		UNS	Machinability (Surface ft/min)	Speed as a % of B1112	Hardness (Nominal, HRB)	Yield Strength (Min, ksi)
Nickel	RA330®	N08330	35-45	24	86	30
	RA333®	N06333	20-25	14	76-95	39
	RA 602 CA®	N06025	20	12	–	39
	600	N06600	25-35	18	85	35
	601	N06601	25-35	18	65	30
	AL-6XN®	N08367	65-75	42	90	45
	625	N06625	20	12	24 HRC	60
	718 AMS 5662	N07718	20-40	18	37 HRC	70
	Nickel 200/201	N02200, N02201	170-200	112	45-75	55
	400	N04400	60-70	39	60-80	15
	Alloy 20	N08020	65	39	94	35
	K-500 Annealed	N05500	60	36	–	40
	K-500 Aged	N05500	25	15	–	85
	825	N08825	25-35	18	135-165	35
	800H/AT	N08811	25-35	18	70	25
	Waspaloy	N07001	20	12	38 HRC	120
	C-276	N10276	20	12	87	41
	C-22	N06022	20	12	75-90	47
	HASTALLOY B-2	N10665	15-20	11	60-80	39
	X	N06002	20	12	96	–
	INVAR 36	K93600	30-45	25	80 max	35 (Typical)
Duplex Stainless Steels	ZERON® 100	S32760	30-65	29	28 HRC	80
	2205	S31803, S32205	50-65	35	31 HRC max	65
	2507	S32750	30-65	35	28 HRC	80
	LDX 2101®	S32101	78-106	56	31 HRC max	65
Stainless Steels	RA 253 MA®	S30815	45-60	32	91	45
	310	S31008, S31009	70-75	44	78	30
	309	S30908	70-75	44	83	30
	321	S32100	75	45	82	30
	347	S34700	75	45	87	30
	446	S44600	75	45	85	–
	416 Annealed	S41600	170	103	27 HRC	49
	416 Hardened	S41600	80	48	28 HRC	–
	440C	S44004	65	39	56 HRC	–
	PRODEC® 303	S30300	100-105	62	91	30
	PRODEC® 304/304L	S30400, S30403	90	55	92	30
	PRODEC® 316/316L	S31600, S31603	100	61	92	30
	N-50 (XM-19)	S20910	20-35	17	96	55
	N-60	S21800	20-35	17	92	50
	17-4 Annealed	S17400	75	45	34 HRC	–
	17-4 H1150	S17400	80	48	33 HRC	125
	15-5 Annealed	S15500	75	45	33 HRC	–
	13-8 Annealed	S13800	75	45	44 HRC	–
	A-286 (AMS 5737)	S66286	30-35	20	31 HRC	95
	A-286 (AMS 5732)	S66286	30-35	20	32 HRC	85
Titanium	6-4	R56400	30-40	21	–	120
	6-4 ELI	R56401	30-40	21	30-34 HRC	110
	6-4 STA	R56401	15-45	18	–	120-155
Cobalt	188	R30188	15	9	98	67
	René 41	N07041	12	7	33-40 HRC	115
	L-605 (25)	R30605	15	9	97	45
Carbon Steel	B1112	AISI B1112	165	100	–	120
	12L14	AISI 12L14	325	197	84	60
	1215	AISI 1215	225	136	91	60
	1137	AISI 1137	135	82	88	55
	1018	AISI 1018	120	72	72	53
	1045	AISI 1045	75	45	84	45
	H11	T20811	75	45	56 HRC	–
	4340	G43400	65	39	40-60 HRC	121

The alloys described in this document work harden rapidly during machining and require more power to cut than do the plain carbon steels. The metal is "gummy", with chips that tend to be stringy and tough. Machine tools should be rigid and used to no more than 75% of their rated capacity. Both workpiece and tool should be held rigidly; tool overhand should be minimized. Rigidity is particularly important when machining titanium, as titanium has a much lower modulus of elasticity than either steel or nickel alloys. Slender work pieces of titanium tend to deflect under tool pressures causing chatter, tool rubbing and tolerance problems.

TOOLING

Make sure that tools are always sharp. Change to sharpened tools at regular intervals rather than out of necessity. Titanium chips in particular tend to gall and weld to the tool cutting edges, speeding up tool wear and failure. Remember - cutting edges, particularly throw-away inserts, are expendable. Don't trade dollars in machine time for pennies in tool cost.

Feed rate should be high enough to ensure that the tool cutting edge is getting under the previous cut thus avoiding work-hardened zones. Slow speeds are generally required with heavy cuts.

LUBRICANTS

Sulfur-chlorinated petroleum oil lubricants are suggested for all alloys but titanium. Such lubricants may be thinned with paraffin oil for finish cuts at higher speeds. The tool should not ride on the work piece as this will work harden the material and result in early tool dulling or breakage. Use an air jet directed on the tool when dry cutting, to significantly increase tool life.

Lubricants or cutting fluids for titanium should be carefully selected. Do not use fluids containing chlorine or other halogens (fluorine, bromine or iodine), in order to avoid risk of corrosion problems.

MACHINING SPEEDS

The machinability rating quantifies the machinability of various materials. The American Iron and Steel Institute (AISI) determined machinability ratings for a wide variety of materials by running turning tests at 180 surface feet per minute (sfpm) and arbitrarily assigned 160 Brinell B1112 steel a machinability rating of 100%. The machinability rating is determined by measuring the weighed averages of the normal cutting speed, surface finish, and tool life for each material. Machinability rating less than 100% is more difficult to machine than B1112 and material with a value more than 100% is easier.

The speeds shown on the prevoius page are for single point turning operations using high speed steel tools. This information is provided as a guide to relative machineability, higher speeds are used with carbide tooling.

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