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Machinability Ratings

Skill Builder

Overview

There are many different metals commercially available. Some are easier to machine than others. Many years ago, a system was developed to rate the relative ease or difficulty of machining various metals. These ratings are called "Machinability Ratings." Machinists and manufacturing engineers use machinability ratings when they select tool material, feed rates, and machine speeds for metal cutting and grinding operations. We use machinability ratings along with the other factors included in our Machining and Grinding System Survey when we recommend coolants and cutting oils for these operations. This Skill Builder explains how machinability ratings are established. It also lists the ratings for common metals.

About Machinability Ratings

"Machinability" is not an exact term. It means "the ease with which a given material may be worked with a cutting tool." The cutting process is impacted by variables like cutting speed, dimensions of the cut, tool form, tool material, the cutting fluid, rigidity of tool holding device, and the level of tool/part impact relative to constant or intermittent contact. However, the machinability rating provides a starting point for understanding the severity of a metalworking operation.

Machinability ratings are "relative" ratings. They compare the ease of machining an alloy to a standard. That standard is 160 Brinel hardness B1112 cold drawn steel machined at 180 surface feet per minute. B1112 was assigned a score of 1.00. The machinability of all other alloys is compared to the standard score of 1.00.

The American Iron and Steel Institute (AISI) tested many alloys and compared the normal cutting speed, tool life and surface finish to that obtained when machining B1112. Materials with scores above 1.00 are easier to machine than B1112. Likewise, materials with scores of less than 1.00 are more difficult to machine. For example, Inconel is an alloy that is very difficult to machine and it has a rating of 0.09!

The machinability ratings (MR) in the tables were established for materials with Brinell hardness numbers (BHN) as listed. When a material listed is to be machined and is found to have a BHN different from that shown in the table, a ratio is applied. The ratio of the BHN in the table to the actual BHN of the workpiece is multiplied by the listed machinability rating (MR) to provide the MR of the actual workpiece. For example, a 3140 at a BHN of 197 is shown on the table to have an MR of 0.55. The 3140 to be machined has an actual BHN of 220. Therefore 197 divided by 220 times 0.55 equals 0.49. This means the machinability of the 3140 at a BHN of 220 has an MR of 0.49.

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Machinability Ratings Cont.

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Tables

The attached tables contain machinability ratings for many alloys. The tables used in this Skill Builder were obtained from Tool and Manufacturing Engineers Handbook, Volume 1, Fourth Edition from the Society of Manufacturing Engineers.

Machinability Table - Part 1

Material	BHN	MR	Material	BHN	MR
12% (chrome stainless steel)	165	0.70	A-8640	170	0.55
80B40	195	0.35	A-8645	210	0.50
81B45	179	0.60	A-8650	212	0.45
86B45	212	0.35	A-8740	200	0.55
98B40	185	0.40	A-8745	219	0.45
1020 (Castings)	134	0.60	A-8750	212	0.40
1040 (Castings)	190	0.45	AM 350	420	0.14
1330	223	0.60	AM 355	360	0.10
3140	197	0.55	AMS 6407	180	0.50
3250	220	0.45	AMS 6418	195	0.50
3312	191	0.50	AMS 6427	180	0.50
3340	220	0.45	B-1112	160	1.00
3450	197	0.45	B-1113	170	1.35
4130 (Castings)	175	0.35	C-1008	155	0.55
4130	183	0.65	C-1010	150	0.55
4140	190	0.55	C-1015	131	0.60
4140 (Leaded)	187	0.70	X-1020	148	0.65
4145	200	0.55	C-1025	143	0.65
4340 (100% pearlitic)	221	0.45	C-1030	190	0.65
4340 (Spheroidized)	206	0.65	C-1040	205	0.60
4340 (Castings)	300	0.25	C-1045	217	0.50
4620	170	0.65	C-1050	205	0.50
4640	187	0.55	C-1095	210	0.45
4815	183	0.55	C-1117	170	0.90
5120	191	0.65	C-1118	160	0.80
6130	183	0.55	C-1120	160	0.80
6135	190	0.55	C-1137	197	0.75
6180	207	0.40	C-1141	240	0.50
8030 (Castings)	175	0.45	Cast Iron (soft)	160	0.60
8430 (Castings)	180	0.40	Cast Iron (med)	195	0.40

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Machinability Ratings Cont.

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Material	BHN	MR	Material	BHN	MR
8620	194	0.60	Cast Iron (hard)	262	0.20
8630	190	0.60	Cast Iron (Chilled White)	500	0.70
8630 (Castings)	240	0.30	Cast Iron (Grey Pearlitic)	190	0.70
8720	190	0.60	Chromaoloy	293	0.50
9255	218	0.45	Discaloy	135	0.40
9260	221	0.45	E-3310	196	0.40
9262H	255	0.25	E-4137	200	0.60
A-286	300	0.10	E-52100	206	0.30
A-3115	160	0.65	E-6150	197	0.50
A-3120	150	0.65	E-9310	223	0.40
A-4023	183	0.70	E-9315	204	0.40
A-4027	189	0.70	H-11	190	0.45
A-4032	190	0.70	Hastelloy B (cast)	200	0.12
A-4037	200	0.65	Hastelloy C	170	0.20
A-4042	200	0.60	Hastelloy X	197	0.09
A-4047	209	0.55	Haynes Stellite #21 (cast)		0.06
A-4150	208	0.50	Haynes Stellite #25		0.12
A-4320	200	0.55	Haynes Stellite #31 (cast)		0.06
A-4340	210	0.50	High Speed Steel 18-4-1	220	0.35
A-4820	205	0.45	High Speed Steel 8-2-1	210	0.40
A-5140	202	0.60	Inconel	240	0.30
A-5150	207	0.50	Inconel X	360	0.15
A-6120	187	0.50	Inconel 700	290	0.09
A-6140	205	0.50	Inconel 702	225	0.11
A-6145	207	0.50	Inconel 901	200	0.20
A-6152	195	0.50	Inconel 901	300	

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Machinability Ratings Cont.

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Machinability Table - Part 2

Material	BHN	MR	Material	BHN	MR
M-252	220	0.05	Nodular Iron #1	183	0.60
M-308	352	0.05	Nodular Iron #2	200	0.50
Malleable (pearlitic)	185	0.90	Nodular Iron #3	230	0.40
Malleable (standard)	120	1.10	Potomac M	200	0.45
Molybdenum (cast)	190	0.30	Rene 41	215	0.15
Monel (K Monel)	240	0.35	Rycut 40	187	0.65
Monel (K-R Monel)	240	0.45	Stressproof	203	0.50
Monel (R Monel)	208	0.45	Super Triscent	180	0.40
Monel (S Monel cast)	300	0.25	Turbaloy	135	0.40
NE-9261	198	0.50	Udimet 500	290	0.09
Ni-Hard	550	0.03	V-57	375	0.08
Ni-Resist	145	0.45	Vasco X4	150	0.50
Nimonic 75	220	0.17	Vascojet 1000	190	0.45
Nimonic 80	270	0.12	Waspalloy	270	0.12
Nimonic 90	300	0.10	Tungsten Estimated		0.05
Nitrolloy (135)	200	0.45			

Machinability Table - Part 3 (Stainless Steel)

Material	BHN	MR	Material	BHN	MR
PH 15-7 Mo	270	0.20	403	200	0.55
17-4 PH	388	0.28	405	145	0.60
17-7 PH	200	0.20	410	160	0.55
301	183	0.55	416	200	0.90
302	178	0.50	418	160	0.40
303	180	0.65	420	207	0.45
304	160	0.40	430F	147	0.65
310	160	0.30	440C	240	0.35
316	195	0.35	440	160	0.50
317	195	0.35			

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Machinability Ratings Cont.

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Machinability Table - Part 4 (Titanium Alloys)

Material	BHN	MR	Material	BHN	MR
A-55	160	0.30	C-130	255	0.18
A-70	188	0.27	C-140	285	0.15
A-110	220	0.23	MST	380	0.09
C-120	240	0.20			

Machinability Table - Part 5 (Aluminum Alloys Wrought & Cast)

Material - Cast	BHN	MR	Material - Wrought	BHN	MR
A-132-T		1.10	2011		2.00
A-214		2.00	2014-T		1.40
A-356-T		1.40	2017-T		1.40
B-113		1.80	2024-T		1.50
D-132-T		1.30	3003		1.80
108		1.40	3004		1.80
112		1.80	5052		1.90
122-T		1.40	5056		1.90
195-T		1.90	4032-T		1.10
212		1.60	6051-T		1.40
218-T		2.40	6061-T		1.90
220-T		2.30	6063-T		1.90
319-T		1.60	7075-T		1.20
333-T		1.30	Aluminum-bronze (5% Al)		0.60
355-T		1.60			
750-T		1.80			

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Machinability Ratings Cont.

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Machinability Table - Part 6 (Other Materials)

Material - Cast	BHN	MR	Material - Wrought	BHN	MR
Aluminum-bronze (8% Al)		0.60	Leaded nickel-silver (12% Ni)		1.30
Aluminum-bronze (9.25% Al)		0.60	Leaded nickel-silver (18% Ni)		1.50
Aluminum-bronze (9.5% Al)		0.60	Leaded phosphor-bronze (5% Tin)		1.50
Aluminum silicon-bronze		1.80	Leaded silicon-bronze		1.80
Architectural Bronze		2.70	Low brass (80% Cu)		0.90
Beryllium-copper (no heat treat)		0.60	Low leaded brass		1.80
Chromium-copper		0.60	Low-leaded (tube)		1.80
Commercial bronze (90% Cu)		0.60	Manganese bronze		0.90
Cupro-nickel		0.60	Medium leaded brass		2.10
Deoxidized Copper		0.60	Muntz metal		1.20
Electrolytic tough-pitch copper		0.60	Naval brass		0.90
Extruded leaded nickel-silver (10%Ni)		2.40	Nickel		2.00
Forging brass		2.40	Nickel-silver (18% Ni)		0.60
Free-cutting brass		3.00	Nickel-silver (20% Ni)		0.60
High-leaded brass		2.70	Phosphor-bronze (5% Tin)		0.60
High-leaded brass (tube)		2.40	Phosphor-bronze (8% Tin)		0.60
High silicon-bronze		0.90	Phosphor-bronze (10% Tin)		0.60
Leaded commercial bronze		2.40	Red brass (35% Cu) selenium or tellurium copper		2.70
Leaded copper		2.40	Special free-cutting phosphor bronze		2.70
Leaded naval brass		2.10	Zinc		2.00

Summary

The use of the machinability rating is a method to assist you in recognizing how easy or how hard a given alloy is to machine in comparison to others. Like any specific appliction method, there is always a plus-or-minus leeway to applying the values. Again, use this as a guideline to understand the difficulty of machining.

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