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EFFECT OF VARIOUS COMBINATIONS OF GAS ON FEATURES OF PROTECTIVE WELDING WITH ELECTRODE GAS OBTAINED BY STEEL SHEET SP37-0

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ABSTRACT
Welding protective process with consumed electrode has a wide application in industry due to high welding speed, possibility of machinery process and well protection of melt basin. In the recent years, subject of protective gases was considered because of improvement in welding and enhancing its physical and mechanical features. Current research investigates effect of various combinations of gas on features of protective welding with electrode gas obtained by steel sheet sp37-0. There were 6 combinations of carbon dioxide and argon gases used for welding. After radiography and tension tests, it was found that increase of carbon dioxide in mixture of CO_2-Argon gases would increase depth of melt basin. On the other hand, melt spraying arc also increased due to stability reduction. Results of radiography test showed that increase of CO_2 gas would gradually remove radiography defects so that it was found no defect in welding with pure CO2. Analysis of samples' mechanical features showed that their final strength was dramatically not followed by combination of protective gases but it is somehow influenced by combination ratio of protective gases; generally, it can be concluded that changes in ratio of gases would cause improvement of welding process and better product.

KEYWORDS: electrode. Gas, Protective welding, SP37-0

INTRODUCTION

GMAW is a rapid welding method that is now used widely in pipe production lines and automotive industries. On of the important parts in GMAW process is its protective gas; protective gas has 2 important effects, i.e. protecting melt basin and melt droplets from surrounding atmosphere and also producing plasma and necessary heat for welding operation. On the other hand, change in combination of protective gas (depending on combination type) causes different structures and creating welding with different appearance.

Background of research conducted about effect of gas combination on welding process with protective gas is as follows:

- Effect of protective gas combination on shape of outer welding
- Its effect on surface tension of transferring melt droplets
- Its effect on type of melt transfer and amount of produced smoke
- Study of effect of protective gas combination on welding features

The research implies that quality and efficiency of welding process depends on protective gas; it also influences metal transfer and spraying amount. Results of studies conducted in this field show that protective gas not only is influential on welding features but also it determines shape and pattern of influence. In the recent years, there were several studies conducted to study effect of protective gas combination on different aspects of GMAW welding. Protection of arc and melt basin is often performed by using neutral gases such as helium and some oxidizing gases. According to results, it was found that changes in protective gas combination causes some changes in microstructure and welding shape; it also influences mechanical features of welding metal. Furthermore, some studies are conducted about effect of protective gas chemical combination on welding appearance such as penetration depth and welding width. These studies are performed about surface tension of melt droplet moving from top of electrode to melt basin. These studies show that little amount of oxygen added to Argon would enhance appearance and transmission of droplet; but since CO2 is a cheap protective gas than exact calculations of carbon dioxide that should be added to Argon would determine optimum toughness and other mechanical features of melt basin.

Some studies present a new technology to obtain better quality and efficiency. They use physical features of welding arc produced by alternative current of protective gases. Novikov et al presented an advanced technology for the first time about alternative current of protective gases for GTA and GMA welding methods. They found that defects (porosity and crack) were reduced using argon and pure helium in 1420 and 1460 aluminum alloys. Barabokhin et al found that ductility and strength of welding joints in 1460 aluminum alloy would increase with Argon and helium alternative current. Nakamura et al reported a sample of GMA welding process controlling protective gas combination alternatively; they designed a welding torch to achieve high efficiency.

In contrast to common traditional methods, Kang et al studied a new technique that uses another several types of protective gases in welding area. In fact, these studies were used in order to better understanding of this technology. They found that alternative current of pure helium and Argon causes creation of a welding with less porosity and penetration depth, and also wider welding.

Patschger et al studied effect of protective gas on austenitic welding joints. Also, they studied changes in mixed protective gas with neutral gases and/or other gases. Further, they studied effect of oxygen on welding appearance in a deep welding mode. Keskitalo et al showed that nitrogen wasted by laser welding could have a significant impact on strength of duplex stainless steels; this could be reduced by using nitrogen as protective gas during laser welding. In addition, they found that using nitrogen as protective gas also increases austenite levels in welding material. Jin Kim et al studied effect of nitrogen added to argon (as protective gas) on welding corrosion of duplex stainless steels. Their results showed that strength against corrosion would improve due to increase in austenite phase.

Studies have shown that adding a little oxygen to argon protective gas would enhance welding final shape and melt transfer. According to studies, it is perceived that change in protective gas combination has some effects on welding mechanical features, its clearance and toughness. CO_2 is used as a protective gas for this process, since it is a relatively cheap gas. Also, determining specific and optimum amount of combination of CO_2 and Argon gases has a high importance in order to obtain welding structure with optimum mechanical features, high toughness and clean welding. In the current study, we investigate effect of various combinations of gas on features of protective welding with electrode gas obtained by steel sheet sp37-0. In welding process, there are mutual impacts created by reactions of metal gas on arc and weld. On the other hand, amount of forces available in melt basin is also a function of several factors such as surface oxide layer and melt surface tension.

Preparation of welding sample

First step of this experiment is making initial sample of welding test due to ASME standard (figure 1):

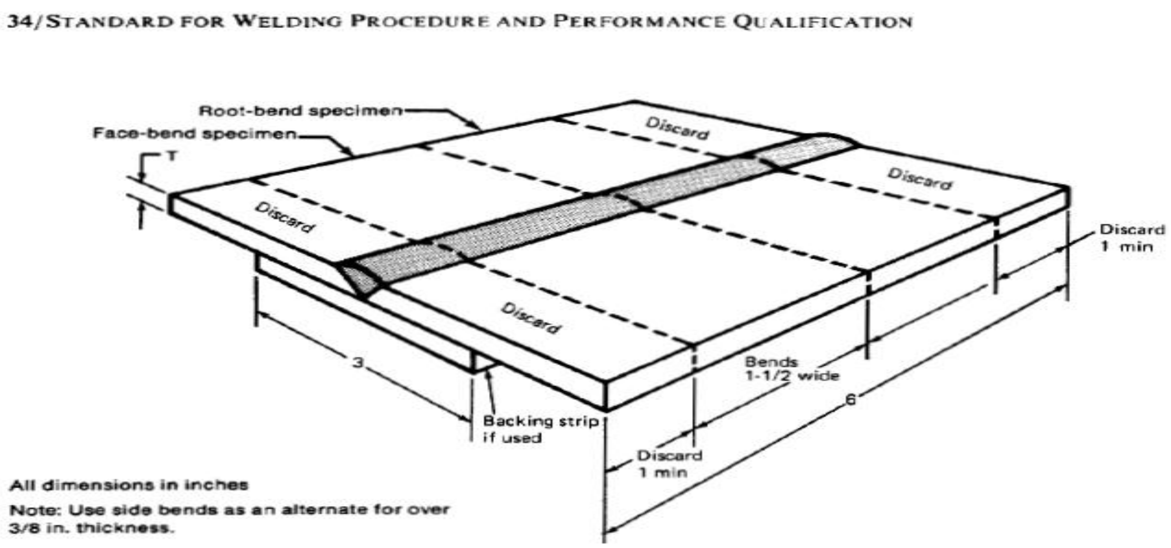

Figure (1) welding initial sample base on ASME standard

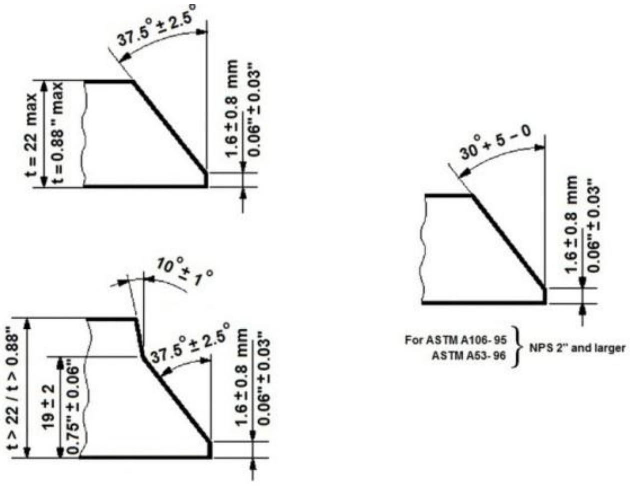

Figure (2) making proper angle for welding based on ASME standard

Welding process

In this experiment, gases were measured using two ball flow meters tied on pure CO_2 and pure Argon capsules. The total output of gases was considered as 10 lit/ min. the welding machines used in this test was cool water Euro Mag 50 machine, Messer Griesheim Co, Germany. The welding operation was done due to ASME standard in 1G welding situation. Also, the welding wire used in this test was SG2 (with diameter of 1.2) produced by Zanjan welding wire Co.

Results of welding appearance

Though welding is performed with 100% gas but welding appearance is not better than combination modes of two gases. Also, samples that are welded with combinations of protective gas have not a beautiful appearance (though they have higher amounts of CO_2 than Argon). Figure 3 shows welding appearance for pure CO_2 and Argon gases.

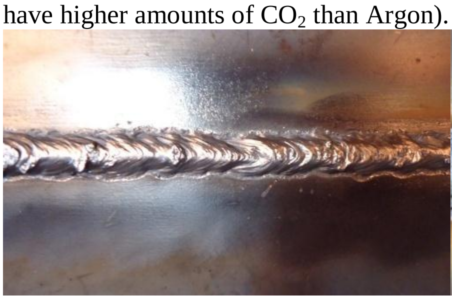


Figure (3 a) welding with pure CO_2 **Figure (3b) welding with pure Argon**

The comparison of welding appearance (for welded samples) with mixture of CO_2 and Argon gases is showed in figure 4 in which amount of CO_2 had increased from top to bottom;


Figure (4a) welding with ratio of 80:20 **Figure (4b) welding with ratio of 60:40**

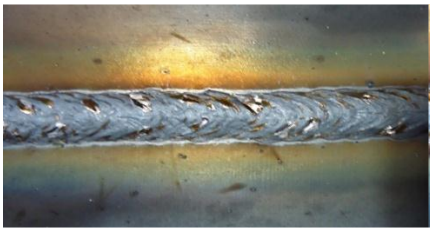
Figure (4c) welding with ratio of 40:60


Figure (4d) welding with ratio of 20:80

According to appearance of welding shown in figures 3 and 4, it is observed that welding with pure Argon gas creates an irregular but steady and uniform appearance (figure 3b); but this is not true about CO_2 gas. Figure (3a) shows appearance of a welding created by pure CO_2 gas having surface cracks. Also decrease in amount of Argon gas (protective gas combination) would reduce electrical arc radiation leading to easier welding; this continued till the amount of CO_2 gas achieved to 60%. On the other hand, decrease of Argon gas would increase welding spray due to reduction of electrical arc stability.

The other point of observations is welding speed. As said before, welding speed with pure Argon gas is very low but increase in CO_2 would improve speed significantly since availability of oxygen in protective gas causes more flow of melting metal. On the other hand, increase in CO_2 gas compared to Argon would reduce speed due to decrease in temperature of melt basin; with increase in CO_2, more energy is employed to break H_2O molecules apart and to reduce temperature of melt basin.

Results obtained by radiography test

Radiography test of samples shows that there are some defects in welding with pure argon and/or combinations with more Argon which are removed by increase in amount of CO_2; so that there is no defect observed in welding with 40% of CO_2 or more.

As it is observed in radiography test analysis, there is no defect reported in sheets T04 to T06; but there are some little defects observed in sheets T01, T02, and T03. And as said before, sheet T02 was once failed in radiography test.

Results obtained by tension test

Table 1 shows delivery average and final strength for tension sample and percent of protective gas combination.

Table (1) delivery average and final strength

Final strength average MPa	Delivery average MPa	Tension test sample	Gas mixture amount
388	268	Sample F	**Ar 100%**
410	302	Sample E	**Ar80% Co2 20%**
398	280	Sample D	**Ar60% Co2 40%**
390	265	Sample C	**Ar40% Co2 60%**
409	292	Sample B	**Ar20% Co2 80%**
389	284	Sample A	**Co100%**
402	278	Sample BM	**Base Metal**

As it is observed, amount of changes ion final strength is not meaningful, mostly close to final strength of primary material; but difference in delivery amount is high, even delivery amount in samples C and F is lower than that of primary material. Figures (5) and (6) show delivery and final strength amounts compared to increase in amount of CO_2 gas.

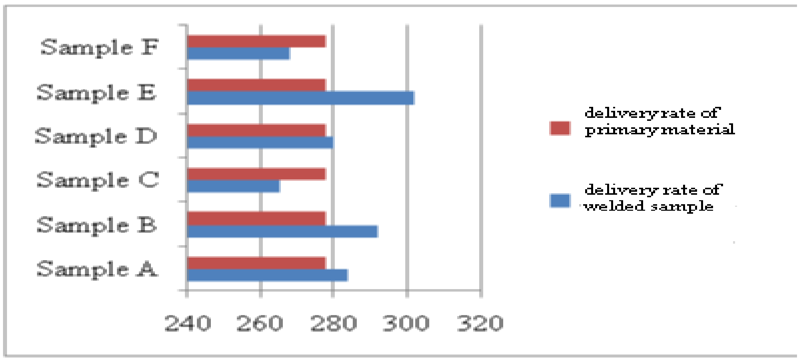

Figure (5) comparison between delivery amount of welded sample and primary material

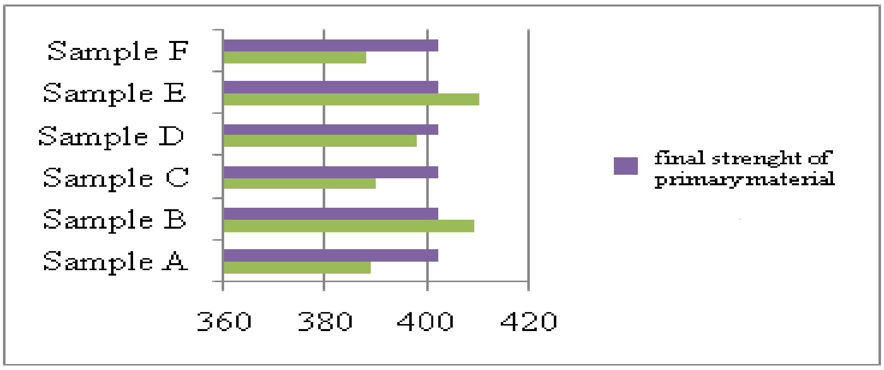

Figure (6) comparison of final tension between welded sample and primary material

Points obtained by tension test

•Using Argon or CO_2 pure protective gas alone has not a proper appearance and strength compared to combining these two together.

• using gas with ratio of CO_2 to Argon (60:40) causes reduction in strength of structure.

•The most desirable result in gas combination is observed in ratio of 80% Argon and 20% CO_2.

• The failure position in all samples is primary material.

CONCLUSIONS AND RESULTS

As it was observed, welding operation with 100%Argon or CO_2 protective gas has not a good appearance; also it has not a better impact on mechanical features than that of mixing these two gases. Meanwhile, there is not a better result observed in terms of appearance and mechanical features in case of combining these two gases compared to when mixture amounts of gases are more distant from each other in terms of percentage. In contrast to Jin Kim et al who studied impact of nitrogen added to argon as protective gas in corrosion of duplex stainless steels, the current study considers mixture ratio of Argon and CO_2 gases leading to better result in terms of welding appearance and mechanical features.

Generally, gas combination ratio of this research had a better result in terms of welding appearance and mechanical features. Among several combinations of these two gases, the mixture of 80% Argon and 20% CO_2 had either a better result in welding appearance than that of other ratios and its delivery rate and final strength improved compared to primary material. But the notable point of this combination is defects reported by radiography test; the sample of 1st radiography test was failed with this combination ratio, also the 2nd one had little defects. Thus, it is concluded that this situation has a better result while welder's capability is also effective. Therefore, having a strong structure requires gas combination with ratio of 80% Argon and 20% CO_2 and also a skilled welder. But the other point observed in this study is that ratio of 80% CO_2 and 20% Argon obtained a good result in tension test; also radiography test reported no defects (though this combination has not a good appearance). Thus, it is possible to use this combination in joints that welding appearance is not important and/or welder has not high skill.

The other notable point is that ratio of 80% CO_2 and 20% Argon is cheaper than ratio of 20% CO_2 and 80% Argon. But the most important point to consider is that delivery rate and final strength in welding with both ratios mentioned above have higher amounts than that of primary material, i.e. welded structure is more strength than a not-welded one in terms of tensile strength.

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