Hastelloy C-2000 Alloy

Heanjia Super Metals Co., Ltd

Hastelloy C-2000 alloy introduces the novel configuration to the versatile Nickel-Chromium-Molybdenum alloy offering extensive resistance to the corrosive environments. By the excellent resistance to the oxidizing and reducing conditions, the **Hastelloy C-2000 alloy** offers an outstanding performance in the chemical processing operations.

Chemical composition of C-2000 alloy

Ni	Cu	Cr	Mo	Co	Fe	Si	Mn	C
59	1.6	23	16	2	3	0.08	1	0.01

Physical properties of hastelloy C – 2000 alloy

Density	At room temperature	8.50 g/cm3
Thermal Conductivity	At room temperature	9.1 W/m•K
Mean Coefficient of Thermal Expansion	77oF to 200oF	12.4 m/m•K
Electrical Resistivity	At room temperature	128 microhm-m
Thermal Diffusivity	At room temperature	0.025 cm^2/s
Specific Heat	At room temperature	428 J/kg.°C
Dynamic Modulus of Elasticity	At room temperature	207 GPa
Melting Point	1328-1358°C	

Corrosion Resistance by Hastelloy C-2000 Alloy

To make the nickel alloy resistant to corrosive media, it needs the high concentration of chromium by which the alloy becomes able to resist the wider oxidizing media like ferric acids, cupric ions and more. The reducing media like hydrated hydrochloric or sulfuric acid needs high concentration of molybdenum as well as tungsten.

With the help of high content of chromium, the C-2000 corrosion resistance alloy offers excellent resistance to oxidizing media like nitric acid and solutions like ferric ions, cupric ions and dissolved oxygen.

The tensile properties of **Hastelloy C-2000 corrosion resistance alloy** at the room temperature are provided below:

Thickness, inch	Tensile Strength, ksi	Yield Strength, ksi	Elongation, %
0.063	109.0	52.0	64.0
0.125	111.0	57.0	63.0
0.250	113.0	55.0	62.0
0.500	110.0	50.0	68.0
1.00	109.0	54.0	63.0

The Hastelloy C-2000 solves the alloy design dilemma. The large magnitude of chromium is mixed with molybdenum and copper, adequate to offer resistance to the reducing conditions while no loss of metallurgical consistency. In the hot reducing concentration of sulfuric acid, the C-2000 alloy offers better performance than the alloy C-276. The C-2000 alloy also offers excellent resistance to the boiling and hydrated hydrochloric acid. On the other side the rate of corrosion increases to 20 mpy at the concentration between 1 to 1.5 wt %. The C-2000 alloy offers superior resistance to corrosion at the concentration of 3% weight.

Pitting and Crevice corrosion resistance

The **Hastelloy C-2000 corrosion resistance alloy** also offers resistance to pitting and crevice corrosion that is widely introduced in the commercial processes. In order to determine the pitting and crevice corrosion provided by Hastelloy C-2000, it is evaluated at the critical crevice and pitting temperature in the acidic medium of 6 % ferric chloride by following the ASTM G 48 procedures.

ALLOY	Critical Crevice Temperatures, oC	Critical Pitting Temperatures, oC
316L	0	15
254SMO	30	60
625	40	100
C-22	80	>120
C-276	55	>120
C-2000	80	>120

The above data shows the minimum temperature at which the pitting and crevice corrosion occurs in the acidic ferric chloride in 72 hours. Another acidic solution is 11.5 % sulfuric acid, 1.2 % hydrochloric acid, 1 % ferric chloride and 1 % cupric chloride that is widely used to evaluate the resistance to pitting corrosion. This solution is called as green death.

The following table shows the comparison of critical pitting temperature of Hastelloy C-2000 with other alloys:

Alloy	Critical Pitting Temperature, oC
316L	25
625	75
C-4	90
C-22	120
C-276	105
C-2000	110

Seawater is one of the strongest corrosion media that consists of aqueous salts. It is bumped into marine operations and seashore oil refineries as well as used as coolant in the coastal industries. The crevice test is conducted in the still and dynamic water at 29oC or 3oC. Double samples of every testing alloy in the still and dynamic water are evaluated for 180 days. Every sample consists of double crevice spots.

ALLOY	Still water	Still water	Dynamic water	Dynamic water
	No. of spots	Depth, mm	No. of spots	Depth, mm
316L	2	1.80	2	0.32
254SMO	2	1.25	2	0.01
625	2	0.11	2	<0.01
C-22	0	0	0	0
C-276	1	0.12	0	0
C-2000	0	0	0	0

Stress Corrosion Cracking:

Boiling solution of 45% magnesium chloride is used to evaluate the resistance to stress corrosion cracking offered by Hastelloy C-2000 alloy. The following table shows the time needed to cause cracks in the different alloy's materials:

Alloy	Cracking Period
316L	2 hours

254MO	2 hours
625	No cracks in 1008 hours
C-22	No cracks in 1008 hours
C-276	No cracks in 1008 hours
C-2000	No cracks in 1008 hours

Mechanical Properties of Hastelloy C-2000 Alloy:

Form	Annealing Temperature	Thickness/ Diameter	Yield Strength	Tensile Strength	Elongation
	oC	Mm	MPA	MPa	%
Sheet	1163	0.6	372	752	61
Sheet	1163	2.0	400	786	62
Plate	1149	4.8	407	745	63
Plate	1149	6.4	393	731	63
Bar	1149	9.7	331	745	67
Bar	1149	19.1	345	738	69

Welding of Hastelloy C-2000 Alloy

The C-2000 alloy has similar welding, forming, and machining features that are equivalent to C-276 alloy. In order to weld the Hastelloy C- series alloys, basically three methods are followed.

For sheet welds and plate root passes, GTAW or Gas tungsten arc welding process is recommended. For plate welding, the gas metal arc welding method is recommended.

For field welding, the shielded metal arc process is preferred by using the coated electrodes. The submerged arc welding process is not preferred because it is featured with extensive heating of the primary metal and slow weld quenching. In order to decrease the precipitation of second phase in the heat affected welding zones, high interpass temperature up to 93oC is preferred. In these processes, welding of the cold treated alloy is not preferred because these may get sensitized quickly and cause residual stress. The water quenching after the complete solution annealing is preferred for cold processed alloy prior to welding. The grease, oil and other contaminated particles should be removed.

<u>Filler Metal</u>

Hastelloy C-2000 filler wire is preferred for gas tungsten arc and gas metal arc welding. Hastelloy C-2000 electrodes are preferred for shielded metal arc welding.

Impact properties of Weldments

Welding Process	Form	Position	Temp, oC	Impact Strength, J
Synergic Gas Metal arc welding	Transverse Sample from Welded Plate of Thickness 12.7 mm./0.5 in	Mid-Weld	-196	142
		Heated Region	-196	203
Shielded metal arc welding	All Weld Metal Sample taken from Plate Weld	In Weld	Room Temp	71
			-196	45

The tensile properties of weldments are shown as following:

Welding Process	Form	Temp	Yield strength	Tensile Strength	Elongation
		oC	MPa	MPa	%
Gas Tungsten Arc Welding (GTAW	Transverse Sample from Welded Plate of Thickness of 12.7 mm/0.5 in	260	326	642	42.1
	All Weld Metal Sample of Diameter 12.7 mm/0.5 in from Cruciform	260	391	614	47.4

Synergic Gas Metal Arc Welding (GMAW)	Transverse Sample from Welded Plate of Thickness of 12.7 mm/0.5 in	260	352	654	43.1
	All Weld Metal Sample of Diameter 12.7 mm/0.5 in from Cruciform	260	394	620	46.4
Shielded Metal Arc Welding	Transverse Sample from Welded Plate of Thickness of 25.4 mm/1.0 in	Room Temp.	364	718	58.1
	All Weld Metal Sample of Diameter 12.7 mm/0.5 in from Cruciform	450	386	565	43.9

Machining of Hastelloy C-2000 alloy

In the below table the instructions are provided to perform the machining process on the wrought materials. The particular machining tasks change with the conditions of operation.

Operations	Carbide Tools	High Speed Steel Tools
Drilling	C-2 grade not recommended, but tipped drills may be successful on rigid setup of no great depth. The web must be thinned to reduce thrust Use 135° included angle on point, Gun drill can be used. Speed: 50 sfm. Oil2 or water-base coolant. Coolant-feed carbide tipped drills may be economical in some setups	M-33, M-40 series1 or T-15: Use short drills, heavy web, 135° crank-shaft, grind points wherever possible. Speed: 10-15 sfm Feed: 0.001 in. rev. 1/8 in. dia. 0.002 in. rev. 1/4 in. dia 0.003 in. rev. 1/2 in. dia. 0.005 in. rev. 3/4 in. dia 0.007 in. rev. 1 in. dia. Oil or water-base coolant. Use coolant feed drills if possible.
Normal Roughing; Turning or Facing	C-2 or C-3 grade: Negative rake square insert, 45° SCEA4 , 1/32 in. nose radius Tool holder: 5° neg. back rake, 5° neg. Speed: 90 sfm depending on rigidity of set up, 0.010 in. feed, 0.150 inch., depth of cut, Dry , oil, or water-base coolant.	
Finishing; Turning or Facing	C-2 or C-3 grade: Positive rake square insert, if possible, 45° SCEA, 1/32 in. nose radius. Tool holder: 5° pos. back rake, 5° pos. side rake. Speed: 95-110 sfm, 0.005-0.007 in. feed, 0.040 in. depth of cut. Dry or water-base coolant	

Heat Processing of Hastelloy

Wrought Hastelloy C – 2000 alloy is kept into solution annealed form, if specified. The standard solution annealing processing includes heating up to 1135oC, subsequently air or water quenching is performed. The components that are hot forged are solution annealed before final forging.

Fabrication

The Hastelloy C-2000 alloy offers superior fabrication properties, and cold forging is the recommended method of shaping. It can be conveniently work processed due to its high ductility. It is normally stiffer as compare to the austenitic stainless steels so more energy is needed while cold forging.

Applications of Hastelloy C-2000 Alloy

1. Chemical processing industrial reactors, heat exchangers
2. Pharmaceutical industrial reactors and dryers
3. Flue gas desulfurization systems.
