WELDWELL Spectrum

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WELDWELL®

Highlights

Temper Embrittlement – An Overview
Virtual Welding Simulator
Welding of Corrosion Resistant Alloys Castings
Understanding Laser Cladding
Postweld Heat Treatment (PWHT)
Welding of Thin Sheet Metal

IN SERVICE TO THE WELDING COMMUNITY

Editorial

Dear Readers,

Greetings from the editorial team of Weldwell Spectrum Team. We are pleased we place Spectrum Volume 32 Combined Issue #1& 2 January to June 2025.

The highlights of the issue are:

Many low-alloy steel components when exposed in the 3700 - 5000C temperatures get degraded due to the ambient conditions.

"Temper Embrittlement – An Overview" explains the phenomenon, evaluation and mitigation techniques of this important problem.

"Welding of Corrosion Resistant Alloy Castings" lists dome of the popular grades of CRA castings and provides a guide by recommending suitable welding consumables for them.

"Understanding Laser Cladding" gives a brief on the technique, considerations and pros and cons for selecting the feedstock between wire and powder for cladding with laser.

"Welding of Thin Materials" discusses the considerations, tips during welding and the features of the equipment while using the conventional GTAW process.

"Virtual Welding Simulator" describes the innovative equipment to train welders without costly spending on filler metals and mock stocks. This tool is also proving a boon for the upskilling of welders.

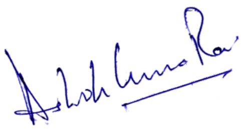
Post weld heat treatment) is a common term heard by all involved with welding. This treatise,

"Postweld Heat Treatment"(PWHT) explains the key concepts that have to be considered for adapting this procedure.

It is hoped you will find these interesting and informative.

Kindly send us your comments and feedback to enable us to improve.

Thank you,



Ashok Rai

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TEMPER EMBRITTLEMENT – AN OVERVIEW

Introduction: Temper embrittlement is a type of brittle failure thatcan occur in steels, particularly in low alloy steels, when they are exposed to certain temperature ranges for prolonged periods. This phenomenon can significantly compromise the material's mechanical properties, especially its toughness and ductility. When steel undergoes temper embrittlement, it becomes prone to brittle fracture, potentially leading to catastrophic failure.

A significant number of components of various section/ sizes, such as boiler headers, steam pipes, turbine casings, pressure vessels, blades, fasteners, HP-IP rotors, turbine disks etc. are designed to operate in the susceptible temperature range, where temper embrittlement can occur during service. It is a major cause of degradation of toughness of Cr-Mo (low alloy steels) used in thermal power generating plants as well as in the petroleum industry that are most susceptible to this phenomenon, after long service at high temperatures in the 370^0 to 595^{0}C range.

Foto 1: Effect of Temper Embrittlement

PRINCIPLE:

Temper embrittlement occurs in steels due to the non-equilibrium segregation of impurity elements (like phosphorus, antimony, or tin) atgrain boundaries during tempering, leading to reduced toughness. This process involves impurities accumulating at grain boundaries, which then become more susceptible to brittle fracture. The phenomenon is most pronounced in the temperature range of 3500-525°C. These elements, such as phosphorus, tin, antimony, and arsenic, are typically present in low concentrations as contaminants which promote temper embrittlement.

Impurities reduce the cohesive strength of grain boundaries, creating an easy path for fracture. When the Grain Boundary (GB) energy of a material is reduced by the presence of an alloy element, the concentration of the element in the GB is higher than in the matrix due to the "disordered" state of the GB compared to the matrix. Segregation is reversible at temperatures above the susceptible temperature range.

An IIW (International Institute of Welding) document summarized that temper embrittlement affects the toughness of Cr-Mo steels that are exposed to temperatures 348^0 – 600^{0}C. Slow cooling through the critical range following tempering or PWHT, or service exposure in that temperature range, can lead to temper embrittlement

Evaluation of Temper Embrittlement:

In most cases, the hardness and tensile properties of the material do not show any change as a result of embrittlement, but the transition temperature can be raised by as much as 100^{0}C for embrittling heat treatment.

1. Impact Testing:

The occurrence of temper embrittlement can be determined by Charpy V-Notch (CVN) tests that measure the change in the ductile to brittle transition temperature, before and after heat treatment. The decrease in notch toughness due to temper embrittlement can be measured by observing changes in the ductile-to-brittle transition temperature through impact testing before and after the heat treatment.

2. Fracture Surface Analysis:

Examining the fracture surface of tested samples can reveal intergranular fracture, a characteristic of temper embrittlement. The embrittlement is usually assessed by measuring the shift in Charpy transition temperature (usually for 50% shear) before and after an embrittling heat treatment, such as the step ageing heat treatment

3. Step Cooling Treatment:

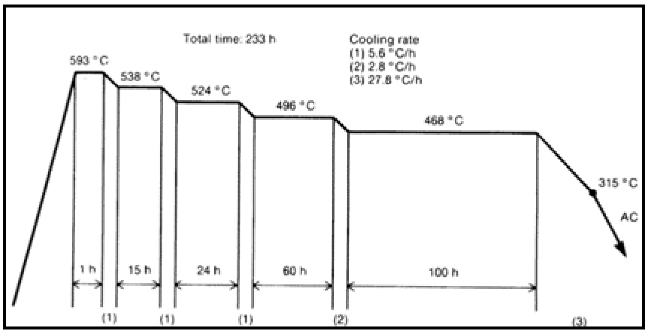
The susceptibility to temper embrittlement is evaluated with a step-cooling test using cyclical thermal aging This is a severe test to evaluate steel's susceptibility to temper embrittlement, involving a step-cooling process.

4. Isothermal Aging:

Holding the material at temperatures within the embrittlement range for a certain period can also be used to assess the effect of temper embrittlement.

Step Cooling Evaluation:

The susceptibility to temper embrittlement is evaluated with a step-cooling test simulating in service performance (using cyclical thermal aging), formulated by General Electric as well as by C. F. Braun and Standard Oil of California. This is the most commonly used and accelerated embrittlement procedure for the assessment of pressure vessel



593 °C/1 hr. followed by furnace cool to
538 °C/15 hrs. followed by furnace cool to
524 °C/24 hrs. followed by furnace cool to
496 °C/60 hrs. followed by furnace cool to
468 °C /100 hrs. followed by furnace cool to
315 °C) /0 hrs. followed by air cool

Fig.1:Typical step-cooling for temper embrittlement studies

The step cooling method described in ASTM A387, (refer fig,1) involves holding times and temperatures at specified values. The supplementary requirements in this gives a more stringent requirement for the acceptable degree of temper embrittlement.The advantage of the "step cooling" treatment is the relatively short simulation time (250 hours) which covers the exposure in the whole critical range of temperature with adequate exposure times for each temperature. The lower the temperature, the longer the necessary exposure time due to the slowed down diffusion rate of the segregating elements. The embrittlement on high-temperature tempering may manifest itself in two different ways:

(i) As a result of heating at 450-600°C (irrespective of the rate of subsequent cooling) and effect of temperature, and (ii) As a result of tempering at temperatures above 600°C with subsequent slow cooling within the range of 6000-450°C.

CHECKING FOR TEMPER EMBRITTLEMENT:

There are three main ways to check for temper embrittlement in steel:

The first is to check the notch toughness of the material. A Charpy V-notch specimen is used to verify the reduction of the material toughness due to temper embrittlement.The second is to perform a hardness test on the steel. If the steel is found to be significantly harder than usual, it may be indicative of temper embrittlement.The third way to check for temper embrittlement is to perform a metallographic examination of the steel. This will allow you to look for any changes in the microstructure of the steel that could be indicative of this conditionPrediction Of Temper Embrittlement:

Since temper embrittlement is mainly related to material chemistry, susceptibility can be quantitatively evaluated in terms of composition. A practical approach to minimising temper embrittlement in Cr-Mo steels involves controlling two important factors:

Watanabe J factor applied to parent steels and weld metals J= (Mn + Si) (P + Sn) x104 (in wt %)and Bruscato X factor applied to weld metalsX= (10P + 5Sb + 4Sn + As)/102 (in ppm)

If J is less than or equal to 180, or if X is less than 15, the risk of temper embrittlement is considered to be low. A limit in this form can be specified for procurement, where concerns over temper

As the X and J parameters are specific to particular steels, another newer, albeit less widely used, factor is the Equivalent Phosphorus (P) content, which takes into account the combined effects of various alloying elements. This general expression for embrittlement in weld metals was given by Sugiyama et al.

PE=C+Mn+Mo+Cr/3+Si/4+3.5(10P+5Sb+4Sn+As)

The maximum value for this expression to avoid serious embrittlement depends on the welding process but is given as 2.8-3.0 where coarse-grained weld metal exists.

MITIGATING TEMPER EMBRITTLEMENT:

Various methods can be employed to mitigate temper embrittlement, such as adjusting the heat treatment process, controlling the chemical composition of the steel, or using specific heat treatment strategies like quenching and partitioning (Q&P). Susceptibility to temper embrittlement is largely determined by the presence of the alloying elements manganese and silicon and the tramp elements phosphorus, tin, antimony, and arsenic. Therefore, selection of suitable welding consumables is important. Modern steels are far less vulnerable to temper embrittlement, due to improved control over the presence of problematic "tramp" elements.Kobe Steel has researched extensively and developed an electrode viz. CMA-106N (E9016B3) that fulfils the strict requirement for heavy-wall pressure vessels. The Bruscato X and J factors are well within control.

C	Si	Mn	P	S	Ni	Cr
0.11	0.27	0.79	0.008	0.006	0.19	2.42
Mo	Sb	Sn	As	$\bar{X}$	J	
1.03	0.002	0.003	0.002	10	117	

Table 1: Typical chemical composition of CMA-106N (Weld metal by AC welding in flat position (wt%))

In addition to the chemical elements, CMA-106N is designed to possess a fine micro structure in the weld metal after post weld heat treatment, thus to minimize temper embrittlement. For gas shielded processes special DC specification Cr-Mo filler metals are recommended, as the polarity of welding current affects the chemical composition (C, Si, Mn,and Mo in particular), thus the mechanical properties of the weld metal. A popular filler wire is Kobelco TGS-2CM. This ER90SB3Mnclassified wire

VIRTUAL WELDING SIMULATOR

Welding is a process of metal joining in which both parts to be joined and filler metal if used are melted in a particular direction and allowed to solidify as welding progression happens in the chosen direction. Process of welding, material type and thickness, type of joint are some of the critical variables. Ability of welder and welding operator to deposit consistently same bead and maintain heat input and protect weld from contamination etc also makes an impact on quality of the joint produce. Welding is a critical process that requires a high level of skill and experience.

In short there are number of variables, and one need to choose the right parameters to get a sound defect free and distortion free weld joint. Fixtures and accessories used in welding setup or during and post welding may impact on control of dimensions and protection and access during welding and can leave behind stresses in the joint, which may show up after part or assembly is removed from the fixture.

In competitive market like today where both money and time is limited, and quality expectations are very high or in other words these are the parameters which helps you identify as a special knowledge-based manufacturers. I am sure we have exciting times ahead of us to perfect this art of welding in science and monitor production jobs and simulate new geometries, materials, for dimensions and quality. A virtual welding simulator is a type of welding simulator that uses virtual reality technology to provide a highly immersive and realistic training environment for welders. The user can manipulate virtual welding equipment and materials, and practice welding techniques in a simulated environment that closely resembles the real-world welding experience. The simulator can simulate various types of welding processes, including arc welding, MIG welding, TIG welding, and more.

One of the main benefits of this simulator welding, is that it allows welders to practice and refine their skills in a virtual environment, before moving on to real-world welding. This can help reduce the risk of mistakes or accidents and improve overall welding quality. Additionally, it can provide real-time feedback to the user, allowing them to adjust their technique and improve their skills in real-time. The simulators can also track the user's progress over time, allowing for personalized training and assessment.

The VR Simulator is thus a Safe, Cost-effective and Immersive tool that can be used by beginners to learn basic welding skills or by experienced welders to refine and improve their techniques.

CONTINUED FROM OPPOSITE PAGE

is preferred because the weld metal contains comparatively low carbon, phosphorous and sulphur along with a higher manganese content, that improves fluidity.Further, the gas shielded processes it is vital to assure proper shielding of the weld. Due to the high pre-heat, the gas shield can be distorted and provide less penetration as required. Special nozzles and gas cups are available to reduce the problem.

Summary:

Several factors play a crucial role in the development of temper embrittlement.

- Susceptibility to temper embrittlement is largely determined by the presence of the alloying elements manganese and silicon and the tramp elements P, Sn, Sb and As.
- Steel making practices, such as, larger grain size, strength level of the steel and its heat treatment / fabrication history can also impact its vulnerability to embrittlement
- Conditions the equipment is exposed to also dictates its susceptibility and form of damage. (d) Temper embrittlement has been also related to reheat cracking and low-ductility creep fractures, and a number of types and mechanisms have been proposed, considering carbide precipitation as well as grain boundary embrittling elements.
- Temper embrittlement is most often found in hydro processing units, particularly reactors and hot feed/effluent exchanger components after long term exposure to temperatures above 3430C. Chrome Moly steels used in thermal power generating plants as well as in the petroleum industry are most susceptible to this phenomenon.(f) Extent and rate of the embrittling process depend on the temperature and the exposure time. (g) In general, the loss of toughness is not evident at operating temperature of the equipment but may be susceptible to brittle fracture during start-up and shutdown. Problems have also been encountered during hydrostatic testing of headers and piping or during operational transients, where fracture toughness is critical.

RESOURCES:

Literature from 'KOBELCO Welding'; Technical Knowledge (TWI); Articles from “Total Materia”.

NOTE: For details and availability of suitable consumables contact: sales@weldwell.com

Welding of Corrosion Resistant Alloy Castings

Consumables, Processes and Techniques

Introduction:

Heat and Corrosion resistant castings are cast components made from materials that can withstand degradation from chemical or environmental exposure, making them suitable for harsh environments like chemical processing or marine applications. These castings are often fabricated from alloys like stainless steel, nickel-based alloys, or titanium, chosen for their inherent resistance to corrosion, each offering different levels of resistance to specific corrosive agents. Generally, the designations of cast alloys are descriptive of their chemistry and purpose. These castings offer many other advantages such as: Durability; Cost-effectiveness; Complex shapes; Strength-to-weight ratio etc. They are crucial in industries like chemical processing, oil and gas, and marine engineering, where equipment is exposed to corrosive substances or environments. Examples of corrosion-resistant castings include Pumps; Valves; Heat exchangers; Fittings and piping; Mixers and Vessels.

WELDING OF CAST STEELS:

Welding cast steel is carried out mostly to repair casting defects in new steel castings, old steel castings and sometimesfor joining them to wrought products like plates etc. In addition, overlaying of castingswith higher alloys, such as in valves, pumps etc., is also undertaken to improve corrosion resistance, wear resistance, high temperature service and forcost considerations.

Many of the compositions used for castings are quite similar to those of standard wrought types.Though welding of these high-alloy castings is not difficult, it is different from welding of wrought alloy plates/pipes and requires special considerationsand welding procedures that factor potential cracking, oxide formation, and the need for stress relief. It involves choosing appropriate welding processes, filler materials, and pre/post-weld treatments to maintain the material's corrosion resistance and structural integrity at high temperatures. While SMAW is a versatile process, Gas-shielded processes like GTAW and GMAW are more-suited.GTAW, in particular, offers higher quality welds, due to the inert gas protection that prevents contamination and oxidation of the weld pool and less heat input, which is crucial for castings to prevent distortion and cracking. The specific choice will depend on factors such as weld thickness, complexity of the casting, and desired weld quality. This article focusses on the typical requirements and challenges during welding of the corrosion resistance resistant castings, which constitute major volume of high alloy castings.

STAINLESS STEEL CASTINGS

(a) Welding consumables for cast austenitic stainless steels such as CF8; CF8M; CF8C; CF8MC; CF3; CF3M; T15C; CK3MCuN; CG3M; CG8M and CN7M are usually same as for their equivalent wrought grades. Austenitic Welding Consumables, electrodes and filler wires of grade 309L and 309MoL are sometimes used for dissimilar welds between duplex and other stainless steels or carbon steel. They offer good weldability and corrosion resistance. environments at an affordable cost.(b) Welding consumables for the common martensitic stainless-steel castings are:

Grade UNS #	Chemical Composition %	Electrode / Filler Wire
CA 6NM 1.4317	11.5-14 Cr, 3.5-4.5 Ni, 0.40-1.0 Mo	E410NiMo-15/16
CA15 1.4107	11.5-14Cr; 0.15C (max)	ER410
CB7Cu-1 1.4540	15,5-17Cr;3.4-4.6Ni; 2.5 3.2Cu; 0,07C(max)	E630-15/16

Note:Titania(-15) used for AC & Lime coated (-16) used for DC

Table1: Common Martensitic Steel Castings

DUPLEX STEELS CASTINGS

Duplex stainless steelswere developed essentially with the 4 alloying elements (Cr, Ni, Mo & N) but in different proportions to deliver superior strength, high corrosion resistance especially to chloride. The microstructure of cast duplex stainless steel contains approximately equal amounts of austenite and ferrite. Duplex stainless-steel castings have been used extensively by pump and valve industries supplying products in to a wide range of industrial applications. First generation cast duplex stainless steels such as CD4MCu (J93370) have been used for more than fifty years. There are now various second-generation cast grades, such as CD4MCuN (J93372) and CD3MWCuN (J93380), that offer improved weldability and corrosion resistance in comparison to the lower nitrogen containing first generation grades. Although easily weldable, its use is limited to 315^{0}C.

Popular Duplex Steel Castings are:

CommonDesignationACI / UNS # ASTM	COMPOSITION / PREN #
CD4MCu 1A J93370 - A890	25Cr-5Ni-Mo-Cu PREN # 31
CD4MCuN 1B J93372 A890/A995	25Cr-5Ni-Mo-Cu-N PREN # 34
CD3MCuN J93373 A890	25Cr-6Ni-Mo-Cu-N PREN # 40
CE8MN 2A J93345 A890/A995	24Cr-10Ni-Mo-N PREN # 37
CD6MN, 3A J93371 A890/A995	25Cr-5Ni-Mo-N PREN # 35
CD3MN 4A J92205 A890/A995	22Cr-5Ni-Mo-N PREN # 35
CE3MN 5A J93404A890/A995	25Cr-7Ni-Mo-N PREN # 41
CD3MWCuN 6A J93380 A890/A995	25Cr-7Ni-Mo-N PREN # 41

PREN = %Cr + 3.3[%Mo + 0.5(%W)] +16(%N)
Table2: Duplex Steel Castings Designations

For welding duplex steel castings, suitable consumables are chosen to achieve the desired micro structure and properties in the weld. Exaton Duplex (2209) Electrodes and Wires- are common choices for welding standard duplex stainless steel grades. They help maintain the dual-phase micro structure (austenite and ferrite) of duplex steel in the weld. Exaton Super Duplex (2594)Electrodes and Wires are used for welding super duplex grades. ER2594 wires often have a higher nickel content to achieve the ideal ferrite/austenite ratio and improve corrosion resistance, especially in harsher environments.

NICKEL-BASE CASTINGS:

They are used primarily for their superior heat-resistant and corrosive-resistant qualities. These castings are essential in environments where durability and reliability are critical, making them ideal for a variety of industrial applications. These nickel-based castings are classified according to their main elements such as Ni-Mo; Ni-Cu; Ni-Cr-Mo castings.Nickel base castings are vital in industries such as aerospace, chemical processing, and power generation due to their exceptional properties. Their durability and resistance to extreme conditions ensure long-term performance and reliability, reducing maintenance costs and down time. Popular castings and the welding consumables are listed in the next table.

Grade	Filler Wire	Electrode
M35-1 N24135	ER NiCu -7 Monel 60	E NiCu -7 Monel 190
M35-2 N24020	ER NiCu -7 Monel 60	E NiCu -7 Monel 190
M30H N24135	ER NiCu -7 Monel 60	E NiCu -7 Monel 190
M25S N24025	ER NiCu -7 Monel 60	E NiCu -7 Monel 190
M30C N24130	ER NiCu -7 Monel 60	E NiCu -7 Monel 190

Table 3: Ni-Cu Castings

Grade	Filler Wire	Electrode
N7M	ER NiMo -7	–
J30007	Hastelloy B2	–
N12MW	ER NiMo-10	E NiMo-10
J30012	Hastelloy B3	Hastelloy B3

Table 4: Ni-Mo Castings

CAST	**Filler Wire**	**Electrode**
CW2M N26455	ER NiCrMo -4 INCO C-276	E NiCrMo -4 INCO C-276
CW6M N30107	ER NiCrMo -13	E NiCrMo -13 EXATON Ni 59
CW6MC 2.4856	ER NiCrMo -3 INCONEL 625	E NiCrMo -3 INCONEL 112
CW12MW N30002	ER NiCrMo -4 INCO C-276	E NiCrMo -4 INCO C-276
CZ 100 N02100	ER Ni -1 NICKEL 61	E Ni -1 MWA MACNICRO E200
CY 40 N06040	ER NiCr -3 NICKEL 82	E NiCrFe -3 NICKEL 182
CX2MW N26022	ERNiCrMo -10 NICKEL 622	ENiCRMo -10 NICKEL 122
CU5MCuC N08826	ER NiCrMo -3 NICKEL 625	E NiCrMo -3 NICKEL112

Table 5: NiCrMo Castings

Note: For availability of all above welding consumables contact sales@weldwell.com

RESOURCES:

Welding of High Alloy Castings - By E.A. Schoefer, Consultant, Steel Founder's Society of America; ***Heat and Corrosion Resistant Castings: Properties and Applications*** - NIDI; ***Emerson Process Management Technical Literature***

POSTWELD HEAT TREATMENT (PWHT)

by R. Scott Funderburk - Key Concepts in Welding Engineering
(Published in Welding Innovation XV, No. 2 – 1998 by Lincoln Foundation)

What is PWHT?

Postweld heat treatment (PWHT), defined as any heat treatment after welding, which is often used to improve the properties of a weldment. In concept, PWHT can encompass many different potential treatments; however, in steel fabrication, the two most common procedures used are post heating and stress relieving.

When is it Required?

The need for PWHT is driven by code and application requirements, as well as the service environment. In general, when PWHT is required, the goal is to increase the resistance to brittle fracture and relaxing residual stresses. Other desired results from PWHT may include hardness reduction, and material strength enhancements.

Post Heating

Post heating is used to minimize the potential for hydrogen induced cracking (HIC). For HIC to occur, the following variables must be present (see Figure 1): a sensitive microstructure, a sufficient level of hydrogen, or a high level of stress (e.g., because of highly constrained connections).

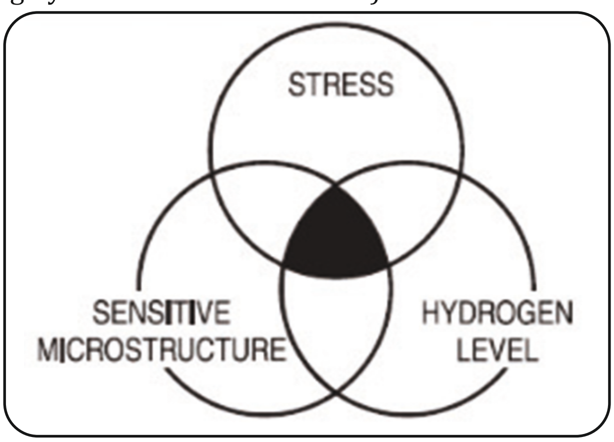


Fig.1: Criteria for hydrogen induced cracking (HIC)

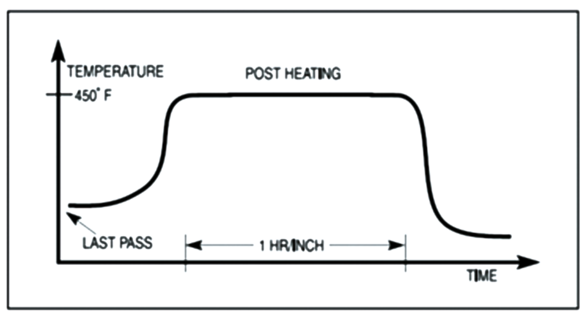
In ferritic steels, hydrogen embrittlement only occurs at temperatures close to the ambient temperature. Therefore, it is possible to avoid cracking in a susceptible microstructure by diffusing hydrogen from the welded area before it cools. After welding has been completed, the steel must not be allowed to cool to room temperature; instead, it should be immediately heated from the interpass temperature to the post heat temperature and held at this temperature for some minimum amount of time. Although various code and service requirements can dictate a variety of temperatures and hold times, 450°F (230°C) is a common post heating temperature to be maintained for 1hour per inch (25 mm) of thickness.

Post heating is not necessary for most applications. The need for post heating assumes a potential hydrogen cracking problem exists due to a sensitive base metal microstructure, high levels of hydrogen, and/or high stresses. Post heating, however, may be a code requirement. For example, ASME Section III and the National Board Inspection Code (NBIC) both have such provisions. The Section III requirement for P-No. 1 materials is 450 to 550°F (230 to 290°C) for a minimum of 2 hours, while the NBIC requirement is 260 to 290°C for a minimum of 2 hours.

Furthermore, post heating is often required for critical repairs, such as those defined under the Fracture Control Plan (FCP) for Nonredundant Members of the AASHTO/AWS D1.5 Bridge Welding Code. The FCP provision is 230 to 315°C for "not less than one hour for each inch (25 mm) of weld thickness, or two hours, whichever is less." When it is essential that nothing go wrong, post heating can be used as insurance against hydrogen cracking. However, when the causes of hydrogen cracking are not present, post heating is not necessary, and unjustifiable costs may result if it is done.

Stress Relieving

Stress relief heat treatment is used to reduce the stresses that remain locked in a structure because of manufacturing processes. There are many sources of residual stresses, and those due to welding are of a magnitude roughly equal to the yield strength of the base material. Uniformly heating a structure to a sufficiently high temperature, but below the lower transformation temperature range, and then uniformly cooling it, can relax these residual stresses. Carbon steels are typically held at 600 to 675°C for 1 hour per inch (25 mm) of thickness.



Fig,2:Post heat applied immediately after last pass

Stress relieving offers several benefits:

(a) For example, when a component with high residual stresses is machined, the material tends to move during the metal removal operation as the stresses are redistributed. After stress relieving, however, greater dimensional stability is maintained during machining, providing for increased dimensional reliability.

(b) In addition, the potential for stress corrosion cracking is reduced, and the metallurgical structure can be improved through stress relieving. The steel becomes softer and more ductile through the precipitation of iron carbide at temperatures associated with stress relieving.

c) Finally, the chances for hydrogen induced cracking (HIC) are reduced, although this benefit should not be the only reason for stress relieving. At the elevated temperatures associated with stress relieving, hydrogen often will migrate from the weld metal, and the heat affected zone. However, HIC can be minimized by heating at temperatures lower than stress relieving temperatures, resulting in lower PWHT costs.

Other Considerations

When determining whether to post weld heat treat, the alloying system and previous heat treatment of the base metal must be considered. The properties of quenched and tempered alloy steels, for instance, can be adversely affected by PWHT if the temperature exceeds the tempering temperature of the base metal. Stress relief cracking, where the component fractures during the heating process, can also occur. In contrast, there are some materials that almost always require PWHT. For example, chrome molybdenum steels usually need stress relieving in the 1,250 to 1,300°F (675 to 700°C) temperature range.

Thus, the specific application and steel must be considered when determining the need, the temperature and time of treatment if applied, and other details regarding PWHT.

The filler metal composition is also important. After heat treatment, the properties of the deposited weld can be considerably different than the "as welded" properties. For example, an E7018 deposit may have a tensile strength of 75 ksi (500 MPa) in the "as welded" condition. However, after stress relieving, it may have a tensile strength of only 65 ksi (450 MPa). Therefore, the stress relieved properties of the weld metal, as well as the base metal, should be evaluated. Electrodes containing chromium and molybdenum, such as E8018-B2 and E9018-B3, are classified according to the AWS A5.5 filler metal specification in the stress relieved condition. The E8018-B2 classification, for example, has a required tensile strength of 80 ksi (550 MPa) minimum after stress relieving at 1,275°F (690°C) for 1 hour. In the "as welded" condition, however, the tensile strength may be as high as 120 ksi (825 MPa). The objective of this article is to introduce the fundamentals of postweld heat treatment; it is not meant to be used as a design or fabrication guide.

For specific recommendations, consult the filler metal manufacturer and/or the steel producer. For Further Reading A SM Handbook, Volume 6 – Welding, Brazing, and Soldering. American Society for Metals,1993. Bailey, N. Weldability of Ferritic Steels.

SPOTLIGHT ON NEW BRAND

Global Leader in Tungsten Carbide -Based Wear Solution

Weldwell Speciality Pvt Ltd, India's trusted name in special and critical welding - surfacing solutions, is proud to announce a strategic collaboration with Technogenia, the world-renowned French manufacturer specializing in advanced tungsten carbide wear protection products. Founded in 1979 in France, Technogenia has built a reputation for excellence in hardfacing products and technology, such as ***Spherotene®; Lasercarb®; Technosphere® and Technodur® Welding Ropes; Technocore® Cored Wires***

Weldwell will represent Technogenia in India as their authorised distributor and cater Indian industries with State-of-the-art Tungsten Carbide Wear Protection Products

Technogenia's hardfacing solutions and comprehensive range of products are engineered to withstand the harshest environments and are extensively used in: Mining, Mineral Processing and Foundries: Oil & Gas: Steel and Cement: Agriculture and Dredging. This collaboration is set to deliver *Next Generation High Performance, Globally Proven Tungsten Carbide Wear Solutions* to Indian industries, offering not only materials but complete systems and technical support for abrasion, erosion, and impact wear protection.

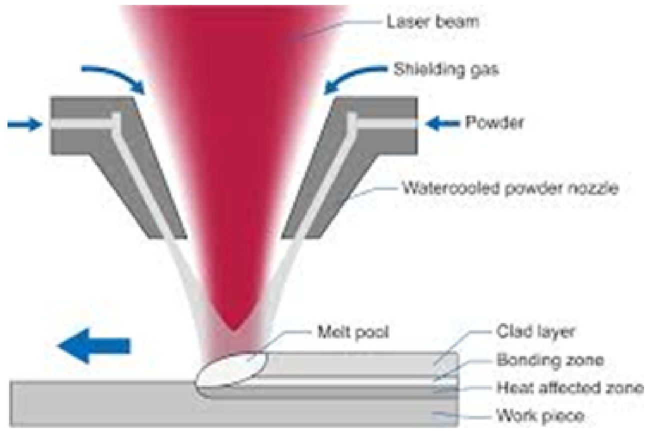
For technical support and availability contact thermalspray@weldwell.com

UNDERSTANDING LASER CLADDING

Introduction: Although many materials that resist corrosion also have good strength and toughness, they tend to be high-value alloys (e.g. nickel alloys, titanium alloys, or stainless steels). Other corrosion resistant materials, such as gold, platinum, CoCr alloys, glass, paints or polymers are either extremely costly and/or do not have the required strength. Applying corrosion resistant materials as a cladding onto cheaper base materials is often the most cost-effective engineering solution. While normal weld cladding is typically used for thick layers (2 to 20 mm), for thinner coatings cladding by laser is preferred. Typically, the normal thickness in industrial applications ranges from 0.5 mm to 1.5 mm for a single layer. Multiple layers can be applied to achieve thicker protection. Cladding thickness is adjustable by varying process parameters like laser power, scanning speed, and wire or powder feed rate. The Laser cladding process uses a laser to melt and fuse a powdered material onto a substrate, creating a protective or functional layer. The thickness of this layer can be precisely controlled, making it suitable for a wide range of applications. Two primary methods of delivering the coating material are powder-based and wire-based laser cladding. Each technique offers distinct advantages and disadvantages, making it crucial to understand their nuances to select the optimal process for specific applications.

CHOOSING THE RIGHT TECHNIQUE

- The selection of the appropriate laser cladding technique depends on several factors:
- Desired properties of the cladding layer: For complex alloy compositions and fine-grained micro-structures, powder-based cladding is often preferred.
- Required deposition rate: Powder-based cladding offers higher deposition rates for thicker coatings.
- Part geometry and complexity: Wire-based cladding may be more suitable for simple geometries.
- Cost considerations: Wire-based cladding is generally more cost-effective due to simpler equipment and lower material costs.
- Environmental and health concerns: Powder-based cladding may require additional measures to mitigate airborne particle emissions. By carefully considering these factors, engineers and manufacturers can make informed decisions to select the optimal laser cladding technique for their specific applications.
- **POWDER-BASED LASER CLADDING**



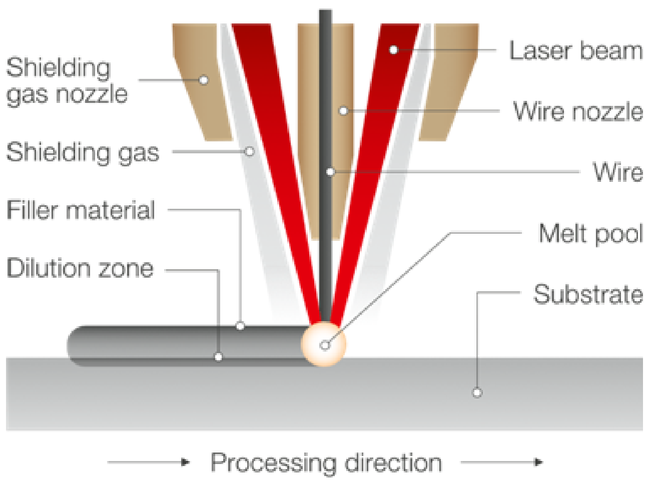
In powder-based laser cladding, a metal powder is fed into the process zone, where it is melted by the laser beam. This method offers exceptional flexibility in material selection, allowing for the creation of intricate alloy compositions tailored to specific requirements. By carefully controlling the powder feed rate and laser parameters, precise control over the micro structure and properties of the cladding layer can be achieved.

KEY ADVANTAGES:

- **Customization: The ability to create customised** alloy compositions opens up a wide range of possibilities for tailoring the properties of the cladding layer.
- Complex Geometries: Powder-based cladding is well-suited for components with intricate shapes and geometries.
- High Deposition Rates: Depending on configuration of the laser system, it is possible to achieve high deposition rate.
- **KEY DISADVANTAGES:**
- Initial investment is high.
- Powder Handling: Proper handling and feeding of the powder are essential to prevent clogging and ensure consistent deposition.
- Environmental Concerns: Powder-based cladding can generate airborne particles, necessitating appropriate ventilation and filtration systems.

WIRE-BASED LASER CLADDING

In wire-based laser cladding, a metal wire is fed into the process zone, where it is melted by the laser beam. This method is generally simpler and more cost-effective than powder-based cladding. It is well-suited for applications requiring straightforward coatings with consistent properties.



Key Advantages:

- Lower Cost: Wire feed stock is typically less expensive than metal powders. Consistent Properties: Wire-based cladding offers reliable and consistent coating quality.

Key Disadvantages:

- Limited Material Selection: The choice of materials is more restricted compared to powder-based cladding.
- Less Flexibility: Wire-based cladding may not be suitable for complex geometries or intricate alloy compositions.

Resource:

Proceeding paper-'Comparison of laser cladding with powder and hot and cold wire techniques'- Janne Nurminen; Jouko Riihimäki; et al ;Laser Automation -Blog

NATIONAL THERMAL SPRAY CONFERENCE (NTSC 2025) EVENT

NTSC 2025 - Inauguration by His Excellency Dr. Kambhampati Hari Babu, Hon'ble Governor of Odisha

The 2nd National Thermal Spray Conference & Expo (NTSC 2025), a landmark event in the field of thermal spray technology and surface engineering, was inaugurated by His Excellency Dr. Kambhampati Hari Babu, Hon'ble Governor of Odisha in the presence of Prof. T N Singh, Director, IIT Patna, Dr Ramanuj Narayan, Director, CSIR-IMMT and Ministers, Govt. of Odisha, many eminent dignitaries from the relevant industry. This prestigious event was organized by the CSIR-IMMTand ITSAin Bhubaneswar, Odisha, from 21st-23rd February, 2025, bringing together top scientists, researchers, industry leaders, and policymakers.

Thermal spray & welding are an important part of modern engineering elements, whose applications in several sectors including aerospace, automobile, medical engineering, energy & power generation, and defence & space technologies are there. The conference highlighted the progress in material science and surface engineering, which plays vital role in these industries. Thermal Spray technology enhances the durability and efficiency of critical components, driving economic growth and sustainability. One of the most significant aspects of this conference was the collaboration between research institutions & industries and their equal participation.NTSC 2025 showcased the latest advancements in thermal spray coatings and their applications across multiple industries. It featured keynote lectures from renowned experts, covering topics such as plasma spray, HVOF, cold spray, suspension and solution precursor spray techniques, nanostructured and composite coatings, corrosion-resistant coatings, and energy-efficient coating technologies. There was also a dedicated expo zone will feature leading thermal spray equipment manufacturers, material suppliers, and research institutions, offering live demonstrations of cutting-edge coating deposition techniques, process optimization, quality control innovations and witness the latest advancements shaping the industry.With the focus on innovation, sustainability, and performance assessment, the conference provided a platform for discussions on emerging trends and future prospects in the field. The insights and innovations that emerged from this conference will not only contribute to scientific progress but also pave the way for real-world applications that benefit industries and society alike.All participants had an opportunity to engage in meaningful discussions, explore new research avenues, and collaborate towards pioneering solutions.

WELDING OF THIN SHEET METALS

Introduction:

Thin sheets of metal < 3.1 mm, are often used to create small, complex structures in steel, aluminium, stainless steel or other alloys. They can be found in a wide variety of sectors, including the automotive, aeronautics, chemical storage tanks, HVAC systems street furniture, household appliance industries etc.

Thin sheet welding has thus become an essential technique enabling assembly of thin parts with precision, while preserving the integrity and aesthetics of the material. Burn-through, warping, distortion, and overfill are the most common defects encountered when welding thin metal. The primary cause of most issues with welding thin metal is poor heat control, which refers to the ability to maintain the correct temperature during the welding process. Mastering thin sheet welding involves using specific techniques and equipment to minimize heat input and maintain the material's integrity.

Key Considerations for Welding Thin Materials:

Welding thin metal poses challenges due to the need for exact heat control to prevent defects like burn-through, warping, and distortion. These issues arise from inadequate heat management, which can also lead to overfill, poor weld appearance, porosity, and incomplete fusion.

The key to successful thin metal welding is addressing heat-related problems to ensure weld integrity and appearance.

Heat Input-Arc Control - Spatter Reduction - Material Properties-Tack Welding.

The choice of process for precision sheet metal work depends on several factors: the nature of the components to be assembled, their end use, and whether aesthetics or productivity are a priority. Specific welding processes used for thin sheet metal: MIG (GMAW) Welding: -Known for its speed and ease of learning, MIG welding is often a good choice for thin sheet metal, especially when speed is a priority.

MAG (GMAW) Welding: - Often used for thin sheet metal due to its high process speed, weld strength, and low distortion.

TIG (GTAW) Welding:- Offers precise heat control, making it suitable for detailed work and thin materials. Pulsed TIG welding is particularly beneficial for minimizing heat buildup Besides these Spot welding; Plasma welding and Friction stir welding are also adopted.

However, of all these, TIG welding is generally the most preferred and is the focus of this article. Essential Tips for Welding Thin Metals Understanding the issues and choosing the suitable approach, including the welding method and equipment, significantly increases your chances of successfully welding thin metals. However, there are specific tips & and tricks that can substantially increase the odds such as -

- Use Skip or Stitch Welding Technique-*Use Tack Welds-
- Select the Suitable Equipment.

Due to its exceptional heat control, many consider TIG welding a go-to method for thin steel. Most TIG welding machines provide a lower amperage output of 5 amps, allowing them to weld exceptionally thin gauges. There is even a form known as micro TIG welding, designed to work at less than five amps and with micro metals.

However, TIG welding is about more than just the low amperage output. This technique also provides excellent heat control by using a foot pedal or features such as pulse welding. Manually pumping the pedal can help you reduce the heat if you notice you are getting too hot during the weld. Pulsed TIG welding is an automatic feature that makes TIG welding thin metal a breeze. You set the frequency, and the current oscillates between the high and low amperage during the weld. During the high amps, the arc melts the pieces and filler metals. During the low amps, the arc persists, but low heat promotes cooling and avoids heat buildup. That way, you reduce the overall heat input and thermal stress produced by rapid heating and cooling, which causes warping and distortion.

Specialized Equipment and Accessories

Kemppi offers solutions for welding thin materials, particularly with their Master Tig series and specific welding processes like MAX Cool and Micro Tack. These technologies focus on minimizing heat input, controlling the arc, and reducing spatter, which are crucial for achieving high-quality welds on thin sheets.

MasterTig AC/DC

Special Features for Thin Material Welding:

MicroTack: is designed for tack welding thin sheet components (up to 4mm thick) of carbon steel, stainless steel, and titanium. It uses a high-current pulse to fuse materials together with minimal heat input, reducing burn-through and deformation. *MAX Cool*: is designed for low heat input welding, making it suitable for thin sheet welding and MIG brazing. It's particularly effective for root passes and achieving high-quality welds on thin materials. *Double-Pulse TIG:* This technique combines slow and fast pulsing to optimize TIG welding for thin materials, fillet and corner joints, and welds with high visual quality requirements.

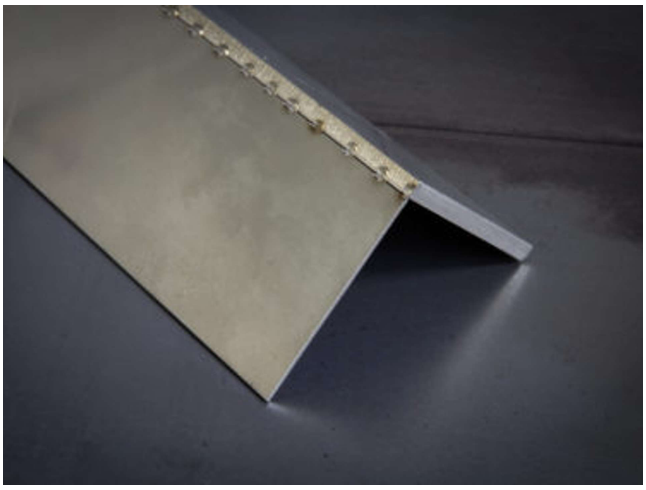
Wise Thin: This process, optimizes short arc welding for sheet metal and thicker plates, even with wider gaps.

Wise Penetration: This welding function maintains consistent penetration regardless of stick-out length, ensuring reliable welds on various materials, including thin sheets.

***Compact Welding Machines*:** Kemppi's Minarc T series, like the Minarc T 223 ACDC, are compact and portable TIG welding machines that offer high-quality AC/DC TIG welding and weld cleaning capabilities, suitable for various welding applications, including thin material welding.

For availability of suitable machines contact nivek@weldwell.com.

EXAMPLES OF THIN WELDING



NEWS FROM INDUSTRY

EXPANDING EV ECOSYSTEM IN INDIA

Chhatrapati Sambhaji Nagar (Aurangabad) lying on the Delhi-Mumbai Industrial Corridor (DMIC) node, is witnessing growing significance in the EV sector with heavy investments.

- *Toyota Kirloskar Motor* - The greenfield plant will manufacture electric and hybrid vehicles. With an investment of ₹21,000 crore and spread over 827 acres. The plant is expected to be operational by January 2026, generating 26,000 direct and indirect jobs.
- *JSW Green Mobility* is setting up an electric cars and commercial vehicle manufacturing facility on 636 acres of land in the Bidkin node of Aurangabad Industrial City (AURIC). The project involves an investment of ₹27,200 crore and expected to create 5,000 direct and 15,000 indirect jobs. Production is slated to begin within 12 to 18 months.
- *Ather Energy*- India's fourth-largest electric scooter maker, plans to set up its third manufacturing facility in Bidkin, AURIC, Chhatrapati Sambhaji Nagar, Maharashtra. This new facility will manufacture both electric two-wheelers and battery packs. With Rs.2,000cr investment the plant will produce up to one million units of vehicles and battery packs annually.

TRANSFORMING GADCHIROLI (MAHARASHTRA) INTO A STEEL HUB

Jindal Stainless Ltd - is planning to invest Rs 40,000 crore in Gadchiroli Maharashtra to establish a stainless-steel manufacturing facility. It will produce a comprehensive range of stainless-steel flat products of varying grades and a focus on DSS production for diverse established sectors. With a strong focus on mineral resources, particularly iron ore, and in related industries like cement and mining will facilitate industrial development in the area.

MARCH OF NTPC TOWARDS ALTERNATE ENERGY

(a) *NTPC*- by leveraging nuclear energy's reliability through its ASHVINI (Anushakti Vidhyut Nigam Ltd) and NPUNIL (NTPC Parmanu Urja Nigam Ltd) projects, is committed to accelerate Nuclear Power Deployment in the country. By targeting 2DW capacity by 2032 and net zero emissions by 2070, it is the first Indian Energy company to declare Energy Compact Goals at the UN HLDE. By adopting nuclear energy NTPC is reshaping India's energy landscape, driving economic growth, and ensuring sustainability

(b) *Tata Power Renewable Energy (TPREL)* has signed a power purchase agreement (PPA) with NTPC to develop a 200 MW clean power project. The project is set to be completed within 24 months and expected to generate approx.1300 million units of electricity annually. The project would consist of solar, wind and battery energy storage system. (BESS) The collaboration reinforces TPREL's position as a leader in India's renewable energy sector.

(c) *BGR Tech and Stargate Hydrogen* collaborate for hydrogen production in India

This integration is expected to enhance the reliability and efficacy of hydrogen generation systems tailored for Indian use. They have collaborated to bring AstraGate's revolutionary high-pressure AWE technology to India. The Stellar Series Alkaline Water Electrolysis, Stargate's top-of-the-line product, has a single stack capability of up to 100 Nm^3/h (500 kW) and is operational at pressures of up to 32 bar. This approach focuses on minimising maintenance and operating costs, which makes it a viable option for green hydrogen production. BGR Tech's pilot plant, which consists of a Hydrogen Purification System (HPS), a Gas Separation Unit (GSU), and an Ultra-Pure water treatment unit, will use a Stellar Series electrolyser. This integration is expected to enhance the reliability and efficacy of hydrogen generation systems tailored for Indian use. BGR-Tech's proprietary pilot plant located in Chennai is expected to produce green hydrogen by May 2025, which will be used as a test resource to further investigate and improve the system's effectiveness and reliability.

TESTAMENT TO INDIGENOUS SPACE TECHNOLOGY GROWING CAPABILITIES

Agnikul Cosmos successfully conducted a sub-orbital test flight of its "Agnibaan" rocket, named "SOrTeD" (Sub-Orbital Technological Demonstrator) within its own launchpad Satish Dhawan Space Centre in Sriharikota. This mission marked a significant milestone for India's private space industry, as it was the first time a privately developed rocket with a 3D-printed, semi-cryogenic engine was launched. The Agnibaan rocket utilizes a single-piece, 3D-printed semi-cryogenic engine, making it a world first in this technology.

SETTING-UP OF ADVANCED MANUFACTURING TECHNOLOGIES IN GLASS

AGI Greenpac Limited - India's leading container glass manufacturer, has announced plans to establish a new manufacturing facility in Madhya Pradesh with an investment of approximately ₹700 crore. This initiative aims to increase the company's production capacity by 25% to meet the growing demand for high-quality glass packaging and is intended to meet the growing demand for high-quality glass packaging. The plant will have a daily capacity of 500 tonnes and will produce glass for sectors like alcoholic beverages, pharmaceuticals, and food. It is expected to be operational within 24 months and will generate over 1,000 direct and indirect employment opportunities. AGI Greenpac aims to integrate advanced manufacturing technologies and sustainable practices into this new facility.