WELDWELL Spectrum

Quarterly Newsletter of Weldwell Speciality Pvt. Ltd.

October - December 2024 | Volume 31 Issue # 4

Highlights

- "Welding of INCOLOY 800 Series Materials"
- "Nitronic - A Super Austenitic Stainless Steel"
- "Carbon and Carbon Equivalent"
- "Thermal Coating Applications in the Steel Industry"
- "Age Hardening (Precipitation Hardening) Steels".

WELDFAB TECH AWARDS 2024

MR. KAPIL GIROTRA, Director

Accepting the 'WELDFAB TECH' "LIFETIME ACHIEVEMENT AWARD",
on behalf of MR. C.C. GIROTRA, MD – WELDWELL SPECIALITY

IN SERVICE TO THE WELDING COMMUNITY

Editorial

Dear Readers,

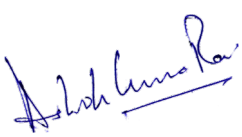
Greetings from the Weldwell Editorial team. We are pleased to place Spectrum Volume 31 Issue # 4 in your hands. This quarter was very eventful, as, our founder and managing director was felicitated with a "Lifetime Achievement Award" by a leading Welding Journal for his contributions to the welding industry at large. It also saw our active participation in the 3-day India-Essen Trade Fair held in Mumbai. The event has been covered and glimpses of the trade fair are included in this issue. The highlights of this issue are:

Stainless Steels have been the preferred choice of material of construction in quite a few industries especially Oil, Gas and Chemical Industries. With more and more applications involving higher temperatures and corrosion resistance, newer grades of Steels are finding usage.

Air Hardening (Precipitation hardening) Steels' and 'Nitronic- A Super Austenitic Steel' give an overview of the sematerials having niche applications.

'Considerations of "Welding of INCOLOY 800 Series Materials" is a treatise to cover the factors to be considered during INCOLOY 800 fabrication. Special Metals specially developed this INCOLOY 800 series to satisfy the demand for economical materials with high-temperature and anti-corrosion properties. Newer applications of thermal Spray Powders are being found, one such application is discussed in "Thermal Coating Applications in the Steel Industry". "Carbon and Carbon Equivalent" stresses on the importance and fundamental aspects affecting the welding process in steels. It is hoped that you will find all these informative and interesting You are requested to kindly offer your comments and feedback.

Happy reading!!



Ashok Rai
Editor

"WELDING OF INCOLOY 800 SERIES MATERIALS"

Introduction: With ever-continuing demands for increased throughput and efficiency, there has been a trend towards higher service temperatures and pressures. This has resulted in continued improvements in material compositions and fabrication techniques, including welding. Of the high-temperature materials developed, Nickel-Iron-Chromium alloy with a low carbon content, good strength and resistance to oxidation and carburization to intermediate temperaturesis now the preferred material of construction in a wide number of industries., such as power generation, chemical processing, and gas turbine. The balanced Ni-Cr-Fe Alloy 800, developed by INCO ALLOYS in 1950s as INCOLOY®800 series of alloys were invented as the result of monitoring and maintaining the ultimate chemical properties for high temperature strength and resistance to oxidation, carburization and other types of high-temperature corrosion. Thiseconomical alloy with a relatively low Ni content,is a single phased, austenitic, solid solution alloy with fine dispersion of gamma prime particles and carbides and with typical composition as follows:

Fe %	Ni %	Cr %	Mn %	Si %
39.5 min	30.0-35.0	19.0 - 23.0	1.50 max	1.0 max

Cu %	Al %	Ti %	C %	S %
0.75 max	0.15-0,60	0,15-0,60	0.10 max	0.01 max

Table 1: Typical Composition of INCOLOY 800Type 800

Nb welding consumables are designed for welding wrought and cast heat resistant alloyswith a matrix composition based on Fe-21Cr-32Ni. Wrought alloys of this type belong to theIncoloy 800 series (alloys 800, 800H and alloy 800HT). These are progressively strengthened withcontrolled and increasing levels of C (to 0.10% max.), Al and Ti (0.15 – 0.60% each). In equivalentcast alloys, Al + Ti are replaced with around 1%Nb, with slightly more carbon than the wroughtalloys. Weld metal composition is closely related to the cast alloy, and is referred to as 'matching' as distinct from the dissimilar nickel-base consumables which are alternatively used.

There are several distinct versions (having same basic chemistry) of alloyINCOLOY 800 (UNS N08800), which have evolved by changes in alloying and grain size requirements. Each one a refinement of the one before, these alloys have set the industry standard in high temperature applications requiring optimum creep & rupture properties.These are primarily driven as a means of enhancing the alloy properties.Incoloy 800H(UNS N08810)with a controlled compositioncarbon content of (0.05% - 1.0%) and Incoloy 800HT(UNS N08811) with a controlled composition with carbon content of (0.06% to 1.0 %) are the two derivatives, used frequently for higher temperatures. Further, the grain size are modified to be ASTM grade 5 or coarser.The combined effects of mechanical and thermal processing of the alloy thus permit higher design stresses to be incorporated than are permitted for the conventional alloy. The considerations of welding these alloys are the focus of this article.

USP of Incoloy 800H Special Considerations for Welding.

*Stable austenitic structure without liability for forming embrittling intermetallic phases

- Satisfactory retained ductility following exposure to service temperatures.
- Scaling resistance at service temperatures (20Cr-32Ni base)
- Good hot strength and stress-rupture performance over service range up to about 9500C. The rupture strength of Incoloy 800H/HT at various temperatures is given in table 2 below.

Temperature		10,000 h		30,000 h		50,000 h		100,000 h	
°F	°C	ksi	MPa	ksi	MPa	ksi	MPa	lcsi	MPa
1200	650	17.5	121	15.0	103	14.0	97	13.0	90
1300	705	11.0	76	9.5	66	8.8	61	8.0	55
1400	760	7.3	50	6.3	43	5.8	40	5.3	37
1500	815	5.2	36	4.4	30	4.1	28	3.7	26
1600	870	3.5	24	30.	21	2.8	19	2.5	17
1700	925	1.9	13	1.6	11	1.4	10	1.2	8.3
1800	980	1.2	8.3	1.0	6.9	0.9	6.2	0.8	5.5

Table2: Representative Rupture Strength-INCOLOY 800H

Selecting Welding Consumables

In general, alloys 800 series have good weldability, but Incoloy 800H, due to its higher carbon content, requires more careful control, as, there is a tendency to form carbides that may affect its properties. The designed alloy performance criteria for weld metal are essentially the same as for equivalent cast and wrought base materials.Based on the above considerations and the composition,the choice is either matching micro-alloyed austenitic stainless steel or over matching nickel welding consumables. The welding of cast 800 series alloys with the micro-alloyed austenitic steel fillers thatmatchthe chemistry and strength to certain extent of the cast alloys due to micro-alloying. However,welding wrought 800 series alloys (especially Incoloy

800H/HT),have historically been welded with nickel-base fillers, due to higher temperatures.

Consumable	C	Mn	Si	Cr	Ni	Mo	Nb
SMAW Electrode	0.10	2.50	0.3	21	32	< 0.5	1.3
Filler Wire	0.15	1.7	0.2	21	33	< 0.1	1.5

Table1: Typical compositions of welding consumables

Notes: Average Carbon level of Filler Wire is typically higher than SMAW deposits to allow for transfer.

Variants with 4.5%Mn are also produced. Creep failures have been observed when welding Alloy 800H Steam Methane Reformer with 21.33Mn filler. The attached 4x micrograph (Fig 1 & Fig 2) shows the extensive cracking located solely in the weld and creep failure occurs at temperatures9000C approximately.

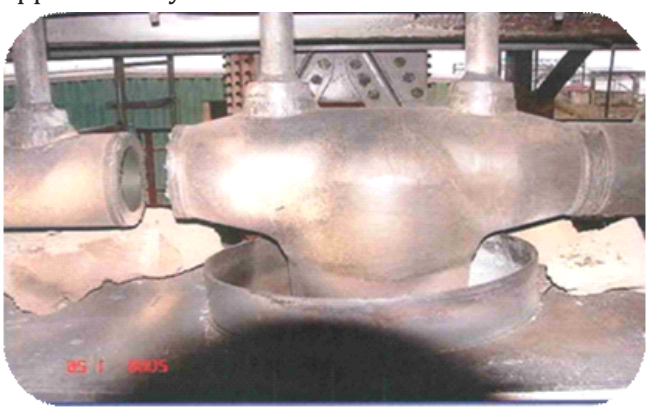


Fig1:Creep Rupture of 21.33 filler joint@ 900°C

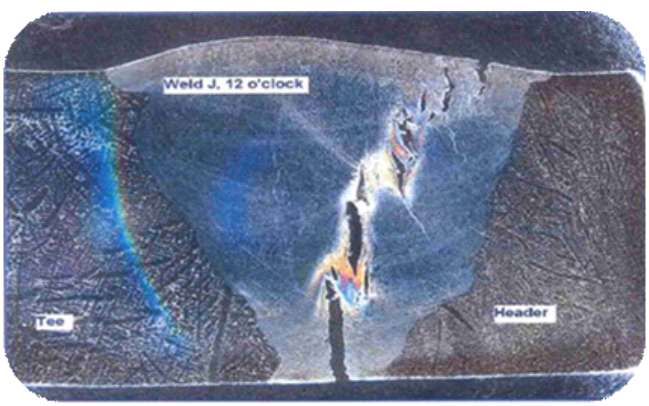


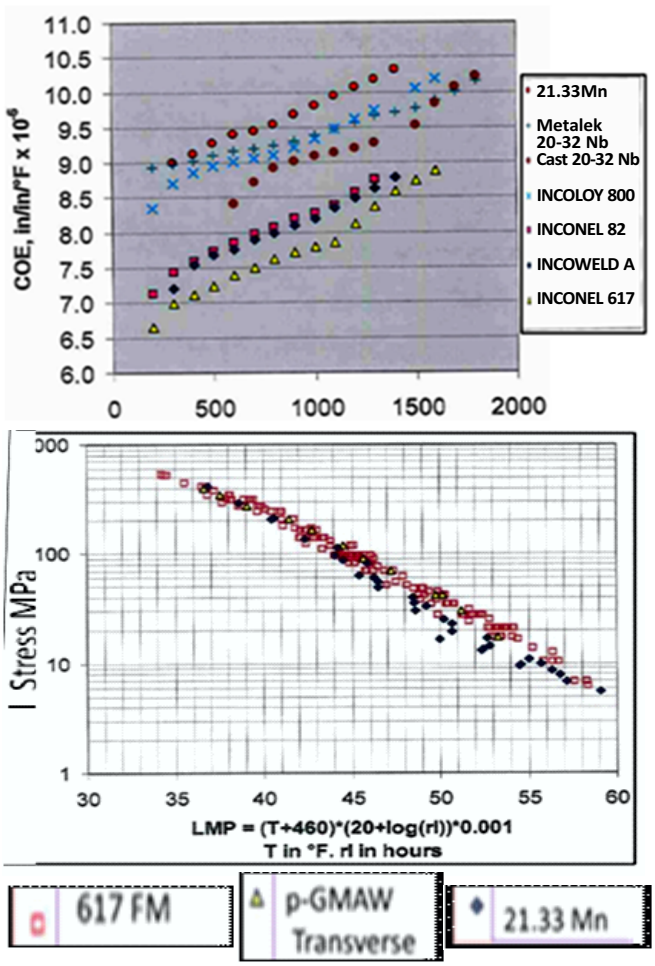
Fig 2 Creep Rupture of 21.33 filler joint @ 900°C

Weld Integrity Study for Welding 800H

Alloys 800H and 800HT have the same good weldability, as alloy 800, and are normally used for applications requiring high creep-rupture strength and should be joined with welding products that have suitable strength characteristics for the intended service. Observations in a recent study of welding Incoloy 800H with micro-alloyed austenitic SS 21.33Mn filler and some nickel welding consumables are tabulated below.

Welding Product	Temperature		Stress for Rupture In			
			1000 hours		10,000 hours	
	°F	°C	kcal	MP_a	kcal	MP_a
INCO-WELD A Electrode	1000	640	51.0	352	39.0	269
	1200	650	24.5	196	16.0	110
	1400	710	11.0	76	7.1	49
	1600	870	3.65	25	1.9	13
	1800	980	0.8	6	--	--
INCONEL Filler Metal 82	1000	540	52.0	359	47.0	324
	1200	650	27.5	190	20.5	141
	1400	700	11.5	79	8.3	57
	1600	870	3.6	24	1.75	12
	1800	960	1.23	9	0.57	4

Table3: RuptureStrength of Welding Products (All Weld Metal Specimens) for INCOLOYS 800H & 800HT



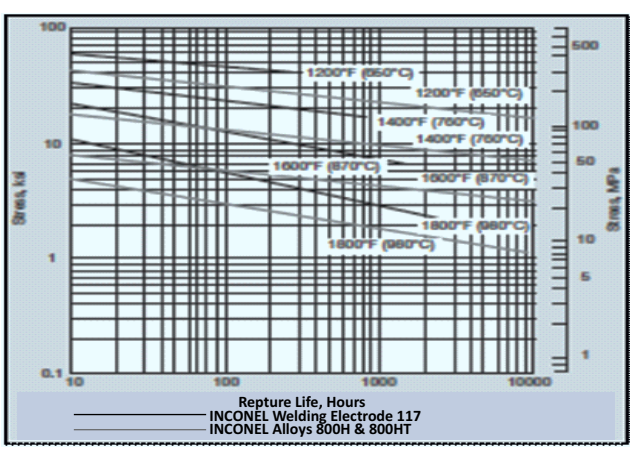


Fig4: Stress rupture life of INCONEL 117 as compared with that of INCOLOYS 800H & 800HT

The analysis of the above tests confirms these facts:

(I) The 21.33Mn Matching Filler although matches the chemistry, but fails in the rupture strength above 900^{0}C

(ii) The potential to creep rupture of the austenitic steel consumables is due to the difference in thermal expansion, as compared to alloy 800.

(iii) At 1400^{0}F:CTE of 21.33Mn is 8.1% higher than average cast base metal CTE, while CTE of 617 FM is 10.2% lower than average cast base metal CTE

(iii) All the filler metals of nickel-based alloys are likely to have a Coefficient of Thermal Expansion (COE) approx. 25% lower than the Incoloy 800 base metal.

(iv) All the data of Inconel FM 617 & WE Inconel 117 illustrate favourable properties in comparison with the base metal over a wide range.

SUMMARY

* The alloy 800H displays a marked tendency to solidification cracking and this can be avoided by strict compositional control and grain size along with correct welding procedures.

* Alloy 800 can be welded without cracking problems even with high heat input welding processes using either high nickel filler wires or a matching electrode.

* Nickel-based filler wire can help solve problems that arise when welding dissimilar materials.

Welding issues such as avoiding defects of lumpy weld beads by manipulating with Nickel consumables.

* Successful quality welding of Incoloy 800H leads to its usage for more demanding applications with constant high temperatures and stress in the power generation, chemical processing, and heat exchangers.

* Three nickel-base filler wire specifications (and/or equivalent electrodes) are commonly applied to the 800 series alloys:

a) AWS ERNiCr-3 (Inconel 82) was the only established choice until the 1970's, although its stress rupture properties were considered to under match the higher strength 800H (and later 800HT) alloys above about 7600C-8000C. The equivalent SMAW electrode is AWS ENiCrFe-2 (Incoweld-A).

b) AWS ERNiCrMo-3 (Inconel 625) became available in the 1970's and, with its superior stress rupture properties, extended good joint efficiencies to the useful upper working range of 800HT at around 760-9500C.

c) AWS ERNiCrCoMo-1 (Inconel 617) arrived during the 1980's and offered further enhancement above the properties of FM625, particularly for alloy 800HT at the highest service temperatures. The aged ductility of Inconel 617 weld metal is also recognised to be higher than Inconel 625, because it does not precipitate the more deleterious Ni3Nb.

Resource: Special Metals-literature, TWI- Welding of Incoloy 800H/HT

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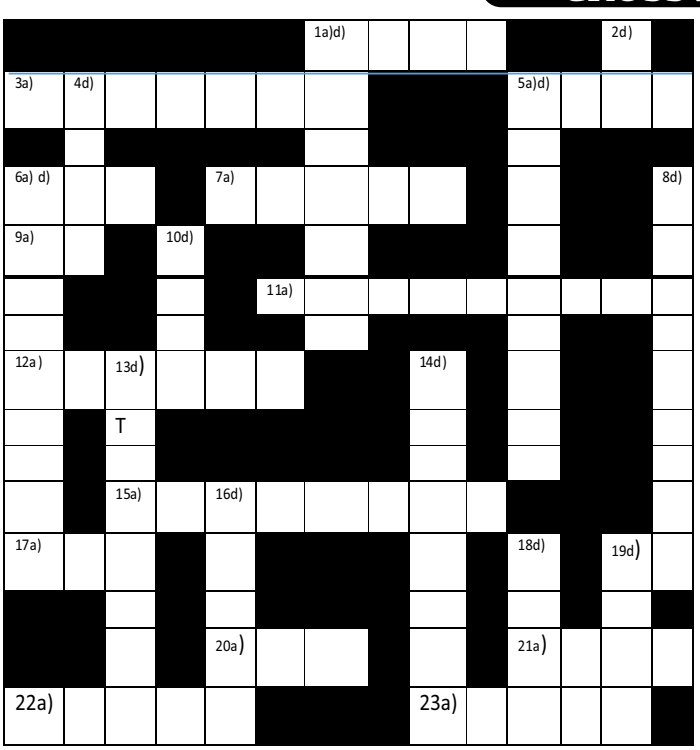


ACROSS

1a) Temporary Joint in Welding (4)
3a) Welding that bonds together thermoplastics, using two heated bars (7)
12a) Welding Speed per minute in GMAW (4)
6a) Unmelted base material that has undergoes changes in its microstructure and properties (3)
7a) High intensity light (5)
9a) Specification of Tungsten Electrode- (2)
11a) Coated metal wires that are consumed during the welding process. (9)
12a) Pre-placed consumable filler wire (6)
15a) The process of initiating the arc (8)
17a) No bronze alloy without it (3)
20a) Operation before welding (5)
21a) First pass or weld bead at the base of a joint (4)
22a) A tool that delivers a controlled heat source, whether a flame or an electric arc (5)
23a) At this stress metal gives way (5)

DOWN

1d) Important mechanical property (7)
2d) Domestic supply Current (2)
4d) Most popular and common welding process (4)
5d) The space between filler metal and base metal in a solid-state weld with filler metal (5-4)
6d) This input is essential for welding (4-5)
8d) GAS which can be used for both cutting & welding (9)
10d) Unpleasant smoke during welding (4)
13d) Straight narrow bead (8)
14d) Unwanted hole/void due to gas entrapment in the weld (8)
16d) A stress concentration point due to geometrical irregularity (5)
18d) Filler metal form for welding (4)
19d) A quantative assessment of crack propagation (4)

SOLUTION ON PAGE # 11

NITRONIC – A SUPER AUSTENITIC STAINLESS STEEL

Nitronic® is the trade name referring to a specific group of nitrogen-enhanced super duplex stainless steels. Originally developed by Armco Steel, the trademark since 2020, now belongs toCleaveland-Cliffs. The term Nitronic® refers to the way in which nitrogen has been used to stabilise and strengthen the alloy. Unlike other kinds of nitrogen-enhanced steel, Nitronic® is notable as the nitrogen has been added internally, rather than being nitrided to the surface of the alloy. This gives it increased durability, even compared to 316L and 304L.

Nitronic Family: Nitronic® 40 was the first grade of Nitronic® developed. It is commonly used in the aerospace industry, where its high performance at ultralow temperatures makes it a good choice for hydraulic tubing at high altitudes. The most widely used Nitronic® alloys are Nitronic® 50 (Fermonic 50, XM19, UNS S20910, 1.3964) and Nitronic® 60 (Fermonic 60, UNS S21800).

Nitronic® 50 is a super austenitic stainless steel, offering improved strength and significantly improved corrosion performance (PREN = 34) over regular 3xx series grades. It is most widely used in the production of valve stems due to its toughness at lower operating temperatures and in a wide range of marine and boat hardware due to its ease of fabrication. Nitronic® 60 is specifically formulated to achieve excellent galling and wear resistance and is used in applications such as connectors. Nitronic 60 (ASTM A276, ASTM A240, AMS 5848, ASTM 479, and ASTM 193/194).is truly an all-purpose metal.

Properties:

The alloy is a nitrogen- strengthened austenitic stainless steel exhibiting high strength and good toughness over a wide range of temperature, Nitrogen alloying in this base composition results in significant improvement in wear resistance in particle-to-metal and metal-to-metal (galling) applications when compared to the more conventional austenitic SS such as Type 304. The oxidation resistance of Nitronic 60 is similar to Type 309 S.S., and far superior to Type 304S.S. The additions of Silicon and Manganese have given this alloy a matrix to inhibit wear, galling, and fretting even in the annealed condition. Chromium and Nickel additions give it comparable corrosion to 304 and 316 stainless steels, while having approximately twice the yield strength. The high mechanical strength in annealed parts permits use of reduced cross sections for weight, and cost reductions through the use of thinner stock.

WELDING OF NITRONIC® 60 ALLOYS

Filler metal A8.2 ER218 is most often used to weld UNS S21800 base metals including Nitronic® 60.

C	0.07	P	0.03
Cr	17.2	S	0.02
Ni	8.6	N	0.12
Mn	8.2	Si	3.9
Mo	0.75 max	Cu	0.75 max
Fe	BALANCE		

Table1: Typical Chemistry of Filler Wire

Weldments in the as-welded condition made by using this filler metal provide one of the best combinations of strength and ductility when subjected to carbide precipitation. The ER218 filler metal has sufficient total alloy content for use in welding dissimilar alloys like mild steel and the stainless steels. and also, for direct overlay on mild steel for corrosion and wear applications when used with GMAW process. GTAW, Plasma arc & EB are not suggested for direct application of this filler metal on mild steel.

Applications

- **Automotive Valves** - can withstand gas temperatures of up to 815°C (1500°F) for a minimum of 80,000 km. (50,000 miles).
- **Fastener Galling**: capable of frequent assembly and disassembly, allowing more use of the fastener before the threads are torn up, also helps to eliminate corroded or frozen fasteners.
- **Pins:** Used in roller prosthetics & chains to ensure a better fit of parts (closer tolerance, non-lubricated) and longer lasting.
- **Marine shafts:** better corrosion than types 304 and 316, with double the yield strength
- **Valves, seats, and trim:** Nitronic 60's galling resistance makes it a good choice for valve stems, seats, and trim.
- **Bushings and Roller Bearings:** Nitronic 60 is used in bushings and roller bearings.
- **Pump Shafts and Rings:** Nitronic 60 is used in pump shafts and rings, including wear rings and lobes.
- **Wear plates, rails guides, and bridge pins:** Nitronic 60 is used in wear plates, rails guides, and bridge pins.
- **Marine shafts:** Nitronic 60 is used in marine shafts, where it offers better corrosion resistance than type 304.

Fasteners for Pumps & Seals

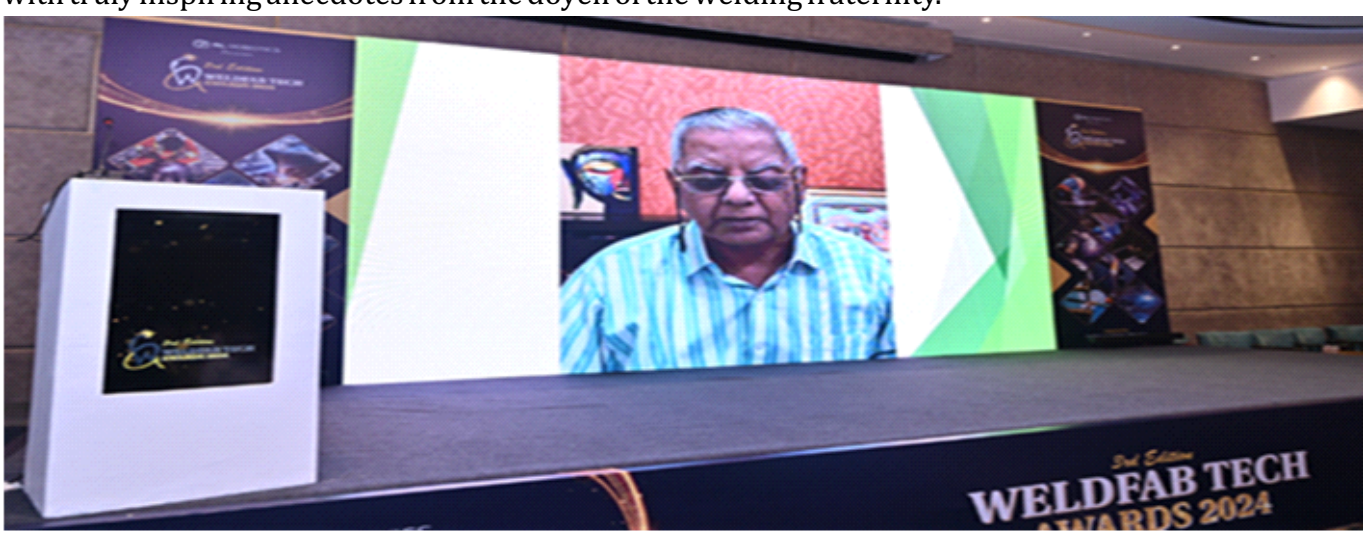
Event Round-up - WELDFAB TECH AWARDS

November 27, 2025 was one of the most memorable day for “Weldwell Speciality Pvt. Ltd.” On this day our founder Managing Director, Shri C.C. Girotra, was honoured and felicitated with 'Lifetime Achievement Award' by “WELDFAB TECH AWARDS ”. WELDFAB TECHTIMES, isa leading magazinecatering to the welding fraternity.The prestigious award,chosen by an eminent jury, is in appreciationof the contributions to the welding industry over the years.

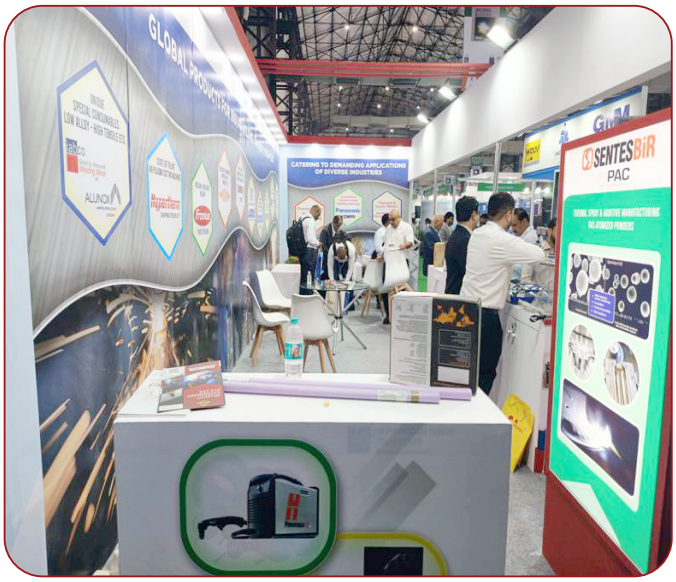
WELDFAB TECHTIMES hosted the 3rdEdition of the presentation ceremony at The Lalit Hotel in Mumbai. Mr. Girotra, due to health reasons could not attend in person, but the same was handed over to his nephew Mr. Kapil Girotra, Director Weldwell.

On this ocassion, a video-clip of the journey, highlighting the accolades and milestones of his50 years career.

Subsequently, Mr Girotra's acceptance speech was relayed. His words of wisdom and the various challenges faced and overcome were heard attentively by the august audience present. It was filled with truly inspiring anecdotes from the doyen of the welding fraternity.



For a glimpse of the India - Essen Trade Fair held in Mumbai turn over leaf.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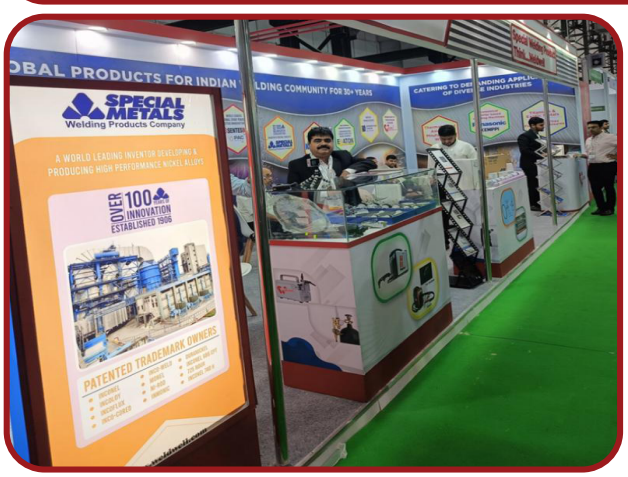
SPECIAL METALS
Welding Products Company
A WORLD LEADING INVENTOR DEVELOPING & PRODUCING HIGH PERFORMANCE NICKEL ALLOYS
OVER 100 INNOVATION ESTABLISHED 1906
PATENTED TRADEMARK OWNERS


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EXCELLENCE IN ENGINEERED COPPER ALLOYS SINCE 1914
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THERMAL SPRAY & ADDITIVE MANUFACTURING
GAS ATOMIZED POWDERS

CARBON AND CARBON EQUIVALENT

Introduction:

Steel is an alloy of iron and carbon along with several other elements in small quantities, all of which have an impact on its properties. Carbon Steels invariably predominantly contain Iron and Carbon in varying amounts, while other ferrousalloy steels also contain other alloys such as manganese, chromium, nickel etc. beside carbon and iron.

Classification	Carbon Content
Low carbon steels	Up to 0.30%
Medium carbon steels	0.31 to 0.45%
High carbon steels	0.45%.
Low alloy steel	
Medium alloy steel	0.25–0.50%
High alloy steel	1.25–2.0%

Table1: Classification of Steels

In all ferrous materials like steel, increasing carbon content affects the mechanical properties as indicated in fig.1 below.

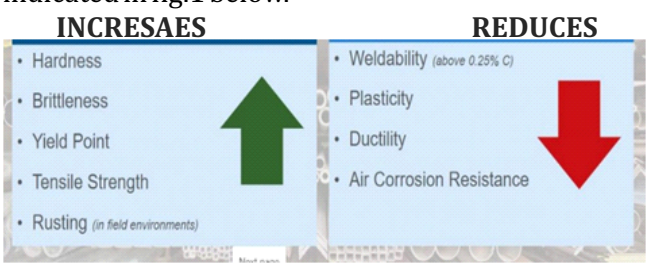
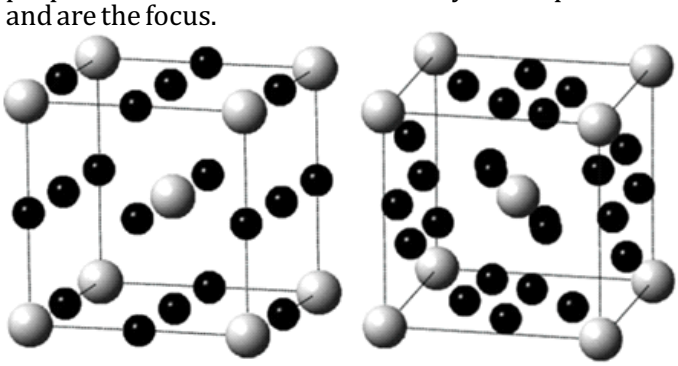


Fig1: Mechanical Properties affected by Carbon Content increase

The increase in Carbon content specifically enhances strength and hardness while reducing the ductility and weldability. The reason for this is, that carbon atoms occupy interstitial spaces between iron atoms disrupting the iron latticemaking it harder for the material to deform plastically. Some of the other elements present in the alloys also affect the mechanical properties. Of the above mechanical properties Hardness and Weldability are important and are the focus.



(a) As shown in the image above, carbon.
(b) atoms do not take the place of iron (Fe) atoms, but rather locate themselves in the spaces in between.This results in a more crowded space between atoms which in turn makes it harder for the material to dislocate.Factors affected during Welding of Ferrous Steels.

Welding is a critical factor in many industrial applications involving both carbon steels and ferrous alloy steels. In arc welding of carbon and alloy steels, hardening of the heat-affected zone (HAZ) of the base metal is normally caused by the transformation of austenite to martensite that results from the rapid cooling of the weld metal leading tothe formation of a brittle microstructure. This effect in the heat-affected zone and high hardenability can lead to cracking, especially during cooling.

The degree of hardening depends on the alloy content and the cooling rate. For carbon and low alloy steels the effect of composition is assessed by means of the empirically developed carbon equivalent (Ceq).

Understanding Alloying Effects

The concept of equivalent carbon content is applicable to ferrous materials in which apart from carbonother alloying elements are included. It is a numerical value that represents the combined effect of carbon and other alloying elements on the hardenability and weldability of steel.CE is calculated using a formula that takes into account the percentages of carbon and other alloying elements (e.g., manganese, chromium, molybdenum, nickel, etc.).

The following formula is most commonly used for determining Ceq, which is adopted by the International Institute of Welding:

$$Ceq = C + \frac{Mn}{6} + \frac{(Cu + Ni)}{15} + \frac{(Cr + Mo + V)}{5}$$

Importance of Carbon Equivalence Number:

Carbon equivalence is used in welding to examine the different alloying elements affecting the hardness of the steel being welded. Carbon equivalent is an essential predictor of steel hardenability, weldability and hydrogen induced cracking. It is a measure of the tendency of the weld to form martensite on cooling and to suffer brittle fracture. Ceq is considered an indicator that can help predict the hardenability or weldability of the base metal. That is, the higher the Ceq, the greater the expected hardness and the higher the preheat temperature. This is why Ceq may be included in material specifications and welding construction codes as either a recommended or mandatory guide for regulating steel selection or for controlling welding procedures.

Mitigation Strategies:

- Preheating the steel before welding can help slow down the cooling rate and reduce the risk of cracking.
- Post-weld heat treatment, such as stress relief, can help to relieve residual stresses and improve the mechanical properties of the weld.
- Selecting welding techniques and parameters that minimize heat input and cooling rates can also help to reduce the risk of cracking.
- Using appropriate filler metals that match the base metal composition and properties can also help to improve weldability.

Contd. Pg # 12

THERMAL COATING APPLICATIONS IN THE STEEL INDUSTRY

- **Introduction:** The steel making processes involves extreme and harsh operating conditions; hence, the production hardware is exposed to degradation mechanisms under high temperature oxidation, erosion, wear, impact, and corrosive environments. These adverse factors affect the product quality and efficiency of the steel making industry, which contributes to production downtime and maintenance costs. Thermal spray is an established industrial method for the surfacing and resurfacing of metal parts. The benefits are typically lower cost, improved engineering performance, and/or increased component life. In addition to original equipment applications, thermal spray coatings are used to repair parts worn and damaged in service, and restore dimensions to machined parts. Thermal spray coatings are also used to restore the dimensions of components that have been worn or corroded, such as printing rolls and undersized bearings. Although the thermal spray coating does not add any strength to the component, it is a quick and economical way to restore the dimensions of parts. Subsequent grinding operations are often needed to smooth the coating's surface and to bring the final dimensions into their appropriate tolerances. Thermal spray coatings for dimensional restoration are being used in every manufacturing industry Application and development of thermal spray coatings for steel making hardware from the molten metal processing stages such as electric arc and basic oxygen furnaces, through to continuous casting, annealing, and the galvanizing line; to the final shaping process such as cold and hot rolling of the steel strips are highlighted. Specifically, thermal spray feedstock materials and processes that have potential to replace hazardous hard chrome plating are discussed. It is projected that novel coating solutions will be incorporated as awareness and acceptance of thermal spray technology grows in the steel making sectors, which will improve the productivity of the industry.

KEY AREAS OF THERMAL SPRAY COATING USED:

- **Rolling Mill Rolls:** Applying coatings like ceramic-metal composites (cermets) or hard metal alloys to working rolls to improve wear resistance against steel strip during hot and cold rolling processes.
- **Furnace Components:** Coating furnace linings, burner nozzles, and lances with heat-resistant materials like zirconia or alumina to protect against high temperatures and corrosive slag.
- **Continuous Casting Moulds:** Using thermal spray coatings to enhance the wear resistance of

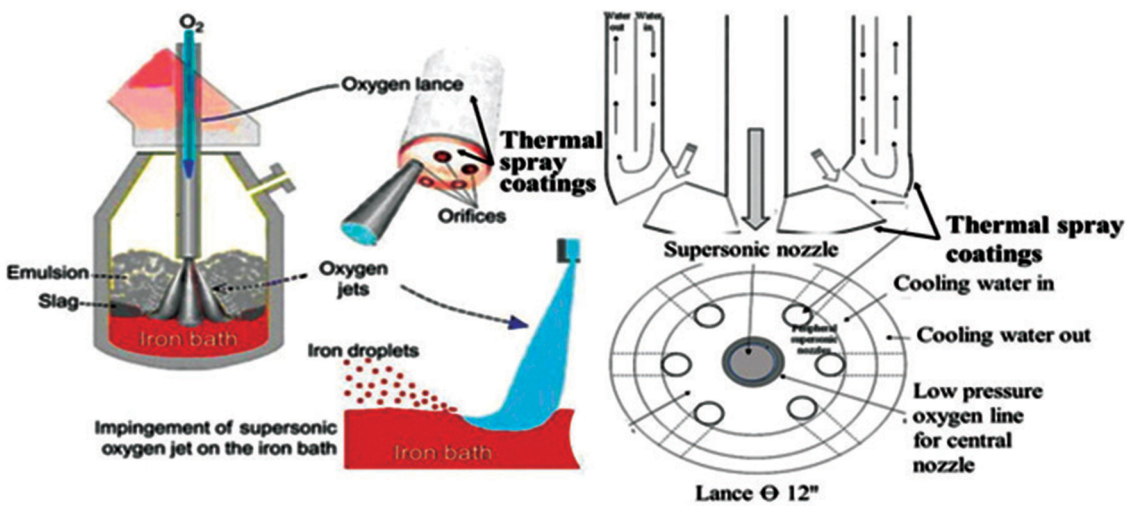


Fig1: Schematic representation of iron and steel production processing

SOLUTIONS TO CROSSWORD # 314 FROM PG # 5

ACROSS

1a) TACK 3a) IMPULSE 5a)INCH 6a)HAZ 7a) LASER9a)EW 11a) ELECTRODE 12a) INSERT 15a) IGNITION 17a) TIN 20a) CUT 21a) ROOT 22a) TORCH 23a) YIELD

DOWN

1d) TENSILE 2d) AC 4d) MMAW 5d) INTERFACE 6d) HEAT INPUT 8d) ACETYLENE 10d) FUME 13d) STRINGER 14d) POROSITY 16d) NOTCH 18d) WIRE 19d) CTOD

mould surfaces, reducing sticking and improving the quality of cast steel products.

- **Steel Processing Equipment:** Coating components like guide rails, deflector rolls, and bridle rolls with wear-resistant materials to minimize wear and tear during steel handling.

Some important benefits of using thermal spray coating in steel production:

- Improved wear resistance: Coatings can significantly increase the lifespan of components exposed to high abrasion, reducing downtime and maintenance costs.
- **Corrosion protection:** Applying protective coatings like zinc or aluminum alloys to steel components can enhance their resistance to corrosive environments.
- **Heat Resistance:** Thermal barrier coatings can be applied to components operating at high temperatures, providing thermal insulation and preventing thermal fatigue.
- **Surface Restoration:** Thermal spray can be used to repair worn or damaged surfaces on existing components, extending their service life.

Common thermal spray coating materials used in the steel industry:

- **Cermets:** A combination of ceramic particles (like tungsten carbide) and metal binders, offering excellent wear resistance
- Oxides: Alumina, zirconia, and chromia coatings for high-temperature applications
- **Nickel-based Alloys:** For corrosion resistance in specific environments

Three main Thermal spray techniques used in the steel industry:

1. **Plasma spraying:** Widely used due to its ability to deposit a wide range of materials at high temperatures
2. High-velocity oxygen fuel (HVOF) spraying: Provides high-density and well-adhered coatings
3. Flame spraying: Suitable for applying thicker coatings on larger components

Conclusion:

- In the steel industry, thermal spray coating is primarily used to enhance the wear resistance, corrosion protection, and heat resistance of critical components like rolling mill rolls, furnace components, continuous casting moulds, and other steel processing equipment, by applying specialized coatings that can withstand harsh operating conditions like high temperatures, abrasive wear, and corrosive slag fumes, thereby extending their lifespan and improving production efficiency. In addition to original equipment applications, thermal spray coatings are used to repair parts worn and damaged in service, and restore dimensions to machined parts. Thermal spray coatings are used to restore the dimensions of components that have been worn or corroded, such as printing rolls and undersized bearings. Note: For availability of all Thermal Spray Powders for all the above applications.

Contact thermalspray@weldwell.com.

Contd. Pg # 10

- Controlling heat input, prescriptive heat treatment using low hydrogen electrodes.
- Summary
- Higher carbon content makes steel more prone to hardening during welding, as the weld cools quickly, leading to the formation of a hard, brittle micro-structure in the heat-affected zone (HAZ).
- The carbon equivalency result not only gives us an idea of the hardness and other qualities, but it tells us the heat affected zone that we're impacting. It allows us to predict whether or not, when we join two metals, that they're going to be compatible.
- The carbon equivalent (CE) value is used to assess the hardenability and weldability of steel. A higher CE value indicates a greater risk of cracking and reduced weldability, often requiring preheating or other measures to mitigate these issues
- Carbon equivalent is a comprehensive tool used, in recent times, to predict steel properties in welding engineering. CE helps predict the likelihood of cracking and other weld defects in alloy steels. CE allows engineers to select steels with appropriate weldability for specific applications.
- The AWS states that for equivalent carbon content above 0.40% there is a potential for cracking in the heat-affected zone (HAZ) on flame cut edges and welds.
- Typically, low carbon steel presents no danger of cracking unless the thickness is over 1" (25 mm). Low carbon steels should be preheated when its thickness exceeds ¾" (19 mm) typically. Medium carbon steels present moderate risk of cracking and should always be preheated. High carbon steels are extremely susceptible to cracking and must be welded with extreme care. High-carbon steels require heat treating before, during, and after welding.

Carbon Equivalent (CE)	Weldability	Preheating
Up to 0.35	Excellent	Not Necessary
0.36 - 0.40	Very good	Recommended
0.41 - 0.45	Good	Necessary
0.46 - 0.50	Fair	Necessary
0.51 and over	Poor	Necessary

AGE HARDENING (PRECIPITATION HARDENING) STEELS

Introduction:

Precipitation hardening or Age hardening of stainless steel is a process that is used for making an excellent class of alloys that have the advantages of both martensitic and austenitic grades of steel. These alloys are similar to other stainless steel and nickel-based alloys, with one major exception- they contain small additions of copper, molybdenum, aluminum, phosphorus, or titanium. The specialized heat treatment process that they go through gives the alloys increased tensile strength (from 850 MPa to 1,700 MPa) and yield strengths of 520MPA to over 1500MPa - some three or four times that of an austenitic stainless steel such as type 304 or type 316, while keeping their effectiveness and ductility. Despite their more complex metallurgy, PH alloys are not necessarily more costly than many non-age-hardenable alloys. In fact, performance may be substantially higher than such alloys, without a cost penalty. Although corrosion resistance is decreased (or possible increased) during the aging cycle, it is only by a slight amount.

Characteristics:

Precipitation hardening stainless steels are classified into one of three groups based on their final microstructures after heat treatment. Martensitic Alloys - e.g. 17-4 PH and 13-8pH; Semi-austenitic Alloys e.g. FV520 and17-7 PH and Austenitic Alloys e.g. A-286. Of all these, 17/4PH martensitic PH steel is the most common and widely used. The name is derived from the compositions 17% Chromium and 4% Nickel. It also contains 4% Copper and 0.3% Niobium. Alternate designations for stainless steels alloy 17-4PH are- Euronorm – 1.4542 UNS # S17400 and SS Alloy630.The other martensitic 13-8pH SS alloy contains about 13% Cr and 8% Ni. Both have great strength and the ability to fight against corrosion. Due to it being costlier and having less corrosion resistance, 17-4pH is preferred. This treatise focuses on this grade of steel.

Properties:

a) **Corrosion Resistance -** Precipitation hardening stainless steels have moderate to good corrosion resistance in a range of environments. They have a better combination of strength and corrosion resistance than when compared with the heat treatable 400 series martensitic alloys. Corrosion resistance is similar to that found in grade 304 stainless steels. In warm chloride environments, 17-4 PH is susceptible to pitting and crevice corrosion. When aged at 550°C or higher, 17-4 PH is highly resistant to stress corrosion cracking. Better stress corrosion cracking resistance comes with higher ageing temperatures. Corrosion resistance is low in the solution treated (annealed) condition and it should not be used before heat treatment.

(b) **Heat Resistance -** 17-4 PH has good oxidation resistance. In order to avoid reduction in mechanical properties, it should not be used over its precipitation hardening temperature. Prolonged exposure to 370-480°C should be avoided if ambient temperature toughness is critical.

(c) **Ease of Fabrication -** The alloys are amenable to cold-working, hot working and machining processes. Through heat treatment, both 13-8PH and 17-4PH stainless steel can be brought to increase their mechanical strength. The grade 13-8 tends to react better when subjected to heat treatment and that is why a greater range of strength characteristics can be set. This flexibility can be of value; particularly if the properties of the material are to be altered to suit a particular application.

Welding of Stainless Steels:

Martensitic precipitation hardening 17-4PH stainless engineering steel possesses very good weldability and can be treated like a 304 grade for welding procedure. As the welding joint goes through a controlled cooling to achieve its properties, it's recommended to bring a 17-4 PH stainless steel up to a solution-treated condition before welding. This temperature is usually within the range of 8700C-10100C (6500F-1,8000F) for one to two hours, followed by a quench. It can be welded with most of the conventional arc welding processes although the best toughness will be achieved with the TIG (GTAW) process as this provides the cleanest weld metal. Autogenous fusion welds are possible with GTAW. of the two "17-4 PH" is generally considered easier to weld than "13-8 PH" due to its better overall corrosion resistance, while "13-8 PH" offers higher strength but can be more susceptible to cracking during welding.

Welding Consumables:

Age hardening stainless steels do not, in general have matching composition electrode or filler metals. When weld deposit is not required to have an equivalent strength level to that of the base material, generally, the most widely used filler wire is 309L or

309LMo. The 309L types are probably the favourite for ease of procurement and versatile performance. This helps to cope with dilution and maintain a crack-free joint. The L grade is preferred (lower carbon), and the Mo-containing grade gives a bit more pitting corrosion resistance and an even smoother arc action for the welder.No preheat beyond usual ambient shop temperature required, stringer beads with a convex geometry and filled craters. For super critical applications in very corrosive and high stress conditions it may be necessary to use a closely matching welding filler wire. The recommended (17%Cr-4%Ni – UNS 317400 grade)nearest matching composition electrode and wire areA7.39 E630A8.46 ER630or AMS 5825 (as is the case with some military applications). The nominal composition (wt%) of this classification is 16.4Cr, 4.7Ni, 3.6Cu. This composition is designed primarily for welding ASTM A564 Type630 and some other precipitation hardening stainless steels. The modified composition prevents the formation of ferrite networks in the martensitic microstructures which may have a deleterious effect on the mechanical properties.

TIPS Welding PH Stainless Steels:

- Weldment design should be given the same attention required for any high strength alloy steel to avoid concentration of residual stress.
- For best weldability it is recommended that the alloys are supplied in the annealed, solution treated or overaged condition and the weld should not be subjected to high levels of stress from severely restrained joint..
- Relatively thin PH stainless steels do not require preheating prior to welding.
- The weld metal and heat-affected zones of single pass welds will respond fairly uniformly to postweld precipitation hardening treatments. Multiple pass welds respond less uniformly, resulting in significant variations in the structure of weld metal, heat-affected zones, and base metal. Annealing after welding will provide a more uniform structure capable of responding uniformly to subsequent precipitation hardening treatments.
- In welding, maintain a short arc (a long arc causes loss of chromium through oxidation) and keep the heat input low (for best ductility and toughness). Use stringer beads, avoid wide weaving, and avoid stress raisers such as sharp corners, threads, and partial penetration welds. Where possible, use starting and run-off tabs, fill craters, and grind out any crater cracks that may appear before continuing welding.
- When matching filler metal is not required, an austenitic stainless steel filler metal of the309 types can be used and will provide greater ductility. The low carbon (309L) or stabilized (309Cb) versions are preferred to prevent chromium carbide precipitation if the weldment is to be postweld heat-treated in the sensitizing temperature range.
- Due to the presence of aluminium and/or titanium in many alloys only the inert gas shielded arc welding processes should be used.
- Depending on the application and weld size, the weld metal may be used either as-welded, weldedand precipitation hardened, or welded, solution treated, and precipitation hardened.
- If 17-4 PH is welded to carbon or low alloy steel it is necessary to minimize dilution by appropriate welding technique (no weaving) to avoid hot cracks due to carbon content.
- ER312 filler metal, FM625 & FM 82 are suitable for most dissimilar welding of pH steels.

Applications of PH Steels

- 17-4PH is used in applications requiring high strength, hardness, and corrosion resistance up to 300 °C (600 °F).
- They are used in the oil and gas, nuclear and aerospace industries where a combination of high strength, corrosion resistance and a generally low but acceptable degree of toughness is required.
- Due to the high strength of precipitation hardening stainless steels, most applications are in aerospace and other high-technology industries.
- It is also used in the petroleum, chemical, and firearm industries and in marine applications for its corrosion resistance.
- Some common components include- Gears; Valves and other engine parts; High strength shafts; Turbine blades; Moulding dies; Nuclear waste casks etc.

For welding consumables contact - sales@weldwell.com.

Resources: Precipitation Hardening Stainless Steels – Alloys, Properties, Fabrication Processes'- AZO Metals; TWI-GLOBAL;

NEWS FROM INDUSTRY

March of Indian Companies

(a) ISGEC Heavy Engineering Ltd. has been actively expanding its presence in the defense sector by focusing on manufacturing critical components for military equipment, with recent developments including increased order bookings for defense projects, potential new partnerships with defense organizations, and a visible shift towards more technically complex defense orders, aiming to leverage its engineering capabilities to cater to the growing Indian defense market needs.

(b) L&T Shipbuilding will undertake maintenance of UK Navy ships at itsTN facility. This is the first instance that Royal Navy ships are undergoing scheduled maintenance routines in India.

(c) L&Tin December, 2024, signed a ₹7,629 crore contract with the Defence Ministry for 100 additional of 155 mm/52 calibre K9 Vajra-T self-propelled tracked artillery guns for the Indian Army.

(d) BEML has landed a Rs 136-crore contract to provide 8×8 high mobility vehicles (HMVs) using indigenous designs. These vehicles will be used for the battlefield surveillance system (BFSS) project. The Palakkad facility in Kerala will be the main location for the production of the HMVs. BEML seeks to enhance India's defence capabilities and readiness in order to assist the Aatmanirbhar Bharat objective.

(e) Tata Steel has become the first Indian steelmaker to introduce biochar as a partial replacement for fossil fuels, marking a significant step in its sustainability journey. The company has replaced around 30,000 tonnes of fossil fuel with biochar at its Jamshedpur plant. This shift is expected to cut over 50,000 tonnes of CO2 emissions annually while boosting energy efficiency by replacing part of the pulverised coal injection. The approach, successfully applied in blast furnaces exceeding 3,000 m^3 and 9,000 tonnes per day production, is a global advancement in steelmaking. (Biochar is defined as charcoal and carbon-rich material produced by partial oxidation (pyrolysis at ≤700 °C in the absence or limited supply of oxygen) of carbonaceous organic sources such as wood and plants, excluding fossil fuel products).

(f) Airbus India, the global aerospace and defence leader, is establishing its Global Capability Centre (GCC) in Bengaluru.The company operates an engineering centre in Bengaluru and collaborates with Indian firms like Tata Advanced Systems and Hindustan Aeronautics Limited (HAL) on components and aircraft manufacturing. The company is also involved in defence projects such as the C295 aircraft programme, with the first 'Make in India' C295 set to roll out from Vadodara in 2026.

Upcoming Expansion Plans

* L&T Heavy Engineering received orders for urea reactors from IFFCO and SPIC which will be India's longest urea reactor. Further, an order for LNG equipment for a project in the United States, and order for a loop reactor at a Propane De-hydrogenation (PDH) Polypropylene (PP) plant In Turkey.
* HPCL Rajasthan Refinery Ltd. (HRRL) -- an integrated refinery and petrochemical complex with a capacity of 9 million MT/year currently under construction in Pachpadra, Balotra district of Rajasthan -- has already put certain units into the pre-commissioning stage.
* Chennai Petroleum Corporation, a subsidiary of Indian Oil Corp., plans to establish a new 9 million MT/year refinery at the current site of the Cauvery Basin Refinery after dismantling the existing facilities. This refinery, designed to produce Euro-6 compliant fuels, will meet the rising demand in the southern region and nearby areas and is expected to be commissioned by the end of 2027.

Effective Changes in the constitution of L&T Divisions.

L&T Hydrocarbon Engineering Limited (LTHE) has been fully merged into Larsen & Toubro (L&T) as a dedicated division, effectively becoming a part of L&T's larger Energy portfolio .L&T Defence, now rebranded as "L&T Precision Engineering and Systems," signifies a strategic shift to diversify into non-military equipment and infrastructure projects, utilizing its existing defence manufacturing facilities to produce advanced equipment for civilian applications, aiming to optimize asset utilization and expand business beyond the defence sector. This change also reflects a focus on making better use of its capabilities for non-military applications

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