2205 DSS

Material

S31803, S32205, 1.4462, X2CrNiMoN22-5-3, 022Cr22Ni5Mo3N, 022Cr23Ni5Mo3N

Overview

Duplex stainless steel with a ferritic-austenitic structure resistant to high temperatures, operating in acids and salts NaCl, $CaCl_2$, $LiCl_2$, increased Cr, Mo, and N content, occurring in the supersaturated state at temperatures of 1020 - 1100℃ in the form of tubes and pipes.

2205 duplex stainless steel (2205 DSS) is a two-phase, ferritic-austenitic 22% chromium, 5 to 6% nickel, 3% molybdenum alloyed stainless steel. It contains about 40~50% ferrite in the annealed condition. 2205 has been a practical solution to chloride stress corrosion cracking problems experienced with 304/304L or 316/316L stainless. The high chromium, molybdenum and nitrogen contents provide corrosion resistance superior to 316/316L and 317L stainless in most environments. The design strength of 2205 is significantly higher than 316/316L, often permitting lighter wall construction.

Characteristics

Duplex stainless steel is characterized by good fatigue strength, as well as outstanding intercrystalline corrosion resistance, stress corrosion resistance, pitting corrosion resistance, low coefficient of thermal expansion and work temperature up to 200-250 ℃. Compared to ordinary austenitic acid resistant steels, it exhibits much better strength properties and higher wear resistance and erosion resistance.

Application

DSS resists chloride environments and sulphide stress corrosion and is roughly double the strength of standard austenitic stainless steels. It can be used successfully as an alternative to 300 series austenitic stainless steel in most applications where higher mechanical strength/lower weight is required.

Typical applications include pipework with various applications in the oil-gas, chemical, shipbuilding, aviation, cryogenic, paper, mining, petrochemical, power, Pharmaceutical and Biotechnology industries.

Chemical composition (wt% as per ASTM A789 / A790)

Material	C	Si	Mn	P	S
S31803	≤0.03	≤1.0	≤2.0	≤0.030	≤0.020
S32205	≤0.03	≤1.0	≤2.0	≤0.030	≤0.020
Material	Cr	Ni	Mo	N	
S31803	21.0~23.0	4.50~6.50	2.50~3.50	0.08~0.20	
S32205	22.0~23.0	4.50~6.50	3.00~3.50	0.14~0.20	

Physical property

Density: 0.285 lbs/in^3 (7.88 g/cm^3)
Melting: 2680°F (1470°C)
Thermal conductivity at 68-212°F(20-100℃): 11.0 (19.0) BTU-ft/hr/ft^2/°F (W/m•°K)
Mean coefficient of thermal expansion at 32-212°F: 7.6×10^{-6} (13.7) in/in/°F (um/m•K)
Modulus of elasticity: 27.5×10^3 (190×10^3) ksi (MPa) in tension
Magnetic permeability: ferromagnetic in the annealed and hot rolled conditions.

Corrosion resistance

Compared to conventional austenitic stainless steels such as Type 304 and 316, 2205 DSS possesses superior resistance in most oxidizing and reducing acids; superior chloride pitting and crevice corrosion resistance due to higher chromium, molybdenum and nitrogen content; and superior resistance to chloride stress corrosion cracking.
2205 DSS has good intergranular corrosion in the as-annealed and as-weld conditions. Some intergranular attack may occur in the hot rolled unannealed condition.
For optimum corrosion resistance, surfaces must be free of scale, lubricants, foreign particles, and coatings applied for drawing and heading. After fabrication of parts, cleaning and/or passivation should be considered.

Pitting corrosion resistance
The most common type of corrosion with stainless steel in pharmaceutical and biotechnology applications is pitting in chloride-bearing environments. The increased levels of Cr, Mo, and N in 2205 DSS provide substantially better pitting and crevice corrosion resistance than that of 316L.The relative pitting resistance of a stainless steel can be determined by measuring the temperature required to produce pitting (critical pitting temperature) in a standardized test solution such as 6% ferric chloride. 2205 has a critical pitting temperature(CPT) between that of Type 316L and 6% Mo super austenitic stainless steels. It should be noted that the CPTs measured in a ferric chloride solution provide a reliable ranking of the relative chloride pit-ting resistance, but should not be used to predict the critical pitting temperature in other chloride-bearing environments.

Stress corrosion cracking
At temperatures above 150°F (65°C) the combination of tensile stresses and chlorides can readily crack the 316L grade.This catastrophic mode of attack is termed chloride stress corrosion cracking (SCC) and must be considered when choosing materials for hot process streams.Type 316L should be avoided for applications involving chlorides and temperatures of 150°F (65°C) and higher. 2205 DSS resists SCC in simple salt solutions up to temperatures of at least 250°F (121°C).
DSS exhibits resistance to stress corrosion and cracks in corrosive media such as:
◇ Calcium chloride -$CaCl_2$ at a concentration of 40% at 100 ℃
◇ Lithium chloride - $LiCl_2$ at a concentration of 33% at 120 ℃
◇ Sodium chloride - NaCl at a concentration of 25-28% at 155 °C

Mechanical property

Tensile Strength: 90 KSI min (620 MPa min)
Yield Strength(0.2% Offset): 65 KSI min(450 MPa min)
Elongation: 25% min.
Reduction of area: 45% min.

Heat treatment

Temperature: 1870~2010°F (1020~1100°C)
Rapid cooling in air or water
Hardness: HRC30, HBW290, HV290 max.

Hardening
It cannot be hardened by heat treatment. Can be hardened only by cold working.

Fabrication

Hot working
Heat uniformly to 2000/2100°F (1093/1149°C). Reheat as often as necessary. Cooling in air.

Cold working
Cold working increases strength and hardness. Work hardening rate is lower than Type 304; however, the annealed strength is significantly higher.
In many respects, fabrication with 2205 DSS is similar to the fabrication with 316L stainless steel. However, there are some important differences. Cold forming operations must take into account the higher strength and increased work hardening properties of duplex stainless steel. Higher load capacity may be required of forming equipment, and during forming operations the 2205 grade will show higher spring-back than the standard austenitic grades. The increased strength also makes the 2205 grade more difficult to machine than Type 316L.

Weldability
The same welding methods used with Type 316L can be used for joining 2205 DSS. However, heat input and interpass temperatures must be closely controlled to maintain desired austenite-ferrite ratios and avoid precipitation of undesirable intermetallic phases. A small amount of nitrogen in the welding gas can be beneficial in avoiding these problems. When qualifying a duplex stainless steel weld procedure, it is common practice to evaluate the austenite-ferrite ratio using either a ferrite gage or a metallographic examination. The ASTM A923 test methods are typically used to verify the absence of undesirable intermetallic phases.

The recommended weld filler is ER2209 (UNS S39209, EN1600) and welds without filler (autogenous welds) are only recommended if the weld can be solution annealed after welding to restore the corrosion properties. Solution annealing is accomplished by heating to a minimum temperature of 1900°F (1038°C) followed by rapid cooling.

DSS such as 2205 show lower penetration and fluidity than 316L,which can result in lower welding speeds. The reduced penetration of the 2205 grade can require a modification of the joint geometry. To achieve full penetration, the 2205 geometries may require wider joint angles,larger root gaps, and smaller root lands than 316L.

If the welding equipment can accommodate the use of a filler wire, orbital welds for joining 2205 tubes can be made using 2209 filler wire.As an alternative to filler wire,an appropriate over-alloyed consumable insert can be used. Table 3 summarizes insert mate-rials used to join 2205 tubing.

Electropolishing of DSS

Many pharmaceutical and biotechnology applications require product contact surfaces to be electropolished. The ability to achieve a high quality electropolished surface is, therefore, an important material characteristic. The 2205 grade can be electropolished to a smoothness of 15 micro-inches (0.38 micro-meters) or smoother, which meets or exceeds the surface finish requirements for electropolished surfaces in the ASME BPE Standard. Although 2205 DSS can readily meet the pharmaceutical and biotechnology industry's surface finish requirements, an electropolished 2205 surface is not as bright and lustrous as an electropolished 316L surface. This difference is due to the tendency for slightly higher metal dissolution rates in the ferrite phase compared to the austenite phase during electropolishing.

Available Process

(1) Hot formed, solution annealed, descaled
(2) Cold worked and bright annealed
(3) Cold worked, annealed and descaled
(4) Cold worked, polished (MP, EP etc.)
(5) Cold worked, bright annealed, polished (MP, EP etc.)

Common Tests

Chemical composition
Tension
Hardness
Flaring
Flange
Flattening
Micro structure
Hydrostatic
NDT
Intergranular Corrosion
Surface condition
Shape and dimension
Positive Material Identification