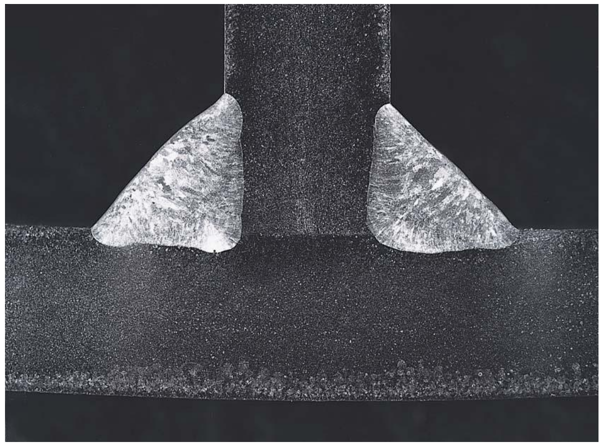

How to Make Economical 6 mm Semi-automatic Horizontal Fillet Welds

Stig Skarborn, P. Eng., IWE

Introduction

The purpose of a welding procedure should be to achieve the required quality at minimum cost. While the first criterion is usually met, it is our observation that the second is often not. This article reviews the Flux Cored Arc Welding (FCAW) and Metal Cored Arc Welding (MCAW) processes and makes recommendations on how to achieve economical welds.

Fillet welds are the most common weld type used to join structural members and are extensively used in mechanical applications, ship building, and many other situations. They are used in corner, tee, and lap joints. Usually they are used for members intersecting at 90°, but a range of 60° to 135° is not unusual. Often very large loads are transferred as is the case for common structural connections using double and single angles, end plates and shear tabs. Typical sizes for structural connections and many ship building applications are 5, 6 and 8 mm single pass fillet welds. This paper has singled out the 6 mm fillet weld for review, since it is a representative size.

Flux-Cored Arc Welding

When gas shielded FCAW first became popular 30-35 years ago, the most usual wire was 2.4 mm (3/32") diameter welded with 100% carbon dioxide. It was used for flat groove welds and flat and horizontal fillet welds. For structural applications a current range of 375 to 425 Amperes was typical for structural work, resulting in a deposition rate of approximately 6.0 kg/hr (Figure 1). Satisfactory 6 mm fillet welds were achieved by welders with normal skills, and welders usually had no problem passing the CSA W47.1, flat position, performance test since penetration and fusion were adequate.

When reviewing the figures it should be noted that for the same current, deposition rate is higher, the smaller the diameter of the wire. Additionally, the data on the figures has been discontinued beyond approximately 450 Amperes for the larger diameter wires, since very few welders will work effectively beyond this value due to the discomfort created by the intense heat generated by the arc.

Eventually smaller diameter, all position, consumables became available; first 1.6 mm (1/16") and then 1.1 mm (0.045"). Typical current ranges decreased to 275-325 Amperes for the former and 225 to 275 Amperes for the latter diameter, with a reduction of deposition rate to 3.8-4.8 kg/hr and 3.8-5.0 kg/hr respectively (Figure 2).

Another development that occurred in this time period was a transition from carbon dioxide to argon/carbon dioxide shielding gases. The result of these two developments was a decrease in productivity, and a decrease in penetration due to the lower current and switch to argon based shielding gases. It is my understanding that more welders than before were then failing their performance tests, than used to be the case.

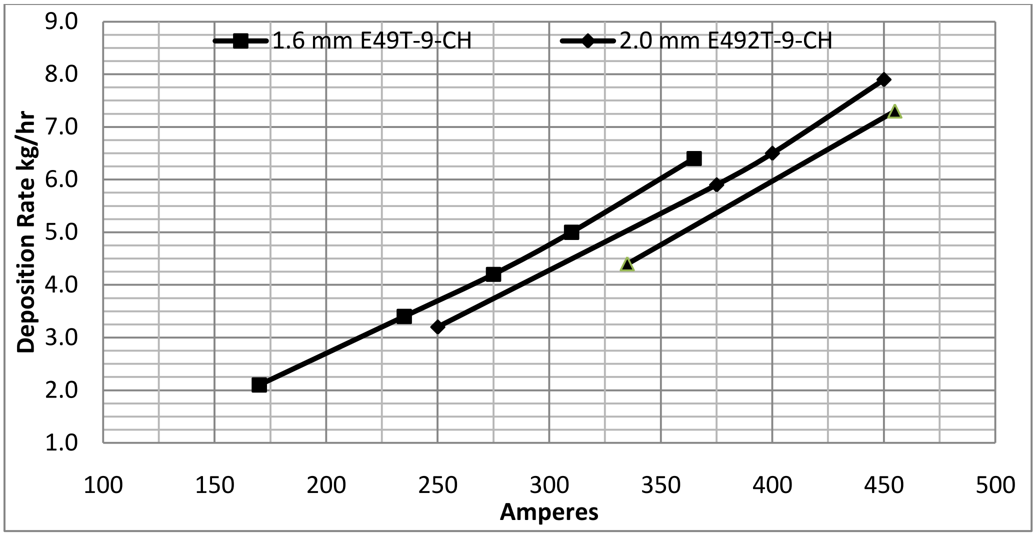

Figure 1 – Typical Deposition Rates for E492T-9-CH Consumables

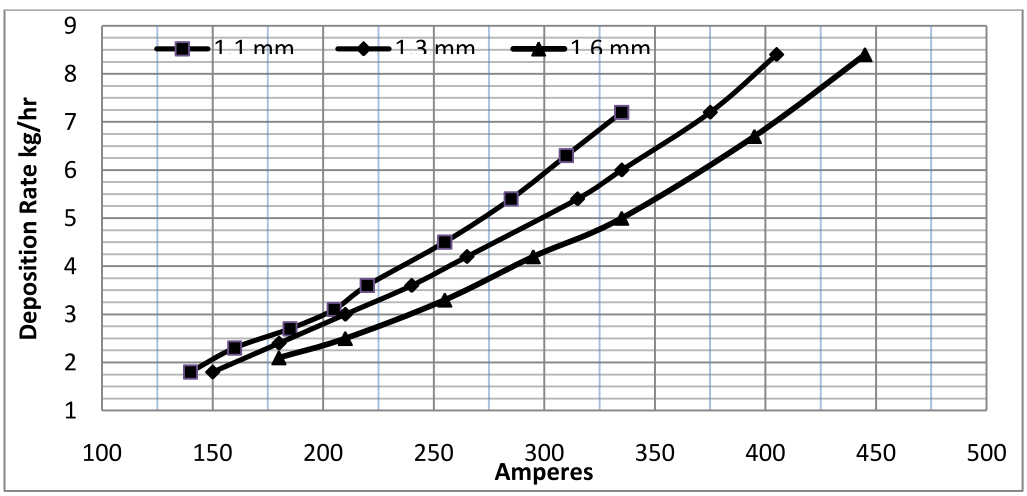

Figure 2 – Typical Deposition Rates for E491T-9-CH Consumables

The change to smaller diameter wires and argon based shielding gases had the following cost implications:

- Additional labour hours.
- More expensive consumables.
- More expensive gases.

The perceived main benefits of the smaller diameter wires and argon based gas were:

- Greater welder appeal.
- Less clean-up.
- All-position capability.

The perceived benefits do not outweigh the substantial increase in labour cost associated with the lower current and thus lower deposition rate for projects where most of the welding is either horizontal fillet welds or flat groove welds. In addition, some consumable manufacturers make 100% CO_2 shielded wires that produce limited spatter, smoke, and fume. There is therefore little reason for using small diameter low current wires for the majority of work in most fabrication shops. Fabricators that do so are not as competitive as they should be, and reduce their profit level from what it could be.

Metal-cored arc welding

Typical deposition rates for both flat and all-position FCAW were given in Figures 1 and 2. A realistic alternative to FCAW is the MCAW process which began to be commonly used in the early 1990's, and for which deposition rates are shown in Figure 3.

If the objective is to deposit 6 kg/hr the required currents for a selection of wire types and sizes is given in Table 1. It can be seen that using E491T-9-CH and E492C-6-CH type consumables require very similar currents for the same diameter consumable. However, the metal-cored wire has several advantages over the FCAW for flat and horizontal position fillet welding, which translate into cost savings:

- No need to remove slag between passes resulting in high duty cycles.
- Little or no spatter to remove after welding.
- Low fume generation resulting in a healthier environment.
- Forehand instead of backhand travel angle results in better visibility for welder.

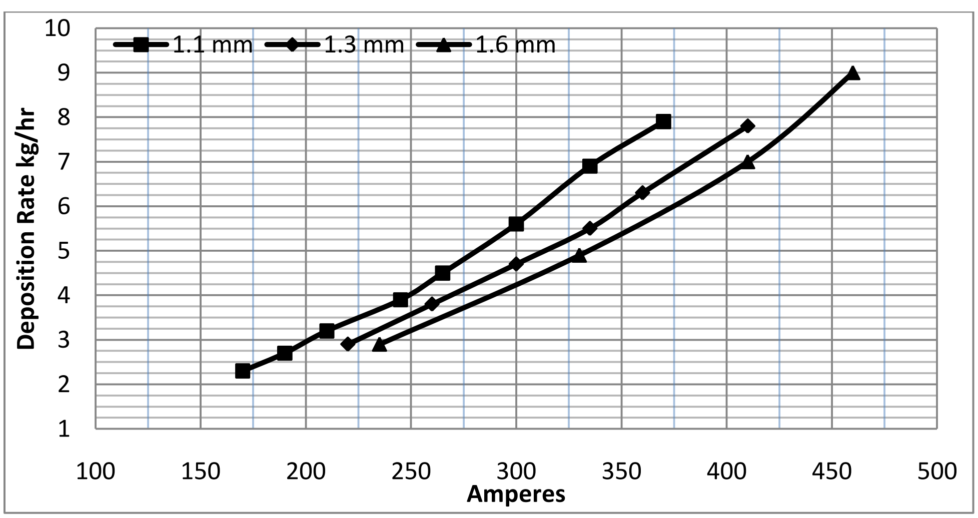

Figure 3 – Typical Deposition Rates for E492C-6-CH Consumables

Consumable					
E492T-9-CH		E491T-9-CH		E492C-6-CH	
Diameter	Amperes	Diameter	Amperes	Diameter	Amperes
1.6 mm	350	1.1 mm	300	1.1 mm	310
2.0 mm	380	1.3 mm	335	1.3 mm	350
2.4 mm	400	1.6 mm	370	1.6 mm	375

Table 1 – Current Required to Deposit 6 kg/hr

Obviously the potential exists for increasing the deposition rate above the 6 kg/hr used for comparison purposes in Table 1. A review of welding recommendations from a number of sources gives currents in the range of 350 to 450 Amperes for welding 6 to 8 mm fillet welds on material thicknesses of 6 mm and above.

It is not the purpose of this article to compare total welding costs between the processes, but it is recognized that MCAW consumables typically cost more than those used for FCAW. In addition, argon rich gases are always used for MCAW, while for FCAW 100% carbon dioxide may be a valid alternative for some FCAW consumables. However, with the substantial increase in duty cycle for MCAW, the labour cost savings more than offset the additional consumable costs.

Recommendations

The welding procedure parameters in Table 2 should seriously be considered for making economical fillet welds in the flat and horizontal positions (and for most flat groove welds). An issue that should be readily apparent is that the welding speeds are, in all probability, considerably higher than what welders are used to, which may cause the welders to reject the process and the suggested parameters. In order to overcome objections and assure proper welding technique, especially to eliminate undercut at high currents and lack of fusion, it is suggested that fabricators implement in-house training, and assure that competent supervision or a lead welder be available to provide guidance. Such training should also occur at community colleges, where too often high productivity semi-automatic methodology is ignored. In these very aggressive times with global competition on many projects, sound technology and economics must dictate shop floor practice.

Electrode wire classification	E491C-6M-H4 or –H8, or E492C-6M-H4 or –H8	
Shielding gas	90% argon, 10% CO_2	
Electrical stickout	20-25 mm	
Current and polarity	DCRP	
Electrode Sizes	1.1 mm	Alternative 1.3 mm
Wire feed speed, m/min	10.2-15.2	7.6-10.2
Amperes	265-335	300-360
Arc Volts	25-28	25-27
Welding speed for 6 mm horizontal fillet weld, mm/min (in.min)	480-745 (19-29)	500-675 (20-26)

Table 2 – Proposed Welding Data for MCAW

Stig Skarborn is a civil/welding consulting engineer and principal of Skarborn Engineering Ltd in Fredericton, New Brunswick. Additional information is available at www.skarborneng.com