parts may have joints to increase their length or surfaced area. Welding is one of the important methods of making joints and the tungsten inert gas welding is a very important method for welding process. In welding beads are formed which are consisted of /reinforcement height, depth of penetration and weld width. These dimensions of the beads indirectly decide the mechanical properties of the weld. In this work many experiments were performed with Tungsten Inert Gas Welding machine to critically analyze the effect of welding voltage on the dimensions of the bead. All the other input variables except the welding voltage were fixed, as the feed rate at 8.47 mm/s, welding speed at 1.19 mm/s and welding current at 100 A for whole the experimentation period. Only the values of welding voltage were varied and the effect of this variation on depth of penetration, weld width and reinforcement height was studied. Total 6 pairs of mild steel plates of dimensions 75 mm x 50 mm x 5 mm were welded for 6 variations of welding voltage. The results were tabulated and were expressed in three different diagrams in which one was for depth of penetration, one was for reinforcement height and one was for weld width. This study explains the sensitivity analysis of the effect of the welding voltage on the three dimensions of the weld bead.

Key Words: Tungsten Inert Gas Welding, Feed Rate, Weld Bead, Input Process Parameters, Reinforcement Height.

1. Introduction

The structures and different parts of any machinery often require addition in length or thickness, which can be attained by several methods but the welding is popular among all the joining methods. The parts of structures to be joined may be of similar or dissimilar material [1]. Several problems are faced in dissimilar welding processes which may result in formation of cracks in weld and heat affected zones, which reduces overall strength of the whole welded structure. Proper research, investigation and detailed study of the process is needed to overcome such problems. The welding parameters must be optimized with their effect on the properties of the weld bead. The mechanical properties of the weld are closely related with the dimensions of the weld bead [2]. The mechanical properties of the weld vary in the welding process due to the variation of input process parameters. The input welding parameters which are generally applied in the work are feed rate, welding voltage, welding speed and welding current. If the weld width is not optimum, the mechanical properties may be in sufficient to bear the applied loads. The reinforcement height of the bead must be proper to provide sufficient strength. The reinforcement height is the distance between the surface of the work piece and the top of the weld. If we consider mechanical engineering the reinforcement height creates problem by producing stress concentration and the metallurgical point of view suggests to have larger reinforcement height so that proper strength is developed due to larger surface area. These two different views suggest proper investigation to have optimum input values [3]. The depth of penetration is the depth upto which, the mixing of base metal material with electrode material takes place. The depth of penetration should be high in the weld but the molten volume of the weld material in any particular set of inputs is considered to be fixed. T/he product of weld width, depth of penetration and reinforcement height is generally constant in any particular set of input parameters, so if weld width is decreased, the product of depth of penetration and reinforcement height will be increased. Other dimensions can be explained in similar manner. To obtain better mechanical properties of the weld, the optimum values of depth of penetration, reinforcement height and weld width are highly needed [4]. The important input welding process parameters which are generally considered by the researchers are depth of penetration, reinforcement height, weld width, feed rate and electrode angle. These parameters affect the properties of weld and should be optimized. Tungsten inert gas welding process was selected for investigation in this work. In TIG welding process generally non consumable tungsten electrode is utilized in the welding torch with a constant current power supply. The range of Current values in TIG welding process is taken as 3 A to 300 A, and the voltage values are taken in the range between 10 V to 35 V. The TIG welding process may be applied manually in some cases and with semi automatic mode in some other cases. In this process non-consumable tungsten electrode is used but some filler material may also be used if some extra properties are to be added. Argon is a heavy gas and can be used as shielding gas in this process but it is generally mixed with helium to be used as shielding gasses. The shielding gases protect the weld from atmospheric contamination [5]. Several extremely materials, ferrous and non ferrous can be welded by TIG welding process. A strong weld can be obtained by welding the sensitive materials which may be aluminum, copper alloys or magnesium. The sensitive metals readily react with atmospheric gasses to form contaminations in any other processes of welding where proper shielding gasses are not used. If the depth of penetration needed is more, direct current electrode negative should be used so that two third of heat is developed at the work piece. The cooling arrangement is needed if the welding current used is very high [9]. The inside diameter of nozzle is taken about 3 times the diameter of electrode for proper weld in TIG welding process. The welding voltage is directly proportional to heat rate, it should be optimum for the best weld.

2. Experimental Procedure

TIG welding process is an important arc welding process in which non consumable tungsten electrodes are used with or without consumable filler metals. Mild steel plates of dimensions 75 mm x 50 mm x 6 mm were cut from a long plate for making the weld. The plates were cut with the help of a power hack saw. A rectifier was utilized for power transmission to the work pieces with the help of a torch and a tungsten electrode. An electric arc was created in between the work pieces and the tungsten electrode. The energy so generated is conducted through the arc and a column of highly ionized gasses and metal vapours. The temperature of about twenty thousand degree centigrade or more is p/roduced in this process. This high heat is used to melt the material and to form the joint. The measurement of bead dimensions with the help of metrological microscope is shown in figure 1, and the process of tungsten inert gas welding process is shown in figure 2.

Figure 1: Measurement of weld bead dimensions using metrological microscope

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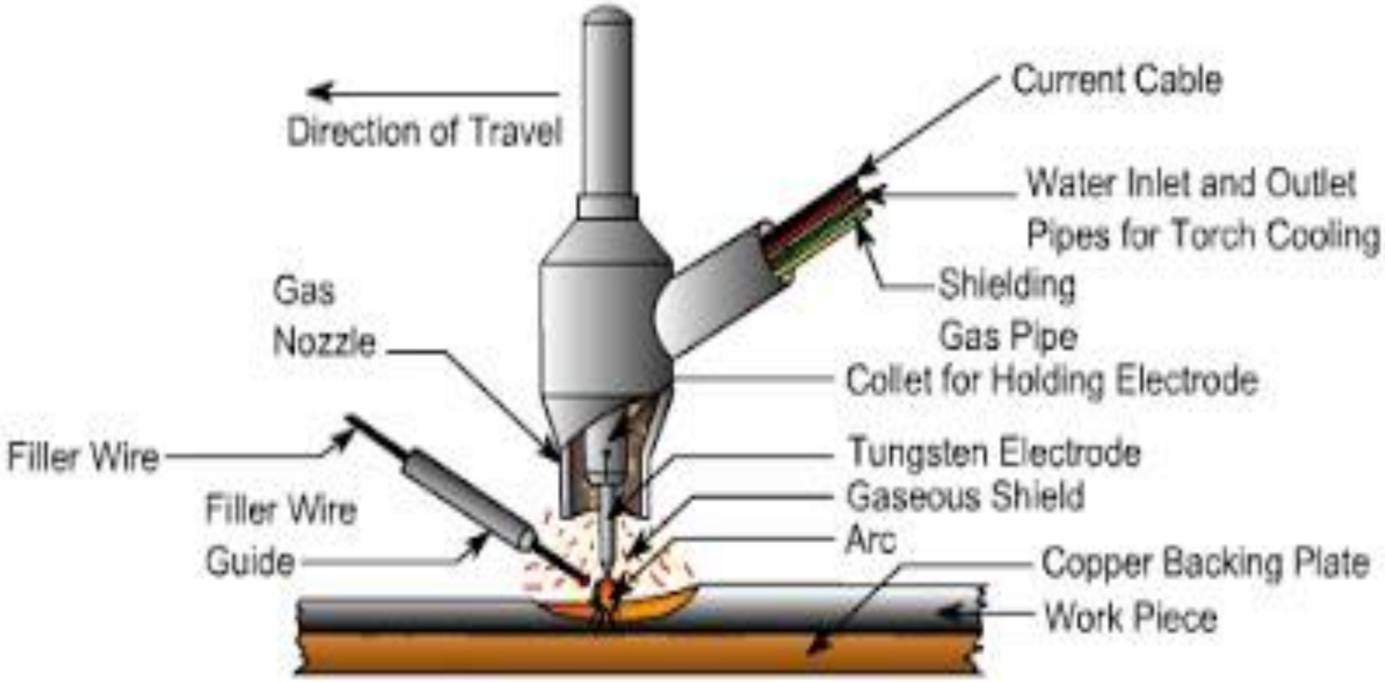

/ Figure 2 :Tungsten inert gas welding Process

To investigate the effect of welding voltage on the dimensions of weld bead, total 12 mild steel plates, all having dimensions of 75 mm x 50 mm x 6 mm were cut from a long plate with the help of a power hack saw. These pieces were rubbed properly with emery papers to remove rust dust etc. so that after welding the weld is contamination free. The feed rate was fixed at 8.47 mm/s, the current was fixed at 100 A, and travel speed of welding was fixed as 1.19 mm/s. There were total 6 welded joints developed to study the effect of welding current. The values of welding voltage were taken as 9 V, 9.3 V, 9.6 V, 10 V, 10.2 V and 10.5 V, respectively. The weld beads were sectioned transversely at two surfaces in such a way that middle portion containing 1 mm thick complete portion containing weld, heat affected zone and base metal were selected for investigation. The welds are generally not proper at start and at the end of the work pieces due to several reasons so these portions are not proper for the study hence these portions are removed. The sectioned parts were ground with the help of emery belt grinders of grades 0, 2 and 3 so that weld width, depth of penetration and reinforcement height become clear and visible. The ground portions were polished with double disk polishing machine. Etching process was done to the polished pieces with the help of a mixture of 2 % nitric acid and 98 % ethyl alcohol solution. The weld width, depth of penetration and reinforcement height were measured for every weld with the help of digital sliding calipers and metrological microscope and tabulated in the table 1. The effect of welding voltage on the dimensions of weld bead were studied with the help of the data of the table showing the relation between welding voltage with weld width, reinforcement height and depth of penetration.

Table 1: Variation of Weld Bead, Depth of Penetration and Reinforcement Height with Welding Voltage

SN	Current (A)	s (Welding Speed) (mm/s)	F (Feed Rate) (mm/s)	Voltage (V)	W W(mm)	DOP(mm)	RH (mm)
1	100	1.19	8.47	9.0	8.36	1.44	1.90
2	100	1.19	8.47	9.3	8.38	1.40	1.91
3	100	1.19	8.47	9.6	8.41	1.37	1.93
4	100	1.19	8.47	10.0	8.49	1.31	1.95
5	100	1.19	8.47	10.2	8.56	1.27	1.97
6	100	1.19	8.47	10.5	8.61	1.25	1.99

3. Result and Discussion

3.1 Effect of Welding Voltage on Weld Width

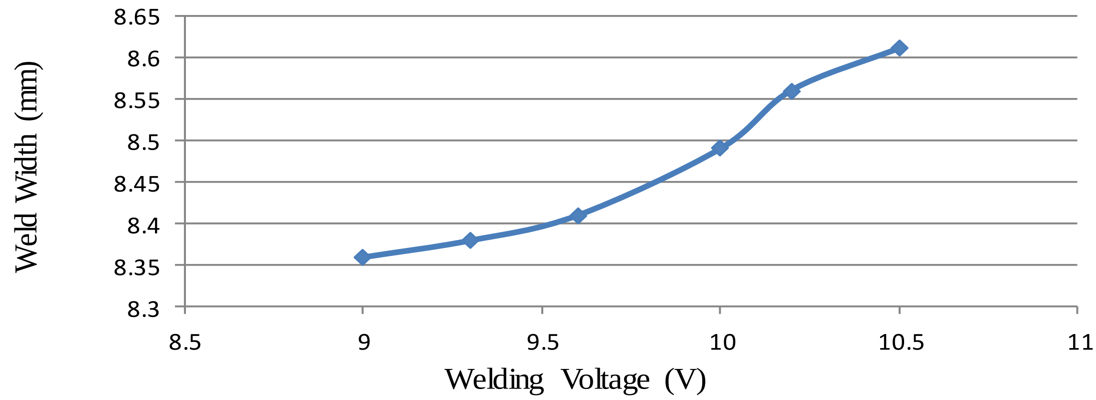

Figure 1 Effect of Welding Voltage on Weld Width

The weld width increased throughout our experimental range with increase of welding voltage as shown in figure1. When the voltage was at 9.0 V, the weld width was found as 8.36 mm. If the voltage was increased to 9.3 V, the weld width increased to 8.38 mm and when the voltage was raised to 9.6 V, the weld width increased to 8.41 mm. When the voltage was increased to 10.0 V, the weld width increased to 8.49 mm and when the voltage was increased to 10.2 V, the weld width increased to 8.56 mm and finally when the voltage was increased to 10.5 V, the weld width increased to 8.61 mm. When the welding voltage is increased the input heat increases as input heat is proportional to the voltage of welding. The input heat is proportional to melt volume or volume of weld. The weld has three major dimensions as weld width, depth of penetration and reinforcement height. If voltage is increased, these dimensions can be supposed to be increased. Sometimes one or more dimensions show opposite behavior i.e. reduces with increase of voltage in that case the remaining dimensions must compensate the opposite behavior presented.

3.2 Effect of Welding Voltage on Depth of Penetration

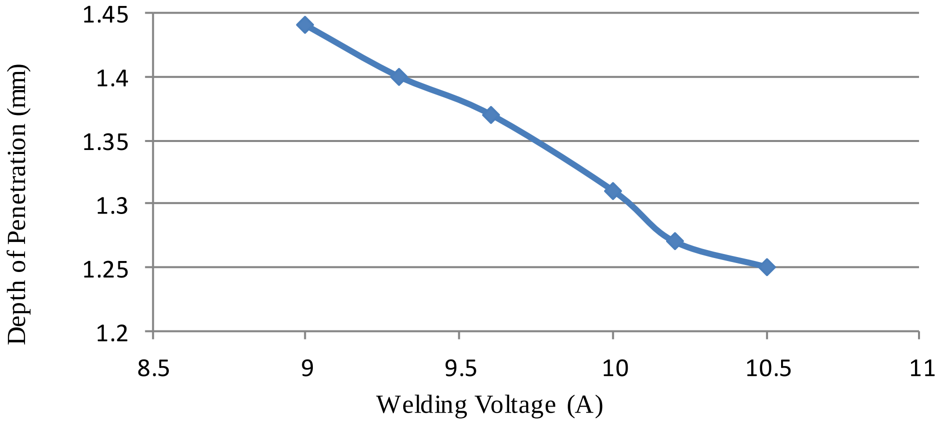

Figure 2 Effect of Welding Voltageeed on Depth of Penetration

The depth of penetration decreased throughout our experimental range with increase of welding voltage as shown in figure 2. When the voltage was at 9.0 V, the depth of penetration was found as 1.44 mm. If the voltage was increased to 9.3 V, the depth of penetration decreased to 1.40 mm and when the voltage was raised to 9.6 V, the depth of penetration decreased to 1.37 mm. When the voltage was increased to 10.0 V, the depth of penetration decreased to 1.31 mm and when the voltage was increased to 10.2 V, the depth of penetration decreased to 1.27 mm and finally when the voltage was increased to 10.5 V, the depth of penetration decreased to 1.25 mm. When the welding voltage is increased the input heat increases as input heat is proportional to the voltage of welding. The input heat is proportional to melt volume or volume of weld. The weld has three major dimensions as weld width, depth of penetration and reinforcement height. If voltage is increased, these dimensions can be supposed to be increased. Sometimes one or more dimensions show opposite behavior i.e. reduces with increase of voltage in that case the remaining dimensions must compensate the opposite behavior presented. As in this case the increase in voltage reduces the depth of penetration as the melt volume covers more surface area reducing depth of penetration and increasing the weld width.

3.3 Effect of Welding Voltage on Reinforcement Height

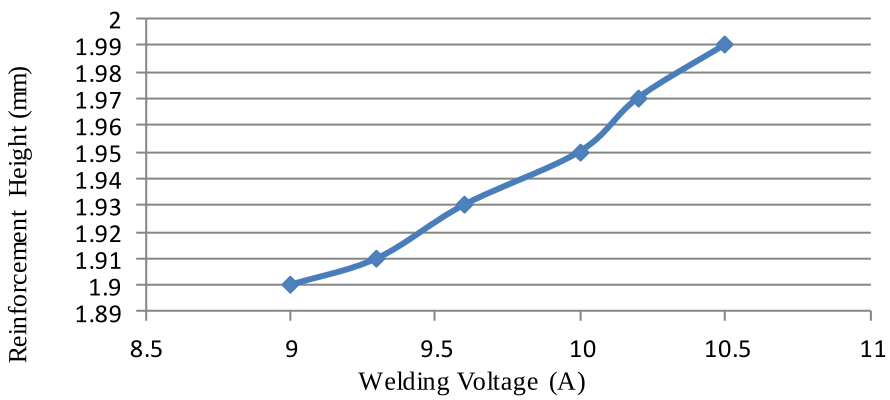

Figure 3 Effect of Welding Voltage on Reinforcement Height

The reinforcement height increased throughout our experimental range with increase of welding voltage as shown in figure 3. When the voltage was at 9 V, the reinforcement height was found as 1.90 mm. If the voltage was increased to 9.3 V, the reinforcement height increased to 1.91 mm and when the voltage was raised to 9.6 V, the reinforcement height increased to 1.93 mm. When the voltage was increased to 10

V, the reinforcement height increased to 1.95 mm and when the voltage was increased to 10.2 V, the reinforcement height increased to 1.97 mm and finally when the voltage was increased to 10.5 V, the reinforcement height increased to 1.99 mm. When the voltage is increased the input heat increases as input heat is proportional to the voltage of welding. The input heat is proportional to melt volume or volume of weld. The weld has three major dimensions as weld width, depth of penetration and reinforcement height. If voltage is increased, these dimensions can be supposed to be increased. Sometimes one or more dimensions show opposite behavior i.e. reduce with increase of current in that case the remaining dimensions must compensate the opposite behavior.

4. Conclusions

The shape of weld bead in case of a welded joint ascertains the mechanical properties of the joint. Weld joint can be designed having optimum mechanical properties with some bead dimensions, which can be recognized with the help of some experiments. This work was aimed to recognize the effect of welding voltage on the bead dimensions, which can be used to determine the mechanical properties of the weld. In this work the relationships of welding voltage with weld width, reinforcement height and depth of penetration were represented with the help of some diagrams. The experimental results obtained indicate that:

1. With increasing in welding voltage from 9 V to 10.5 V, the general trend of the weld width was found to increase from 8.36 mm to 8.61 mm.
2. With increasing in welding voltage from 9 V to 10.5 V, the general trend of the depth of penetration was found to decrease from 1.44 mm to 1.25 mm.
3. With increasing in welding voltage from 9 V to 10.5 V, the general trend of the reinforcement height was found to increase from 1.90 mm to 1.99 mm. The trend was followed throughout the range of experimentation without any exception.
4. The optimum value of welding voltage can be selected as per requirement of weld width, depth of penetration and the reinforcement height with the help of this work.
5. The maximum values of weld width was 8.61 mm at 10.5 V voltage, maximum depth of penetration was found to be 1.44 mm at 9.0 V voltage, whereas the maximum value of the reinforcement height was 1.99 mm at 10.5 V voltage.
6. The minimum values of weld width was 8.36 mm at 9.0 V voltage, the minimum value of depth of penetration was 1.25 mm at 10.5 V voltage and the minimum value of reinforcement height was found to be 1.90 mm at 9.0 V voltage.

Recommendations for Future work

Following are recommendations for future study:

(1)The experiment was performed for low carbon steel, which can be extended to other materials also.

(2)In this experiment the process of welding utilized was the tungsten inert gas welding process, other processes like submerged arc welding and shielded metal arc welding process etc. can also be used.

(3)The range of welding voltage was limited from 9.0 V to 10.5 V; it can be increased for better exposure of the trend of depth of penetration, weld width and reinforcement height with the change of welding current.

(4)Artificial neural networks, Taguchi methods etc can be used to make clearer the study.

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