

HEAT TREATMENT REQUIREMENT FOR LOW-ALLOY MATERIAL

1. INTRODUCTION

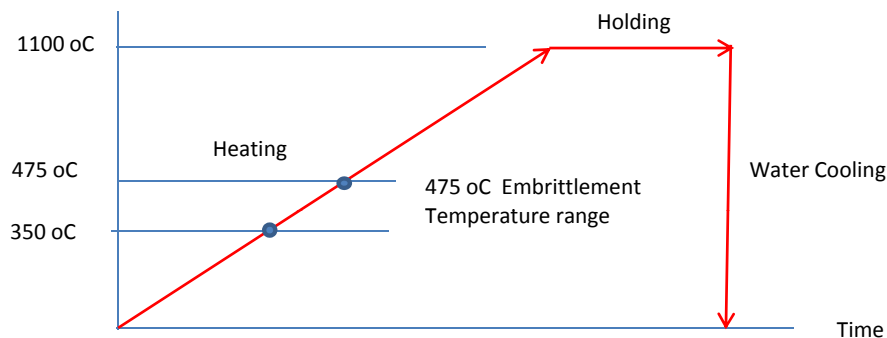
Generally, Cr-Mo Low-Alloy steel (ASTM A387-Gr.12-Cl.2) is well known for heat resistant material as elevated temperature (469 °C ~ 537 °C) service in pressure vessel because of its high strength value and resistant of Creep stress in a contents of 1%Cr-1/2%Mo and it can be free of Hydrogen penetration during welding. However, it should be considering metallurgy character of Cr contents with regard to its weld ability and welding crack. Therefore, all most of welding condition should be required post weld heat treatment as per UCS-56, ASME code, except below thickness 16mm plate.

2. METALLURGY CHARACTER OF Cr-Mo Low-Alloy / CHEMICAL COMPOSITION

- 1) Easily subject to intergranular corrosion due to Cr. Separation from grain boundary of Cr₂₃C₁₆
- 2) Easily hydrogen gas emission during welding
- 3) Easily subject to High temperature Crack around 550 °C at cooling time.

3. HEAT TREATMENT CHARACTER OF Low-Alloy

As mentioned in introduction, Cr-Mo Low-Alloy material should be heat treatment considering its metallurgy character as below chart because of 475 °C embrittlement because local stress occurs between grain boundary during heating and cooling time.



Therefore, all most of Cr-Mo Alloy material should be heat treated as method of water cooling in order to avoid 475 °C embrittlement after heating 1050 °C ~ 1100 °C there by, Cr can not be separated from Carbon grain.

4. HEAT TREATMENT PURPOSE

4-1. PRE-HEATING PURPOSE

- (1) Stress relieving as minimizing contraction
- (2) Avoiding hardening in heat affected zone
- (3) Easy hydrogen emission during welding
- (4) Preventing lack of fusion
- (5) Removing humidity

4-2. POST-HEATING PURPOSE

- (1) Increasing toughness in welding area
- (2) Re-arrangement of recrystallization boundary for each grain layer
- (3) Stress relieving as minimizing contraction
- (4) Preventing welding crack

As summarized above, the most of purpose is to prevent welding crack and minimizing local stress after welding.

5. STRESS RELIEVING METHOD

- (1) Furnance heat treatment (For Cr-Mo, Low-Alloy, heating to 850 oC, Cooling at ambient)
- (2) Local heat treatment (Not recommended method)
- (3) Stress relieving at Low temperature
- (4) Stress relieving by Mechanical method
- (5) Peening

6. HEAT TREATMENT METALLURGY REVIEW

When we review that Industrial practice and related CODE requirement such as ASME and BS, JIS , they regulated heat treatment requirements as similar basis but can not be covered whole of metallurgy condition. For example, when we review that heat treatment requirement as Carbon equivalent method as per BS 2642, we can find that Heat treatment may be required for ASTM A387-Gr.11-Cl.2, because carbon contents is of 0.57% according to below formula.

Carbon equivalent (BS 2642)=

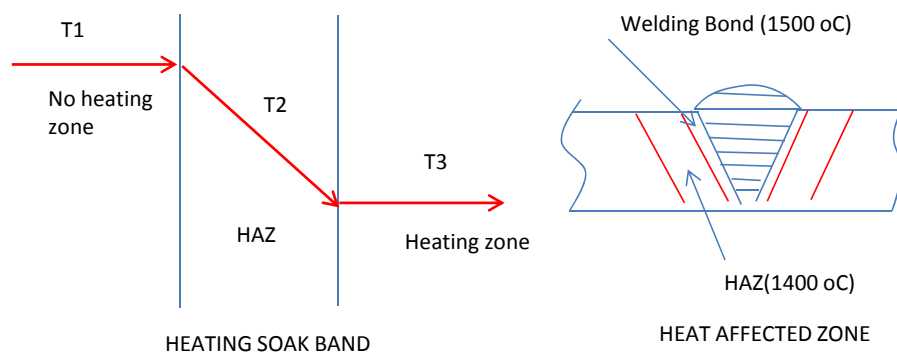
$$C(0.13\%)+Mn(0.49\%)/6+Cr(1.3\%)+Mo(0.52\%)/5+Ni(0.02\%)+Cu(0.02\%)/15=0.57\%$$

When carbon equivalent value is more than 0.45%, pre-heating and post-heating treatment should be performed. However, the problem is that carbon equivalent method also can not be covered every metallurgy condition as mentioned before.

7. CONCLUSION

Mostly welding crack occurs from starting stress increasing between solid solution for each grain boundary of Cr, Carbon, we call this as intergranular stress, and this is no more growing after cooling down but stress is remaining. the best method is doing stress relieving with heat treatment, However, this stress can be removed during equipment operation in high temperature service. We call this as stress relieving with Creep stress, normally Creep is defined as stress strain due to high temperature and regular frequency stress because this Creep moving grain boundary gradually during operation.

Therefore, when we're doing welding in a not confined area and even Cr-Mo, Low-Alloy material, it is not necessary to do heat treatment and moreover, if that is 2'ND boundary of pressure parts, no need to do heat treatment if welding quality is to be verified with NDE test after welding.



Moreover, when it be performed with local heat treatment because of any reason it can not be avoid heating gradient at heating boundary as we called "heating soak band" This heating soak band is similar to heat affect zone(HAZ) at welding, occurs 475 oC embrittlement. Therefore, the best way to stress relieving method is to do furnace heat treatment. If heating and cooling temperature can not be strictly controlled.

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