Flux-cored Wire For Stainless Steel Welding

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This paper describes a advances in the technology of stainless steel welding in Japan. The development and special features of flux cored wire for stainless steels are expalined. Finally, recently developed wires are introduced.

INTRODUCTION

Advances in automatic and semiautomatic welding of stainless steel has been remarkable in recent years, and this is largely due to the development of flux-cored wires for stainless steels. FLux-cored wire for stainless steel first appeared on the market about ten years ago, and its production has increased rapidly. In 1990, the amount of production of flux-cored wire was similar to that of covered electrode, as shown in figure 1.

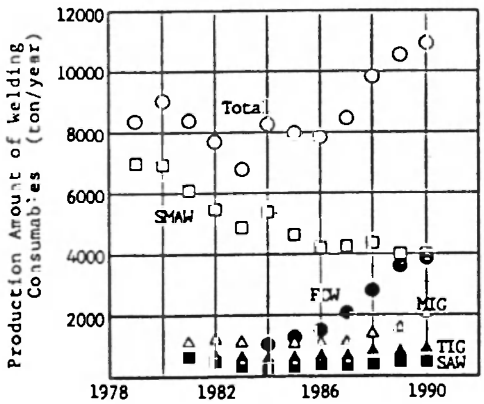

Fig. 1 : Change in the production of Welding Consumables for Stainless Steel in Japan

However it now occupies almost 35% of the total production of welding consumables for stainless steels. Related to the incrasing popularity of fluxcored wire, its application has been expanding, and various types of wire have been developed. In this paper, the superior features of this flux-cored wires and newly developed flux-wires are described.

Features of Flux-Cored Wire for Stainless Steels

Excellent Welding Efficiency : The flux-cored wire for stainless steel provides a 2 to 4 times higher deposition rate compared to covered electrode, as shown in Figure 2. The Maximum allowable welding current for it is more than 250 amperes, which suggests the possibility of further increases in welding efficiency. A comparison of the deposition efficiency is shown in Figure 3. The deposition efficiency of the flux-cored wire is approximately 90%, which is much higher than that of covered electrode.

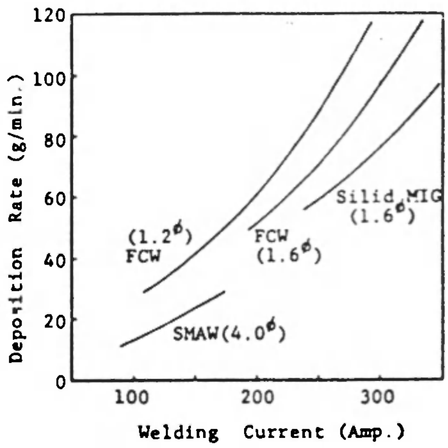

Fig. 2 . Comparision of Deposition Rate

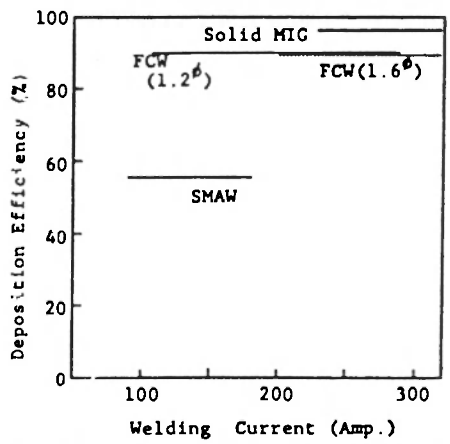

Fig. 3 : Comparision of Deposition Efficiency

Superior Weldability

Wide Range of Welding Conditions : The optimum welding condition range for flux-cored wire for

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stainless steel is much wider than that for solid wire MIG welding, as shown in Figure IV. Flux- cored wire can be used with CO2 as shielding gas, hence the optimum welding voltage range is considerably wider than Ihat for solid wire MIG welding.

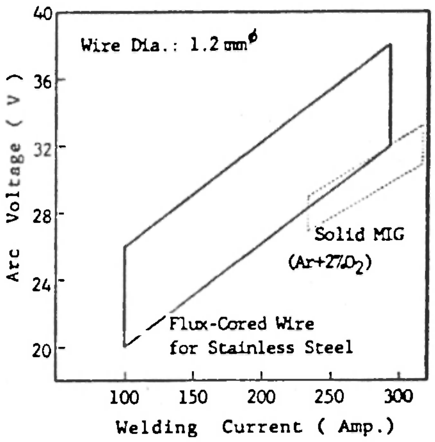

Fig. 4: Comparison of Suitable Welding Condition Ranges between Flux-Cored Welding and Solid MIG Welding.

Low Spatter Generation : During the solid wire CO_2 gas shielded arc welding, a great deal of spatter is generated, making its removal no easy task. In contrast, in welding using flux-cored wire, spatter generation remains low even when CO2 gas is used. Accordingly, spatter removal requires much less labour than it does when using covered electrode. This feature, together with the high deposition rate, permits the total welding cost to be greatly reduced.

Beautifully Shaped Weld Bead : Because of the superior spreading charcteristic of the arc and excellent wettability of molten metals, the weld bead formed in a groove becomes concave, and a sound weld can be easily obtained without insufficient penetration or other welding defects. Also in horizontal fillet welding, it is easy to obtain a flat bead without undercuts or overlaps. The slag forming agent contained in the wire covers the bead surface, thus creating a beautiful bead appearance, and making the bead comparable to that obtained with covered electrodes.

As explained above, flux-cored wire for stainless steel has solved the greatest problem in stainless steel solid wire MIG welding, which is the narrow range of optimum welding conditions, without using any specialized power supply.

Various flux-cored wires for stainless steel are listed in Table 1.

The chemical compositions and mechanical properties of these wires satisfy the requirements of AWS A5.22. As shown in Table 1, the range of applicable steel types has been expanded and most major types of stainless steel can be welded satisfactorily using the flux-cored wire.

TABLE 1 : KIND OF FLUX-CORED WIRES FOR STAINLESS STEELS AND TYPICAL PROPERTIES OF WELD METALS

Trade Name	Applicable AWS	Chemical Composition of Deposited Metals (wt%) C	Si	Mn	Ni	Cr	Mo	Mechanical Properties T.S N/mm^2	El. (%)	vE. (J.O.C.)	Others
DW-308	E308T-1	0.05	0.57	1.48	10.1	20.1	-	571	42	5.5	
DW-308II	E308T-1	0.05	0.39	1.15	9.5	18.5	-	553	35	6.9	for high temp. use
DW-308L	E308LT-1	0.03	0.56	1.43	9.8	19.8	-	552	41	5.5	
DW-308EL	E308LT-1	0.02	0.51	1.46	10.2	19.8	-	546	50	5.4	extra low carbon
DW-308LT	E308LT-1	0.03	0.44	2.17	10.6	18.5	-	521	51	9.8	for low temp use
DW-316	E316T-1	0.04	0.58	1.46	12.3	19.2	2.2	573	40	5.2	
DW-316L	E316LT-1	0.03	0.59	-	12.5	19.3	2.2	556	41	5.1	
DW-316EL	E316LT-1	0.02	0.55	1.40	12.4	19.1	2.2	545	45	5.3	extra low carbon
DW-317L	E317LT-1	0.02	0.58	1.32	12.9	19.5	3.4	589	37	5.2	
DW-347	E347T-1	0.03	0.47	1.41	10.2	19.2	Nb:0.05	566	43	7.2	
DW-309	E309T-1	0.04	0.58	1.21	12.4	24.3	-	612	31	4.8	
DW-309L	E309LT-1	0.03	0.57	1.18	12.5	24.0	-	599	32	4.6	
DW-309MoL	-	0.03	0.59	1.21	12.5	23.8	2.3	705	27	4.2	
DW-329M	-	0.03	0.62	1.11	9.2	24.1	N:0.12	815	26	3.0	duplex stainless
DW-410Cb	-	0.05	0.55	0.68	-	12.3	Nb:0.05	492	35	6.8	
DW-430CbS	-	0.05	0.52	0.62	-	17.3	Nb:0.08	600	27		for cromic stainless steel

TABLE 2 : PENETRANT TEST RESULTS OF TYPE 310 WELD METAL BY OVERLAY WELDING USING TYPE 310 FLUX-CORED WIRE (DW-310, 2 LAYERS OVERLAY WELDING)

location	Welding Current 150 Amp.	Cracking Evaluation 200 Amp.	250 Amp.
0.5 mm below the surface	No Cracking	No Cracking	0.5-1.0 mm length : 3 2.0-3.0 mm Length :4
1.0 mm below the surface	No Cracking	No Cracking	0.5-1.0 mm length : 4 2.0-3.0 mm length : 4
2.5 mm below the surface	No Cracking	No cracking	0.5-1.0 mm length : 5 3.0-4.0 mm length : 5

Newly developed Flux-cored wires for Stainless Steels

Flux-cored wire for all position welding : On construction project, vertical or overhead position welding is often called for, requiring sophisticated skills in welding operation. Because stainless steel exhibits low conductivity and has a lower melting point than mild steels, the molten weld metal can easily sag down during vertical position welding. To solve this problem, this wire controls the slag viscosity at elevated temperatures and enhances the arc stability at lower welding currents. These features have made the all-position welding of stainless steel easier and comparable to that of mild steel, requiring no sophisticated skills in welding operations.

Fig. 5 shows the cross-sectional macrostructure of the weld bead in various position welding using this wire. In each welding position, a flat and beautifully shaped welding bead is obtained. Figure 6 shows the optimum welding condition range for vertical and overhead position welding.

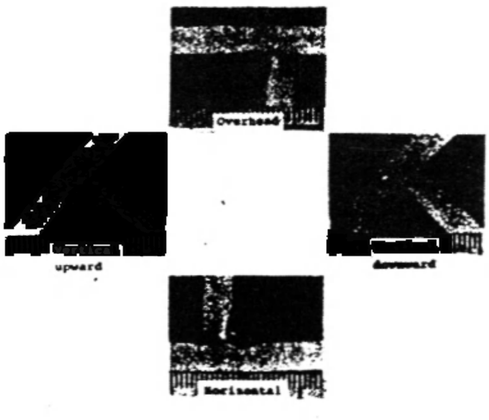

Fig. 5 : Cross-Sectional Macrophotographs of the Fillet Welded Joint using Newly Developed Flux-Cored Wire

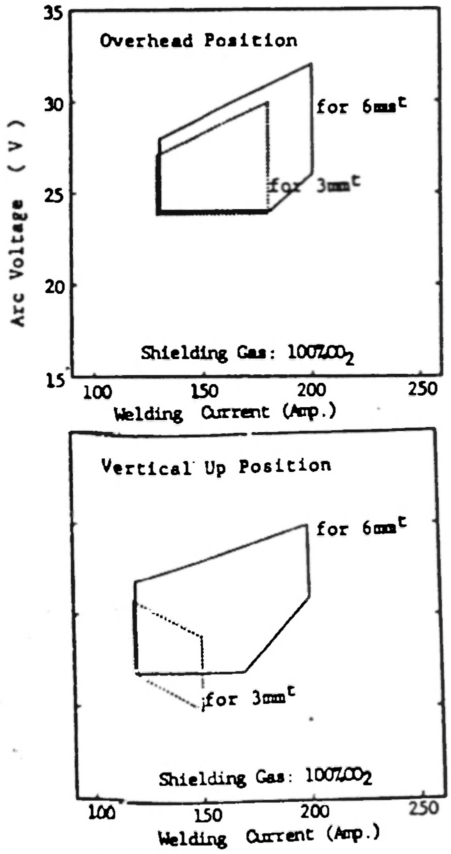

Fig. 6 : Suitable Welding Conditions in Overhead and Vertical Position Welding

Flux-Cored Wire for type 310 Stainless Steel : It is known that type 310 stainless steel has 25Cr-20Ni composition which shows the full austenitic structure and is highly susceptible to hot cracking. Recently, a new flux-cored wire applicable to this steel has been developed. The flux-cored wire itself permits a wide range of welding conditions; however, to prevent hot cracking it is important to understand the optimum welding conditions. Generally in root pass welding of this steel, cracking is most likely to occur. But such hot cracking can be prevented by reducing the welding current to approximately 130 amperes and using a lower welding speed as shown in Figure 7.

TABLE 3 : TYPICAL CHEMICAL AND MECHANICAL PROPERTIES OF TYPE 310 FLUX-CORED WELD METAL

Trade Name	Chemical Composition of Weld Metal (wt%)							Tensile Test			Impact Test
	C	Si	Mn	P	S	Ni	Cr	0.2% Proof Strength N/mm2	Tensile Strength N/mm2	Elong %	Absorbed Energy JAT 0oC
DW-310	0.15	0.60	4.38	0.013	0.003	20.67	26.43	420	615	33	88

TABLE 4 : TYPICAL CHEMICAL COMPOSITION AND MECHANICAL PROPERTIES OF THE FLUX-CORED WELD METAL FOR DUPLEX STAINLESS STEELS.

Wire (Trade Name)	Chemical Composition of Weld Metal (wt%)							Tensile Test		
	C	Si	Mn	P	S	Ni	Cr	0.2% Proof Strength N/mm2	Tensile Strength N/mm2	Elog %
Conventional wire (DW-329M)	0.03	0 63	1.10	0.025	0.008	9.20	24.15	631	821	26
developed Wire (DW-329A)	0.03	0.66	1.18	0.021	0.007	9.34	22.78	557	786	32

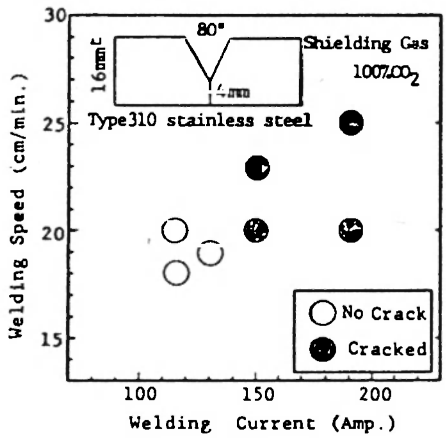

Fig. 7 : Suitable Welding Conditions for Preventing Root Pass Cracking in the Welding of Type 310 Stainless Steel

Table 2 compares a cracking resistance in the case of overlay welding. It also shows that decreasing the welding current is effective to prevent cracks. Table 3 shows an example of the chemical composition and mechanical properties of the deposited metal.

Flux-cored Wire for Duplex Stainless Steels : Duplex stainless Steel has a complex microstructure in which the austenitic phase is dispersed in the ferritic matrix. Because of the higher heat input relative to covered electrode, welding with conventional flux-cored wires often results in coarse grains of duplex structure. Thus the notch toughness of weld metal is insufficient. But a recently developed flux-cored wire provides a notch toughness that is the twice as great as that of conventional wire, through optimum control of the ferrite and austenite ratio. Table 4 shows an example of the chemical composition and mechanical properties of this new wire, and figure 6 shows an example of the impact properties of the weld metal.

At the early stage of the solidification process of the duplex stainless steel, a single ferrite phase solidifies first, and this can sometime cause a hot cracking (solidification cracking). This hot cracking also relates to the bead shape, and can easily occur when the bead is concave. It is therefore necessary to select the optimum wel;ding current and welding speed to prevent of hot cracking.

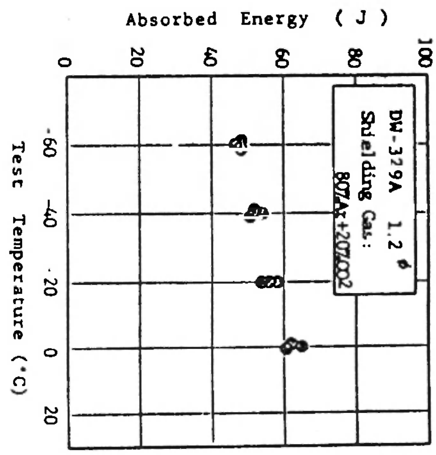

Fig. 8 : Impact Properties of Newly Developed Flux-Cored Wire for Duplex Stainless Steel.

CONCLUSION

This paper described some of superior features of the flux-cored wire for stainless steel, and has introduced some newly developed wires. The author hopes that this information will be useful for the further improvement of stainless steel welding technology.