Study on Hot Cracking Weldability Testing Methods

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Abstract— Weldability testing is majorly used to find the fabricability of materials by various welding processes methods, different filler materials, electrical characteristics to determine the service performance of welded construction. The weldability tests are useful to find the physical behaviour, mechanical behaviours, metallurgical degradation, selection of welding process, selection of filler material, susceptibility to cracking. Weldability is relative suitability of material for welding according to the AWS, Weldability is defined as the capacity of material or combination of materials to be welded under fabrication condition into specific suitability designed structure and to perform satisfactory in the intended service.

Key words: Weldability, Gleeble Testing Varestraint Test, Houldcraft Test, Hot Dctility Test

I. INTRODUCTION

Weldability testing is majorly used to find the fabricability of materials by various welding processes methods, different filler materials, electrical characteristics to determine the service performance of welded construction. The weldability tests are useful to find the physical behaviour, mechanical behaviours, metallurgical degradation, selection of welding process, selection of filler material, susceptibility to cracking. Weldability is relative suitability of material for welding according to the AWS, Weldability is defined as the capacity of material or combination of materials to be welded under fabrication condition into specific suitability designed structure and to perform satisfactory in the intended service.

Introduction

The aspects of weldability testing are Metallurgical compatability of the materials to be welded (Diluton properties), Mechanical soundness (strength, toughness, hardess..etc,) ,Good serviceability of weld joint(under different environment conditions of acidic, basic, corrosion, high temperature, cryogenic conditions).

The weldability assessed by in relation to mechanical defects, operational defects, type of test. Weldability testing can provide a data for selection of filler materials, preheat, PWHT, energy input, weld design. It gives quantitative measurement data. The important type in weldability testing is fabrication weldability test. It can be classified into hot cracking and cold cracking weldability tests [1].

A. Hot Cracking Tests

1) Varestraint Test:

The varestraint test is used to find base-metal weld ability and determine the influence of the welding variables on hot cracking of the base metal. It provided for augmenting conventional shrinkages strains to simulate the large shrinkage strains found in highly restrained production weldments.

The varestraint method can be classified into three types are

1) Longitudinal test
2) Spot test
3) Transverse test

This method mainly used for GTAW process with sheet materials, fusion weld processes. The test is conducted by producing a weld on a cantilevered specimen of one end is fixed and another end is free beginning at one end of the specimen. When the weld done along the center line of the specimen. The specimen is bend is done by using varies strains rates by using varies die radius. [2].

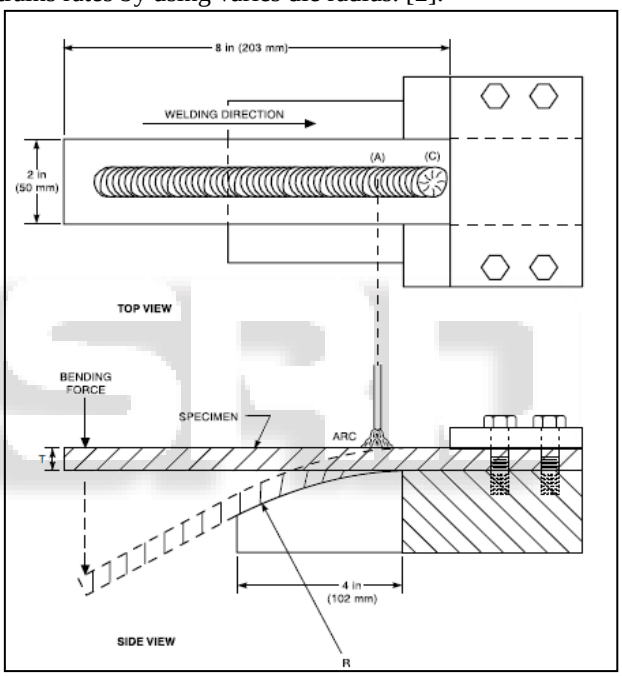

Fig. 1: The Varestraint test fixture

$$e = \frac{T}{(2R+T)}$$

e - Augmented strain
T –Thickness of plate
R – Radius of die

Spot weld test uses small spot welds to develop a susceptible HAZ microstructure .The sample is bent

In recent days the concept of SCTR(solidification cracking temperature range) and MCD (maximum crack distance) are adopted to find the accurate cracking temperature. The strain which initiates the cracking is called as the threshold stress and the stress after no more crack extension is called as saturated test.

John Du-pont,John c lippold , Samuel D.kiser suggest the strain rate for nickel alloys and stainless steels the threshold strain range 0.5 % -2 % and the saturated strain level of 3 % -7%[3].

The significance of this test is used for the analytic investigation of the hot-crack sensitivity of fused base Metal

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& effect of specific alloying elements on this sensitivity and the basic mechanisms of hot cracking.

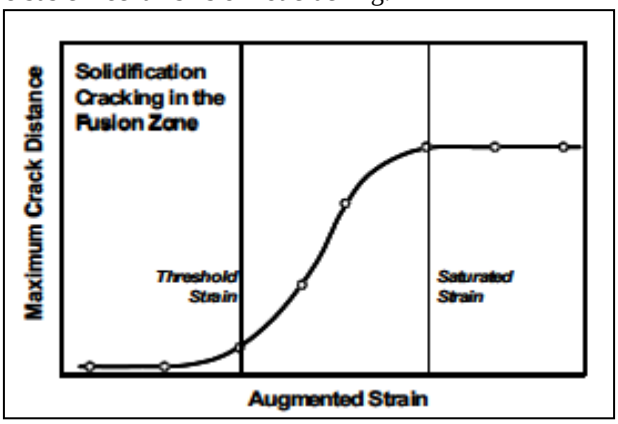

Fig. 2: MCD Vs Strain

SCTR=(Cooling Rate)×(MCD/V)

Here V –welding velocity

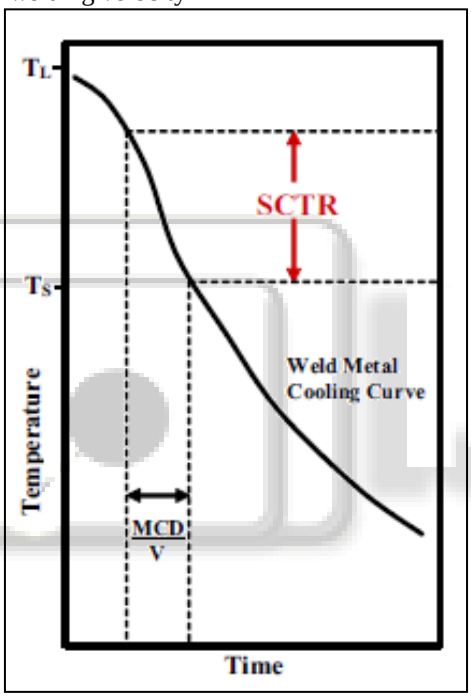

Fig. 3: Method for (SCTR) using the cooling rate through the solidification temperature range and MCD at saturated strain [4].

B. Houldcraft Fishbone Test

The fishbone test is very useful test the hot cracking susceptibility of base metal with different filler materials, weld design, welding variables. The fishbone test is useful to select the filler material. This test method is mainly used for TIG welding and other similar welding processes. It is applicable for thin plates and sheet materials.

The transverse stress build up by the progressive fusion weld with serious of saw cut with increasing saw depth. The saw depth is based on the thermal conductivity of the material .The weldability is measured by the extension of length of cracks throughout the specimen.

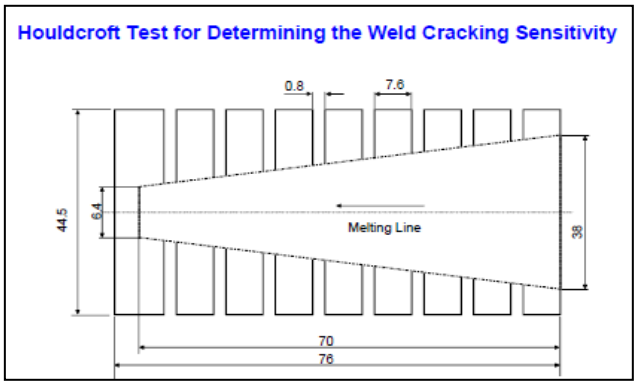

Fig. 4: Houldcraft test specimen

The welding is started from the small saw cut to maximum saw cut distance to build a stress. The susceptibility can be measured by the total extension of the crack in total length of the specimen. This test can be performed with or without filler material.

C. Gleeble based Hot Ductility Test

The Gleeble system is used for high temperature testings. The gleeble test machine can heat the the specimen 10000 ˚C in second. The gleeble testing machine analysis can be used to determine strainage cracking susceptibility, hot cracking susceptibility. The following tests are performed hot compression test, hot tensile test. It gives the following measurements stress Vs strain curve, NST, NDT, DRT, strss relaxation studies data, creep/stress rupture data,phase transformation during heating and cooling, thermal cycling, heat treatment, fatique.

The hot ductility test is used to find the NST, NDT, DRT temperatures. By substracting NST and DRT we can find out the solidification cracking range of the material with or without welding. This test done in on heating and on cooling methods. Which provides Temp Vs Elongation, Temp Vs Reduction area, Temp Vs Strength data. For each temperature condition procedure should done two times to get accurate results.

NST is nil strength temperature at that temperature the specimen fracture because of enough liquid formation between the grain boundaries. NDT is nil ductility temperature at the ductility of the specimen falls to zero. But there is some strength exist in the material. DRT is ductility recovery temperature at which the ductility of the material is starts to regain by the material on cooling.

D. Test Procedure

The hot ductility test of on heating test is used to find the NST and data at that condition. NDT, DRT are find by the on cooling test. For find NST we should know the Ts of the material. If the material is unknown or developing materials we should find the Solidus temperature by DSC or DTA method.

To find NST temperature we should temperatures to do the test. The NST temperatures are selected like this Ts-20˚C,Ts-40˚C,Ts-60˚C,Ts-100˚C…or up to the fracture occurring temperature.

The NDT can be find out by NST -50˚C,NST -100˚C,NST-150˚C,NST-200˚C up to the ductility falls to zero. The DRT temperatures are selected by NDT-20˚C , NDT-50˚C,NDT-70˚C up to ductility regain range.

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The specimen Dimension for NST is 6.25 mm dia rod of length 85 mm or 100mm length with 25m end NC threads and for NDT,DRT are 6.25 mm dia and 125 mm length with 25 mm end NC threads.The number of NC threads for 6.25 mm diameter is 20 threads per inch as per ANSI /ASME B 1.1.

To find DSC the small chips should be made from the drilling or machining methods and should avoid hack saw cutting. Because it includes some carbides and oxides in chips. That will give false data of Ts.

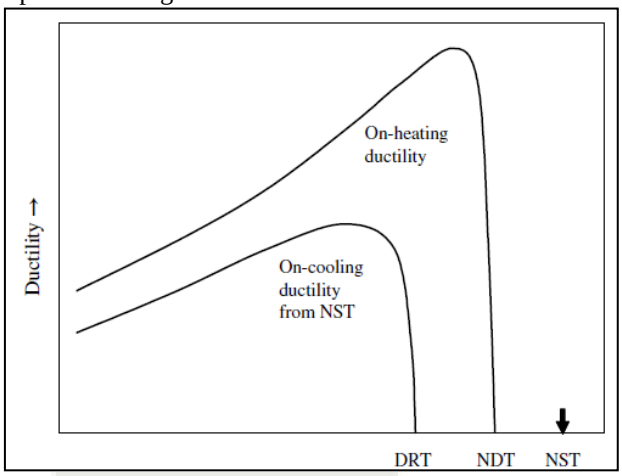
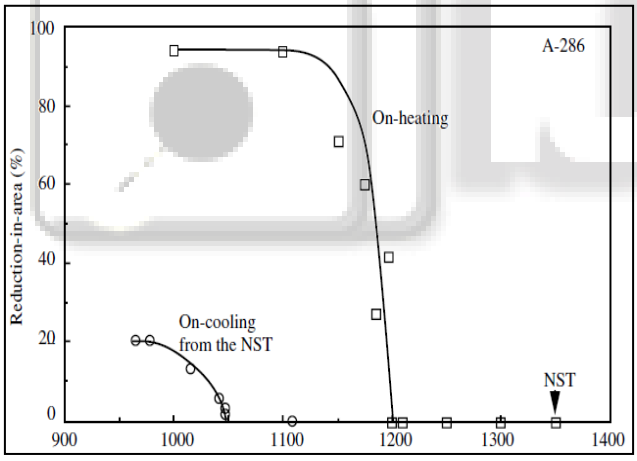


Fig. 5: Hot ductility signature showing on-heating and on-cooling ductility curves and the location of NDT, NST, DRT.



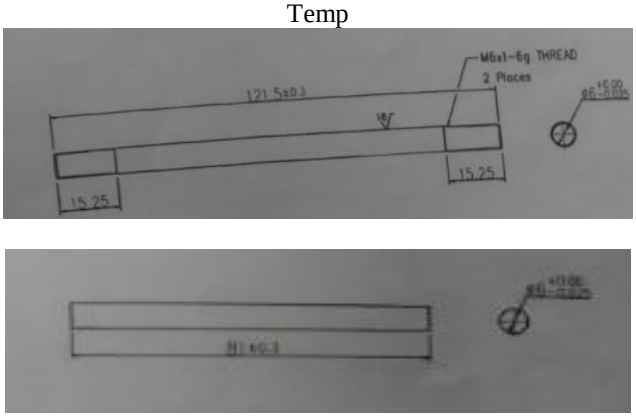


Fig. 6: (a) Specimen for NDT,DRT (b)NST

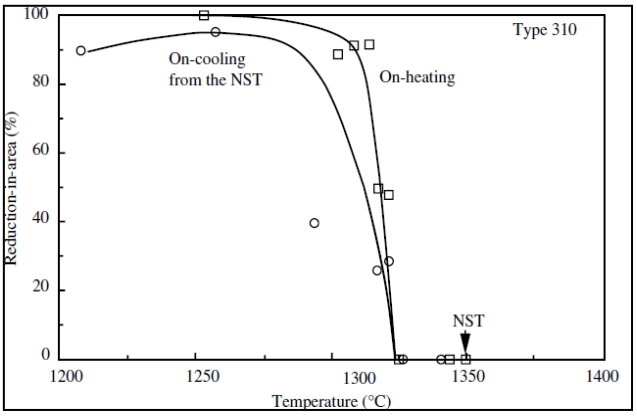


Fig. 7: (a)&(b) Hot ductility test results for (a) Type 310 and (b) A-286 austenitic stainless steels Ref. © AWS

The Hot ductility test done at Ar chamber. On heating test at linear rate of 111˚C/sec under static load of 10 kg until sample failure and pulling sample 50mm/sec.
On cooling test at peak temperature at or below NDT at the cooling rate of 50 ˚C/sec[5].

II. CONCLUSION

The hot cracking tests are used to find out the proper filler material selection, welding process, welding variables and weld design.

The fishbone test is a self-restraint test done by with or without filler materials by TIG and similar welding process.

The varestraint test is a Simulative test restraint is offered externally by die blocks.

The hot ductility test is costly and provide accurate data for NST,NDT,DRT related properties and solidification cracking range. The weldablity testing methods are still in upgrading level. The ohio state university involving development of weldability testing

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