Development of All-Position Fluxcored Wire for Fabrication of Oil & Gas Pipelines

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INTRODUCTION

Year after year, the industrial use of fluxcored and metalcored wire is increasing steadily. In United States and Japan about 20% welding consumables used by industry are of fluxcored wires types.

In the last few years, the quality of FCW has kept improving in terms of operation, reliability, the consistency of the mechanical and chemical properties of the deposited weld metal is note worthy.

Today fluxcored wires enable to obtain a metallurgical quality similar to coated electrodes and a greater productivity than solid wires.

For off-shore structures, design engineers still like to recommend SMAW and SAW consumables because of the additional requirements of impact properties required at sub zero temperatures in as welded condition or after stress relieving condition.

Therefore in order to meet the critical requirements of off-shore structures, development work was undertaken which resulted in development of all-position titania type fluxcored wire having excellent notch toughness at minus 50 degree Centigrade in as welded & stress relieved state.

The wire has been classified as AWS/SFA 5.20 : E 71T-12 MJ and is recommended for welding oil and gas pipelines and off-shore platforms andstructures, NACE/API steel, shipbuilding, bridges, etc.

Development Work

Shielded cored wires are grouped in three categories depending on ingredients of the core. These

three types are as under:

A. Titania type fluxcored wire- All position welding

B. Basic type fluxcored wire- Downhand or Downhand horizontal and vertical up position.

C. Metal cored wires.

Out of these three types, titania type of fluxcored wire is most popular and is capable of welding in all positions including downhand, horizontal fillet, vertical-up, vertical down and overhead. Such wire can be used without problem for welding of pipes hence these wires are gaining more and more popularity.

Therefore it was decided to develop suitable fluxcored wire Type E 71T-12 MJ meeting mechanical properties requirement of off-shore applications.

For off-shore fabrication jobs including pipes, most widely welding consumables are E7018 or E7018-1 which are basic coated hydrogen controlled electrodes Equivalent grades of wire and flux combination are used for submerged arc welding. Therefore the flux cored wires should have almost similar or better mechanical and chemical properties. Therefore it was decided that the FCW under development should meet following properties.

Weld Metal Composition (%)

C= 0.12 max	Cr=0.20 max
Mn=1.60 max	Ni=0.50 max
Si=0.90 max	Mo=0.30 max
S=0.03 max	V=0.08 max
P=0.03 max	Cu=0.35 max

Mechanical Properties of the Deposited Weld Metal : Requirement

Ult. Tensile Strength	:	500 MPa Min.
0.2% proof stress	:	400 Mpa Min.
Elongation(L=4d)	:	22% Min.
Impact at -500 C	:	27 Joules, Min.
Diffusable hydrogen in Weld metal	:	5ml Max. per 100 gm of the weld metal.

Development Work

The FCW is manufactured by using low carbon, low manganese strips. The chemical composition of the strip should have controlled carbon , Sulphur and Phosphorus. Therefore suitable grade of strip having low carbon content and very low level of Sulphur and Phosphorus was selected.

Core Ingredients

In order to get required mechanical and chemical properties of the deposited weld metal it is necessary to select proper ingredients of the flux which are used for manufacturing.

Following main ingredients were used:

A) Rutile sand having controlled particle size and impurity levels.

B) Special arc stabilizers.

C) Very strong deoxidizers which could reduce oxide levels of the deposited weld metal.

D) Ingredients which help to freez the slag quickly and facilitate positional welding.

Based on the experience, and initial laboratory trials, suitable flux formulation was developed.

Using the developed formulation flux cored wire was manufactured in size 1.20mm.

Shielding Gas

It was observed that Argon and CO2 mix gas in the proportion 80:20 is able to reduce oxide level of the deposited weld metal and improve impact toughness properties at minus 50° C.

Moreover shielding mix gas reduces spatter level of the deposited weld metal. Hence it was decide to recommend mix gas for shielding the weld metal.

TABLE 1
CHEMICAL ANALYSIS OF THE DEPOSITED WELD METAL

FCW	C	Mn	Si	S	P	Ni
E71T-12MJ	0.07	1.24	0.33	0.01	0.01	0.40

Testing of the Fluxcored Wires

Following tests were carried out using developed flux cored wire.

i) Chemical composition of the deposited weld metal.

ii) Radiography test.

iii) Mechanical properties of the deposited weld metal in as welded condition as well as after stress relieving at 6200 C.

iv) Mechanical properties of the butt joint assembly welded in 3G position, having single side Vee of 450.

v) Hardness of the deposited weld metal

vi) Diffusible Hydrogen measurement in the weld metal.

Chemical composition of the deposited weld metal.

A weld pad was prepared in downhand position using mix gas as shielding gas. The weld metal pad was analysed in the standard approved laboratory. The chemical analysis results are tabulated in table 1.

The test results of chemical analysis of the deposited weld metal, indicate that Sulphur and Phosphorus levels have been kept very low and small amount of Nickel has been added to obtain desired impact properties at minus 50° C.

Radiography Test Results

All-weld assemblies were prepared in 1G position in accordance with AWS/SFA 5.20 specification and these assemblies were subjected to radiography test. Results obtained were found to be satisfactory meeting Grade standards.

Mechanical properties of the deposited weld metal.

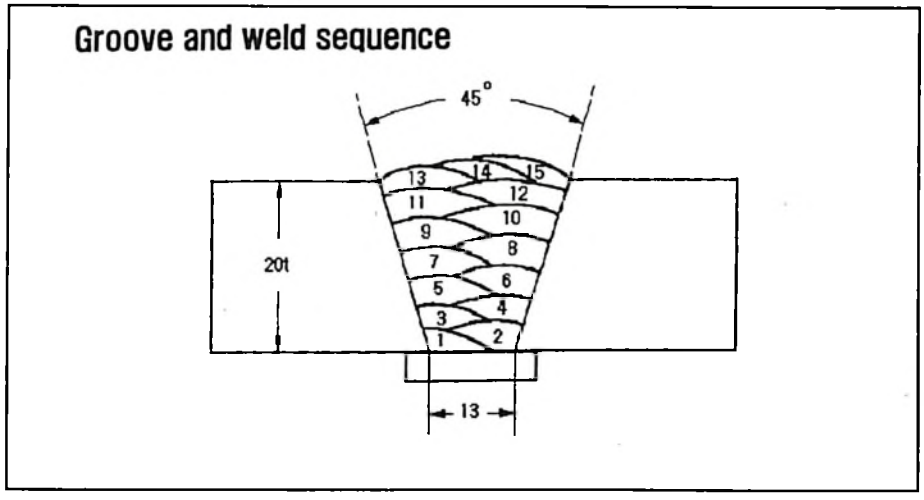
All-weld tensile test specimens were prepared in 1G position in accordance with AWS/SFA 5.20 specification.

Following welding parameters were used while preparing all-weld assemblies.

FCW diameter : 1.20 mm
Welding Position : 1G
Welding Currents : 270-280 Amps
Welding Voltage : 30-31V
Travel Speed : 25-35 cm/min
Heat in-put : 1.40-2.0 KJ/mm

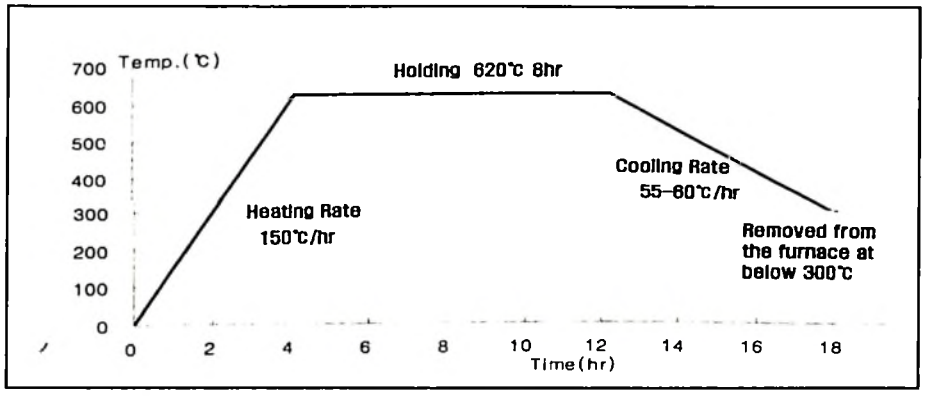
TABLE 2
MECHANICAL PROPERTIES OF ALL-WELD METAL (AWS/SFA 5.20)

Condition	Tensile Test			Charpy V-notch Impact values (joules)	
	Ult tensile Strength MPa	0.2% proof Stress MPa	Elongation % L=4d	Testing temperature - 40° c	- 50° c
As welded	566	507	25.4	115	88
After stress Relieving at 6200c for 8hrs	552	468	30.0	101	78



The first assembly was tested in as welded condition.

The second assembly was stress relieved at 6200 C for 8hrs and thereafter tensile and impact test specimens were tested.



Test results are given in Table 2

Mechanical properties of the deposited weld metal in a butt joint welded in '3G' position.

A butt joint assembly was prepared using 25mm thick plate of A516 Gr 70 having single side bevel angle of 45 degree, root face of 2.5mm and root gap of 3mm, was welded in 3G position using following welding parameters.

Welding parameters

i) FCW diameter : 1.20mm
ii) Welding position : 3G
iii) Welding current : 180-200 amps
iv) Welding voltage : 23-25 V
v) Travel speed : 10-13.5cm/min
vi) Heat input : 2.1-2.85 KJ/mm

BACKING STRIPS

Ceramic backing strips was used of suitable dimension and quality in order to obtain complete penetration and desired weld contour.

IMPACT TEST RESULTS OF THE BUTT WELD ASSEMBLY

Charpy V-notch impact test specimens were machined 2mm below the face and 2mm from the root.

Part of the assembly was given post weld heat treatment at 630 degree centigrade for 3hrs and thereafter impact test specimen were machined.

Test results obtained are tabulated in table 3.

Hardness test results of the deposited weld metal.

Deposited weld metal pad (as welded) was subjected to hardness test. Results obtained are as under:

Hardness test results }192 to 230 HV

Results obtained are satisfactory.

Measurement of diffusible hydrogen in the weld metal.

For preparation of the test specimen for diffusible hydrogen measurement test, following parameters were used.

FCW dia	:	1.20 mm
Current	:	270 amps
Arc Voltage	:	29V
Travelling speed	:	30cm/ minute

Welded specimens were subjected to the measurement of diffusible hydrogen in the weld metal. Results obtained are tabulated in Table 4.

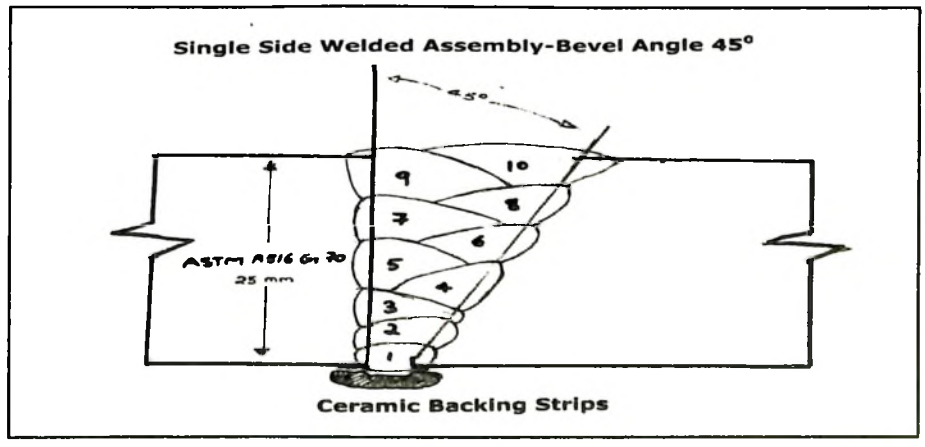


TABLE-3
IMPACT TEST RESULTS OF BUTT JOINT WELDED IN 3G POSITION

Position of V-notch	Testing Temp 0 c	As weld 'joules'	After PWHT at 6300C/3hrs 'joules'
Face 2mm -	40	110	87
Root 2mm -	50	85	38
Face 2mm -	40	115	83
Root 2mm -	50	84	55

TABLE-4
TEST RESULTS OF DIFFUSIBLE HYDROGEN MEASUREMENT IN THE WELD METAL

Product	Diffusible hydrogen In the weld metal,ML/100gm				Average
E 71T-12 MJ	Sp1	Sp2	Sp3	Sp4	ML/100 gm
	4.0	3.5	3.6	3.8	3.7

Test Results obtained are satisfactory.

Discussions :

The fluxcored wire E 71T-12 Mj which is titania type, all-position, has been developed, specially for off-shore structures and pipe welding.

The wire was subjected to all the test such as chemical analysis of the weld metal, radiography test, mechanical properties of the deposited weld metal in as welded and after stress-relieving condition, butt joint mechcanical properties such as impact test, hardness test of the deposited weld metal and diffusible hydrogen test of the deposited weld metal. All the test results have been found to be satisfactory.

Conclusions

i) E 71T-12 MJ titania type fluxcored wire for all position welding has been developed.

ii) It provides excellent notch toughness at subzero temperature upto -50 degree centigrade in as welded as well as after stress relieving condition.

iii) All position welding can be achieved with excellent almost flat bead appearance and very low spatter level.

iv) The diffusible hydrogen level in the weld metal is maximum 4ml./100gm.

v) Recommendation preheat and interpass temperature of 100-150 degree centigrade should be used specially for the thicker joints .

vi) Recommended shielding gas is 80% Argon and 20% CO2 Mix gas, which helps to reduce oxide level in the weld metal and reduces spatter level to a very great extent.

vii) The FCW works very well in all positions including vertical-up, verticaldown, overhead and hence is very useful for welding of various groups of pipes including API/NACE grades. ■