FIFTH GENERATION NICKEL BASE SINGLE CRYSTAL SUPERALLOY

TMS-196

(Developed under NIMS[1] / IHI[2] collaboration)

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[1] High Temperature Materials Center
National Institute for Materials Science
1-2-1 Sengen, Tsukuba Science City, Ibaraki, 305-0047, Japan
Tel: +81-(0)29-859-2503 Fax: +81-(0)29-859-2501 http://sakimori.nims.go.jp

[2] Materials Technology Department, Aero-Engine & Space Operations
Ishikawajima-Harima Heavy Industries co., Ltd
3-5-1 Mukodai-cho, Nishi-Tokyo City, Tokyo, 188-8555, Japan
Tel: +81-(0)424-60-1202 Fax: +81-(0)424-60-1197 http://www..ihi.co.jp

TMS-196

It is an advanced nickel-base single crystal superalloy containing 5wt% Ru and 4.6wt% Cr. This alloy exhibits not only good microstructural stability but also excellent combinations of resistances against creep, thermo mechanical fatigue and oxidation.

Chemical composition, wt%

Element	Co	Cr	Mo	W	Al	Ta	Hf	Re	Ru
TMS-196	5.6	4.6	2.4	5.0	5.6	5.6	0.1	6.4	5.0

Heat Treatment Condition (Typical)

Solution; 1300℃/1h+1340℃/10h→R.T. *, Aging; 1100℃/4h→R.T. +870℃/20h→R.T.*

*Gas Fan Cooling (GFC)

Solidus Temperature : 1390℃
Solvus Temperature : 1286℃
Heat Window for Solution Treatment : 56℃

Physical Constants and Thermal Properties

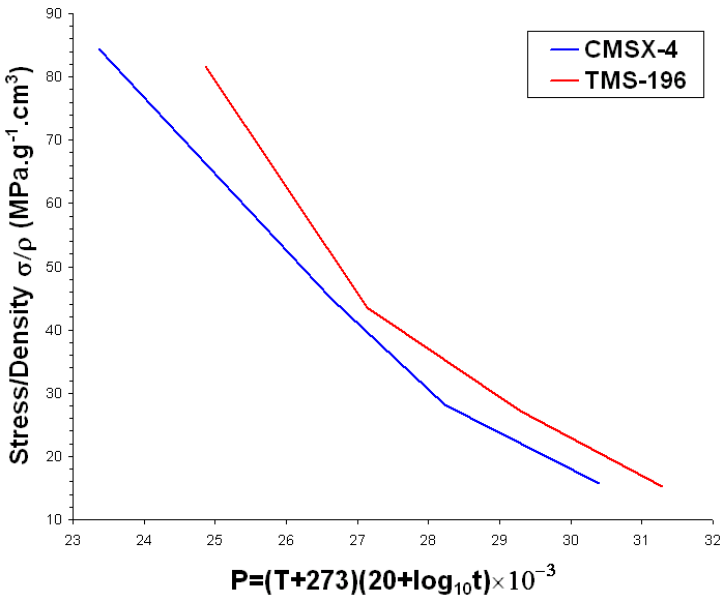
Density…….……..……..……..…… at R.T...……..9.01g/cc

Typical Mechanical Properties

Creep Rupture Strength

Conditions		Rupture life (t)	Benefit over
Temperature, ℃(T)	Stress, MPa	h	CMSX-4 (°C)
800	735	1485	63
900	392	329	18
1000	245	1264	42
1100	137	1526	36

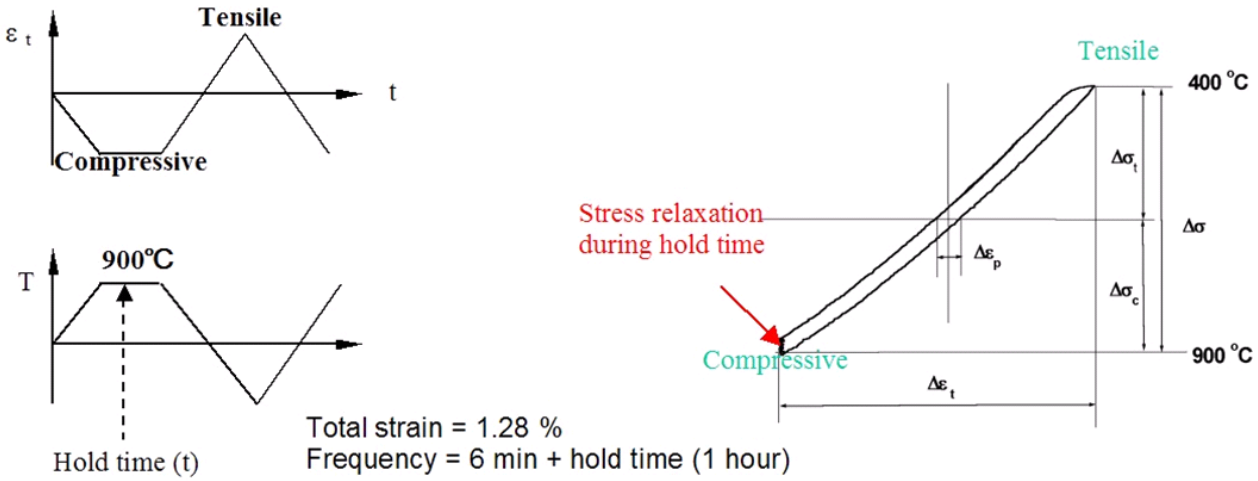
Larson-Miller Plot



Tensile Strength

Temperature ℃	0.2% Proof Stress MPa	UTS MPa
400	929	1195
750	935	1353
1000	758	1001
1100	370	539

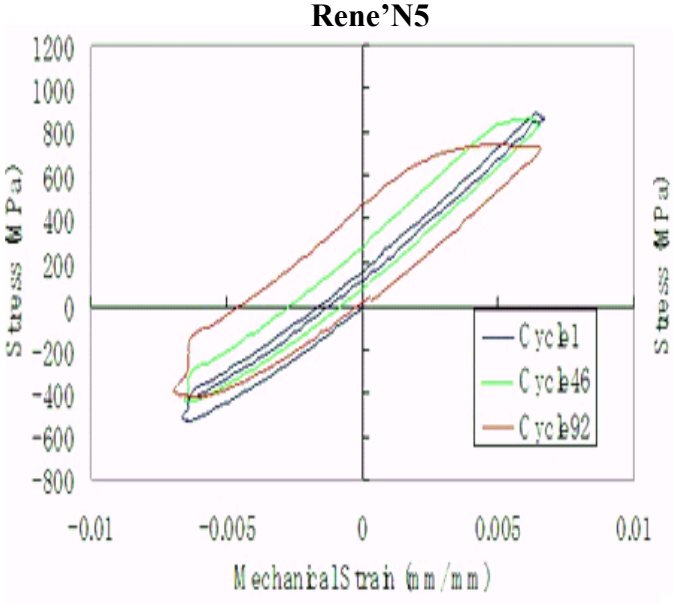
Thermo Mechanical Fatigue



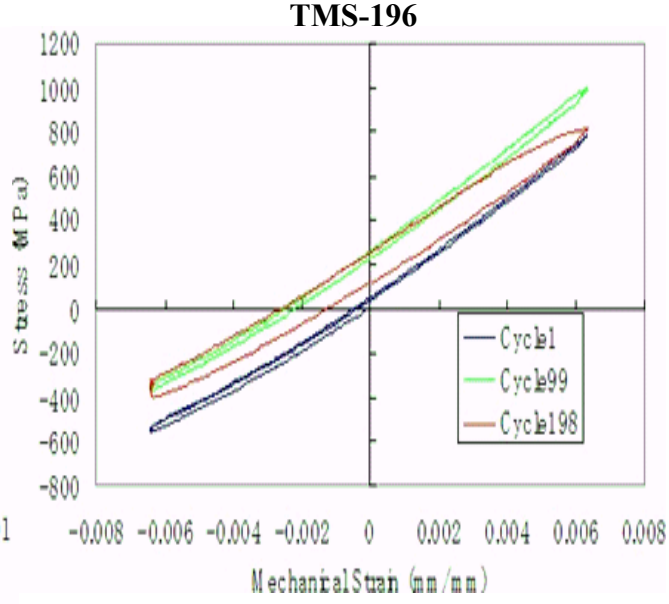
Total strain = 1.28 %
Frequency = 6 min + hold time (1 hour)

Alloy	Cycles to Failure, Nf	Stress Relaxation (MPa)		
		N=1	N-Nf/2	N=Nf
Rene'N5	92	150	140	290
TMS-196	198	20	10	70

Rene'N5



TMS-196



Cyclic Oxidation in Air (1hour per cycle)

Cycles / Temp. ℃(K)	Weight Change, mg/cm^2		
	10 Cycles	20 Cycles	30 Cycles
1100 (1373)	+0.11	-1.71	-2.68

Castability

Several single crystal turbine blades have been successfully cast, and the casting yield of TMS-196 is found to be similar to those of commercial 2nd generation superalloys.

Patents

1) T.Kobayashi, Y.Koizumi, T.Yokokawa,H.Harada, Y.Aoki, M.Arai and S.J.Msaki; Nickel-base Single-Crystal Superalloys, Japanese Patent Pending, Tokugan2004-558425 (2003).
2) T.Kobayashi, Y.Koizumi, T.Yokokawa,H.Harada, Y.Aoki and M.Arai; Nickel-base Single-Crystal Superalloys, EP Patent Pending, PCT/JP03/15619 (2003).
3) T.Kobayashi, Y.Koizumi, T.Yokokawa,H.Harada, Y.Aoki and M.Arai; Nickel-base Single-Crystal Superalloys, US Patent Pending, PCT/JP03/15619 (2003).
4) T.Kobayashi, Y.Koizumi, T.Yokokawa,H.Harada, Y.Aoki and M.Arai; Nickel-base Single-Crystal Superalloys, Canada Patent Pending, PCT/JP03/15619 (2003).

Related Articles

1) A.Sato, H.Harada,. K.Koizumi, T.Kobayashi, T.Murakumo, J.X.Zhang and T.Yokokawa; Journal of the Japan Institute of Metals, **70** (2006) 196-199.
2) K.Kawagishi, A.Sato and H.Harada; Journal of the Japan Institute of Metals, **70** (2006) 188-191.
3) A.Sato, A.C. Yeh, T.Kobayashi, T.Murakumo, J.X.Zhang, T.Yokokawa and H.Harada; 8th Liège Conference 'Advanced Materials for Power Engineering 2006', Liège, Belgium, on the 18 - 20 September 2006.
4) A.Sato, A.C. Yeh, T.Kobayashi and H.Harada; Journal of the Japan Institute of Metals, **70** (2006) accepted.
5) K.Kawagishi, A.Sato, T.Kobayashi and H.Harada; Journal of the Japan Institute of Metals, **70** (2006) accepted.

High Temperature Materials 21 Project

On June 1, 1999, ex-NRIM (now NIMS) launched an R&D project, "High Temperature Materials 21 (HTM 21)" Project, (1999. 6—2010. 3). In this Project we develop high temperature materials for 1700℃ ultra-efficient gas turbines in power generations, small but efficient gas turbines for local power systems, next generation jet engines, high performance space rockets, and so on. These materials include Ni-base single crystal superalloys up to 5th generation alloys with new coating systems, as well as alloys with new concepts, e.g., platinum group metals (PGMs)-base refractory superalloys, Cr-base alloys, and so on. Materials design of empirical and theoretical approaches and microstructure analysis to support the alloy design and developments are also conducted with a major importance. We have world wide collaborations. to enhance the high temperature materials researches mentioned above (Director; Hiroshi Harada).