International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume 1, Issue 5 (Nov-Dec 2013), PP. 13-15

IMPROVE THE WELD QUALITY BY REDUCING HYDROGEN CRACKING BY CONTROL OF VARIOUS WELDING PARAMETERS

Shara Khursheed, Mohd. Raghib Rais, Dr. Shahnawaaz Alam
Department of mechanical Engineering
Integral University, Lucknow ; India

Abstract **Hydrogen cracking is one of the most common defects that get induced in the welding of the pipes or we can say that in pipeline welding. Here in this paper pipes are of X80 steels, the use of this steel had been come into picture since 1985 and it becomes very helpful in transporting oil and gases through long distances and effect and remedies of hydrogen cracking are discussed in order to obtain good weld characteristics in electric arc welding. To prevent cracking and to achieve high strength the X80 steels are made of ultra-low carbon, ultra-low sulphur, micro-alloying elements (niobium, vanadium and titanium) and molybdenum.**

Key Words—Steels microstructure, hydrogen content, electrode type, temperature, current and voltage. Carbon equivalent.

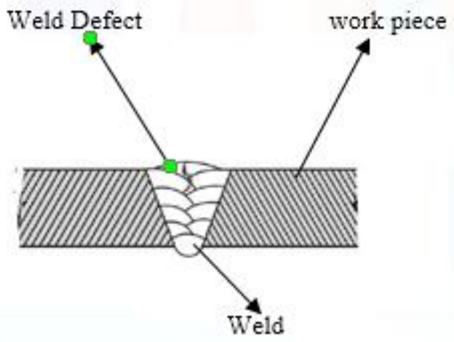


Figure: 1

I. INTRODUCTION

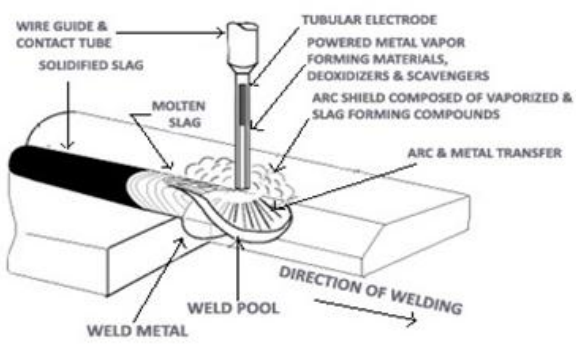
Pipes are very useful in transportation of gases and oil through long distances and during this process they have to be welded at several joints sometimes due to increased hydrogen content or due to residual stresses that develops at the joints cracking can occur. The sources of moisture are atmosphere, tools and flux etc. The cracking that can be induced in the weld is of two types-cold and hot cracking. A vast study has been done on the methods of reducing hydrogen cracking by controlling the various parameters and micro structure of steel.

Hydrogen cracking generally occurs at high temperature because at elevated temperatures steel has austenite structure which has high hydrogen affinity and when the weld cools down it changes to the martensite or pearlite which after

Sometimes get cracked and this is known as delayed or cold cracking in the heat affected zone.

Heat affected zone is the area near the weld metal whose properties and microstructure are change by the welding process. The change in the microstructure of heat affected zone can be clearly visible by the time temperature curve.

Better crack resistance and high weld strength composition of steel with reduced carbon contents. The purpose of present research is to study the effect of various parameters on hydrogen cracking and controlling these factors in order to reduce hydrogen cracking and to increase the weld strength.



Self Shielded Flux Cored Arc Welding
FIGURE : 2

II. SOURCES OF HYDROGEN IN ARC WELDING

a) Air moisture in the air are-
i) Relative humidity
ii) Temperature of the air.
b) Paint
c) Electrode[1]

FACTORS AFFECTING WELD STRENGTH

iii) i) CARBON EQUIVALENT- A carbon equivalent below 0.4 is safe for the weld to avoid cracking; the carbon equivalent can be calculated by the following formula-

$$C.E.=\%C+\%Mn/6+(\%Cr+\%Mo+V)/5+(\%Ni+\%Cu)/15$$

The contents of X80 are given below which should be taken in order to avoid cracking-

Thickness	C	Mn	P	S	Others (Nb,V,T)
7.9m	0.060	1.83	0.011	0.0006	0.19

is clear that if carbon equivalent is calculated than it will come 0.391 which is less than 0.4(C.E.<.0.4). Furthermore, in order to improve more quality we can decrease P, S contents to a certain extent. [2]

i) ELECTRODE TYPE- The acidic type of electrode can impart more hydrogen contents in comparison to basic electrodes but this can create problem of shielding gas. To reduce this problem of shielding gas it can be provided externally means a welding can be done in the environment of the shielding gas.

ii) Hence a basic electrode provides good toughness even at the low temperatures and weld results in much higher hot and cold cracking. The zinc based electrode is one of the best option to be used while welding and can be coded as a E 70110 . So it can be clearly seen that a basic type of electrode with external shielding gas like argon can provide much better weld quality with a good tensile strength and these electrodes may be coated with $CaCO_3$ around 40% and CaF_2 15-20% and can work at 250-270C temperature depending upon manufacturer's instructions. Hydrogen is eliminated from weld by the action of fluorine i.e. forming HF acid as CaF_2 generates fluorine on dissociation in the heat of arc. In the case of arc welding the list of coatings are given below which can perform different functions according to our requirement.[4]

It has been seen that the use of under matched electrodes (the weld metal strength being lower than that of the base metal) effectively reduces hydrogen cracking

Coating constituents	Functions
Calcium Fluoride	Increases fluidity, hydrogen removal
Carbon	Strength and hardness
Calcium carbonate	Arc stabilizer
Quartz	Good Slag removal
FeMn/FeSi	Deoxidizer
Asbestos	Coating strength

Table No: 2

CURRENT- In this current is directly related to the heat supplied (H=I*I*R*T) where-

Hence for raising high weld temperature high current has to be given which may sometimes result in high hydrogen content therefore a preheating of weld metal can be done to avoid this problem but due to this preheating our weld can lose its strength hence it may be done to a certain limit depending on the composition of welding material l[7]

Now a day's waveform control welding (Pulse Welding) is also used. Every arc welding machine consists of waveform characteristics. In traditional steels this is by the control of choke and transformer while in modern and complex machines hardware is designed with electronics to provide optimized waveform control.

III. HOW TO CONTROL HYDROGEN CRACKING-

A. POST HEAT TREATMENT

This is used to reduce the residual stresses that are developed during the welding process. The techniques used for post heat treatment are preheating, peening and vibration etc.

B. PRE HEATING-

The basic function of pre-heating is to slow down the cooling rate and to produce more ductile structure with more resistance to crack. This also reduces the shrinkage stresses develop in the weld. The pre heat weld can be done from 600΄C-800΄C. This makes the temperature difference less between sudden cooling and heating of the weld. One of the most important parameter that cab ne considered during pre-heating is that conversion of austenite (formed at high temperature) into martensite should be avoided and when slow cooling is done insisted of sudden than austenite changes to some soft structure (bainite). We can see from the time temperature curve if the cooling line touches the nose of the curve than austenite changes to the martensite (case of sudden cooling) and preheating enables us to cool in such a way that insisted of touching the nose cooling line passes behind it turning austenite to some soft structure.

Table for Stress relieving temperatures for different materials- [3]

Material	Soaking temperature (^{0}C)
Carbon Steel	595-680
Carbon1/2%-Mo steel	595-720
½% Cr-1/2%Mo Steel	595-720
1%Cr-1/2% Mo Steel	620-730
2%Cr-1/2%Mo Steel	705-760
Low Alloy Cr-Mn-Ni Steels	595-680
2-5% Ni Steels	595-650
9% Ni Steels	550-585
Quenched and tempered steels	540-550

Table No: 3

Pre heat temperature can also be calculated mathematically through the formula-

Tp=Tpcet + Tpd + Tphd + Tpq

Where, Tpcet= Pre-heat temp due to CET [^{0}C]

Tpd= pre-heat temp due to thickness. [^{0}C]

Tphd= pre heat temp due to hydrogen content. [^{0}C]

Tpq= pre heat temp due to heat input. [^{0}C]

Note- this relationship is valid for

CET=.2%-.5%

D= 10mm-90mm

Q= .4kj/mm-4.0kj/mm

For structural steel yield strength to 1000N/mm[5] , [6]

C. PEENING-

After the heat treatment residual tensile stresses can develop in the weld which can lead to the hydrogen cracking hence peening is producing compressive stress just below the skin so to compensate to the tensile residual stresses mostly peening is done by the hammers.

IV. LOSSES DUE TO HYDROGEN CRACKING-

The pipes are today not only used for drainage system but also for the supply of gas and fuel for long distances from one place to another, hydrogen cracking not only lowers the material strength but sometimes presence of hydrogen can also lead to the corrosion problem which may cause us the severe damage of both money and material.

Also the cracking may sometimes results into the small joint opening which not only results in loss of our useful products but in the case of gas or fuels it can also be dangerous from safety point of view.

Hence a considerable economic and other loses can be occur by the hydrogen cracking if it is not eliminated or controlled.

V. CONCLUSION-

Hydrogen cracking is one of the major cause for lowering the weld strength which should be controlled up to the maximum limit as its complete elimination from the weld is not possible and this can be achieve by following ways-

1. A good selection of base material is very important as hydrogen cracking depends widely on the microstructure of heat affected zone.
2. It should be keep in mind that our microstructure should not change to the martensite from austenite(due to sudden cooling) and to achieve this some pre heating should be done to a temperature of 600^{0}C so that this austenite structure turn into some soft structure insisted of turning into martensite.[9]
3. Type of electrode use should always be checked as it leaves significant structure on the weld and joint.
4. Weld should be clean before welding properly.
5. Proper welding parameters and pre heating of air can also be done to control and hydrogen and moisture content.

REFERENCES

[1] Bailey et al “Welding Steels without Hydrogen Cracking” ISBN 855730146.

[2] Kawabata, .; Amano, K; Tanigawa, .; Hatomura, T.; Sujita, Y. Proc. of 11th. Int. Conf. on Offshore mechanics and Arctic Engineering. 1992, vol. V-B, p. 597-603

[3] Kou, S, Welding Metallurgy, 2003, John Willey and Sons, Inc. USA ISBN 0-471-43491-4.

[4] Selection of Electrode from “Welder's Handbook for Welding”.

[5] P M Hill “Cutting and Welding in Naval Construction” , Welding and metal fabrication, March 1991, page 63-72.

[6] Bde Meester , development of base material for welding IIW International conference Florence, Italy 13 July 2000 page 9- 25.

[7] Haddrill, D. M., and Baker, R. C, “Micro cracking In Austenitic Weld Metal," Brit.Weld, j., 12 (8), Aug. 1965, pp. 411-419.

[8] Global pipeline welding and development center, www.subsea7.com

[9] Okatsu, M.; Kawabata, F.; Amano, K. Proc. of the 16th. Int. Conf. on OMAE. 1997, vol. 3, p. 119–124.

[10] Welding of X80 .NF.12.25.