Inconel Alloy 617 (UNS N06617)

Inconel 617 offers high temperature strength and great oxidation resistance. Excellent resistance to pitting and crevice corrosion and general corrosion in reducing and oxidizing conditions. It prevents carburization, spalling and aqueous corrosion. Alloy 617 is commonly used in aerospace and land base gas turbines, fossil fuels, catalyst grid support in acid processing and power production plants.

The processing technology and equipment that are used in the process influence the strength and work hardening rate of alloy. Inconel 617 provides superior heat formability that requires comparatively large force due to its high strength at the high temperature ranges.

Chemical Composition

Carbon (C)	0.05 to 0.15 %
Nickel(Ni)	Rem %
Iron (Fe)	3 %
Silicon (Si)	0.50 %
Manganese (Mn)	0.50 %
Cobalt (Co)	10 to 15 %
Chromium (Cr)	20 to 24 %
Titanium (Ti)	0.60 %
Phosphorous (P)	0.015 %
Sulfur (S)	0.015 %
Molybdenum (Mo)	8 to 10 %
Aluminum (Al)	0.80 to 1.50 %

Boron (B)	0.006 %
Copper (Cu)	0.50 %

Physical Properties

Density	0.302 lb/cubic inches or 8360 kg/ cubic meter
Melting point	2430oF to 2510oF or 1332oC to 1377oC
Specific heat at 78oF or 26oC	0.100 Btu/lb-oF or 419 J/Kg-oC
Electrical resistivity at 78oF or 26oC	736 ohm-cir mil/ft or 1.223 aee-m

Electrical & Thermal properties

Temperature, oF	Electrical Resistivity	Thermal Conductivity	Coefficient of Expansion	Specific Heat
	ohm-circ mil/ft	Btu - in/ft² - hr - oF	10(-6)in./in./oF	Btu/lb-oF
78 of	736	94	-	0.100
200 of	748	101	6.4	0.104
400 of	757	113	7	0.111
600 of	764	125	7.4	0.117
800 of	770	137	7.6	0.124
1000 of	779	149	7.7	0.131
1200 of	793	161	8	0.137
1400 of	807	173	8.4	0.144
1600 of	803	185	8.7	0.150
1800 of	824	197	9	0.157
2000 of	-	209	9.2	0.163

Modulus of Elasticity

Temperature		Tensile modulus		Shear modulus		Poisson ratio
oF	oC	10(6) psi	GPa	10(6) psi	GPa	
74 of	25 oC	30.6	211	11.8	81	0.30
200 of	100 oC	30	206	11.6	80	0.30
400 of	200 oC	29	201	11.2	77	0.30
600 of	300 oC	28	194	10.8	75	0.30
800 of	400 oC	26.9	188	10.4	72	0.30
1000 of	500 oC	25.8	181	9.9	70	0.30
1200 of	600 oC	24.6	177	9.5	66	0.30
1400 of	700 oC	23.3	166	9	64	0.30
1600 of	800 oC	21.9	149	8.4	61	0.30

Mechanical Properties

Inconel 617 alloy offers large mechanical properties at the different temperature limits. It offers high strength at the high temperatures. Its corrosion resistance property at the high temperatures makes its strength more usable.

Temperature		Test time, hours	Yield strength, 0.2%		Tensile strength		Elongation %	Impact strength	
oF	oC		10(3) psi	MPa	10(3) psi	MPa		ft-lb	J
Room temperature		-	46.3	319	111.5	769	68	171	232
1100 of	595 oC	100	46.5	321	111.5	769	69	213	289
		1000	51.8	357	116.5	803	67	223	302
		4000	55.7	384	117.5	810	67	181	245
		8000	59.5	410	121.5	838	61	98	133
		12000	67.6	466	132	910	34	69	94
1200 of	650 oC	100	51.8	357	114.5	789	69	191	259
		1000	66.6	459	133.5	920	37	35	47
		3640	76.3	526	142	979	33	35	47
		8000	76.5	527	144	993	28	40	54
		12000	77.5	534	144	993	32	38	52
1300 of	705 oC	100	58.7	405	126.5	872	38	57	11
		1000	70.5	486	138	952	33	48	65
		4000	70.6	487	138	952	36	48	65
1400 of	760 oC	100	58.3	402	126.5	872	35	56	76
		1000	56.3	388	126	879	37	63	85
		4000	58.1	401	128.5	886	38	62	84
		8000	58.5	403	130	896	40	64	87
		12000	56.4	389	129.5	893	38	67	91

Creep and stress rupturing strength of Inconel 617

Inconel 617 alloy offers high scale of creep and stress rupture strength at the elevated temperature above 1800oF. The characteristics in combination with excellent resistance to oxidizing and carburizing atmosphere provide alloy 617 the capability to offer the prolonged, high stress rupturing strength at the high temperatures. Inconel 617 specimen is used in the solution annealed form prior to revelation. The strength is exhibited to carbide production and exposing temperature at 1200oF to 1400oF to the precipitation of gamma prime phase.

The creeping strength of Inconel 617 in the solution annealed form at the temperature of 2000oF is evaluated. The rupture capability of solution annealed material at the same temperature is observed. The tests are conducted on bar, tubing, and sheet materials. The design standards allowable for Inconel 617 alloy forms are received.

Inconel 617 alloy is commonly used in the annealed form that provides coarse grain structure for the exceptional creeping resistance. It also offers high bending ductility at the standard temperature. The solution annealing is performed at 2150oF, immediately water or air cooling is performed. The cutting tools are sharp and they have high rake angles to

decrease the work hardening of Inconel 617 alloy. It offers excellent welding nature. Inconel 617 filler metal is used in the gas tungsten arc and gas metal arc welding though Inconel welding 617 electrode is used for shielding metal arc welding.

Corrosion Resistance

The content of nickel and chromium in Inconel 617 alloy provides excellent resistance to reduction and oxidation media. The corrosion resistance property of alloy improves with an addition of aluminum. The solid solution strength is obtained by adding cobalt and molybdenum metals. The chemical constituents of **Inconel 617 alloy** include nickel, chromium and aluminum that offer large scale of resistance to oxidation and carburization at the elevated temperatures. These elements with the molybdenum concentration also provide strength to resist the rigorous corrosive conditions.
The resistance to carburization is compared with other Inconel alloys in the carburizing conditions at temperatures up to 2000oF or 1095oC.

In Sulphuric Acid

Acid content %	Corrosion rate			
	175oF or 80oC		Boiling temperature	
	Mpy	mmy	Mpy	Mmy
5	-	-	24	0.61
10	2	0.05	28	0.71
20	32	0.81	97	2.46
30	44	1.12	464	11.89
40	40	1.02	838	21.29
50	94	2.39	-	-

In Phosphoric Acid

Acid content %	Attack rate					
	H3PO4, 175oF or 80oC		H3PO4, boiling		H3PO4 + 1% HF 175oF or 80oC	
	Mpy	mmy	Mpy	mmy	Mpy	mmy
10	0.2	0.005	0.1	0.003	0.9	0.023
20	0.2	0.005	0.4	0.010	2	0.05
30	0.4	0.010	0.5	0.013	1	0.03
40	0.4	0.010	5	0.13	6	0.15
50	0.7	0.018	31	0.79	8	0.20
60	0.4	0.010	50	1.27	6	0.15
70	0.4	0.010	38	0.97	0.6	0.015
85	0.6	0.015	26	0.66	0.4	0.010

In Hydrofluoric Acid

Acid content %	Attack rate			
	Vapour phase		Liquid phase	
	Mpy	mmy	Mpy	mmy
10	44	1.12	126	3.20
20	32	0.81	302	7.67
30	82	2.08	396	10.06
40	85	2.16	424	10.77

Fabrication

LCF fabrication factors

It is noticed that minor residue of cold processing that is obtained through mild forming, is capable to produce significant influence on the creeping resistance of Inconel 617. The second solution annealing is conducted at 2150oF then water cooling is performed to prevent the cold processing results and regain the creeping resistance. The second annealing at 2150oF develops coarse grain structure and hence reduces the LCF activity. The low annealing temperature limits are analyzed on the 10% to 20% cold processed material.

The second annealing at 2050oF after air quenching is sufficient to get recrystallization of the cold processed structure while not increasing the grain development in the regions that get little or no cold processing. The subsequent analysis on the production parts has determined the suitability of second solution annealing processing.

On the base of these factors the following suggestions are made:

Starting through mill solution annealed material, water cooling, cold processing, welding and re solution annealing at 2050oF followed by air quenching. An approved process, when the forging is quite large to second annealing as an assembly, would be to re-solution annealing of the isolated components after forming but prior to assembly.

Welding Features of Inconel 617

Inconel alloy 617 comprises of superior welding character. The filler metal 617 is utilized in the gas tungsten arc and gas metal arc welding however Inconel welding electrode 617 is utilized for shielded metal arc welding.

The composition of filler metal resembles with the primary metal and accumulated welded metal resembles with the wrought alloy in terms of potential and resistance to corrosion features. The tensile characteristics at the elevated temperatures of the welded material are evaluated. The creep rupturing potential of welded material is similar to the wrought material.

Available Forms

Wire, Mesh, Strip, Foil, Plate, Sheet, Rod, Bars, Tubing, Pipe, Flanges