PM End mills UK 2012

Features

High alloyed powder metallurgy steel as cutting material

Outstanding applicable under variable thermical - and mechanical forces

Resitant to extreme bending forces

=> high reliability during difficult operations

=> applicable on instable clamping or workpieces

High wear restistance on the cutting edge

=> long peripheral accuracy on the workpiece

=> improved surface roughness

AlCrN coating for maintaining a superieur warm hardness

=> excellent resistance against oxidation and build up edge

=> long tool live working in abrasive materials

Targeted diameter tolerances on the tool for

- small run out during finishing operations
[+0.03 to 0 / h6]

- effective roughing operations with js12 / h6 tolerances
[DIN 7160 and DIN 7161]

Perfect possibilties in repeatable regrinding and recoating

=> low cost on the tooling by a longer total life cycle of the tools

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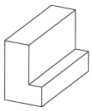
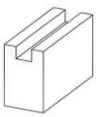
41000 K 30 Series

DIN 844 K, 4 cutting edges, right hand, 30° helix, DIN 1835 B shank, AlCrN coating

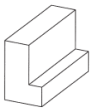
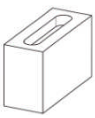
Article number	cutting diameter [-0.03/0]	cutting length	Shank diameter [h6]	O.A.L.	Price [in € / piece]
400051	1.0	3.0	6	49	11.50
400052	2.0	7.0	6	51	10.50
400053	3.0	8.0	6	52	10.50
400054	4.0	11.0	6	55	10.50
400055	5.0	13.0	6	57	10.50
400056	6.0	13.0	6	57	10.50
400057	7.0	16.0	10	66	14.40
400058	8.0	19.0	10	69	14.40
400059	9.0	19.0	10	69	14.40
400060	10.0	22.0	10	72	15.00
400061	12.0	26.0	12	83	21.50
400062	14.0	26.0	12	83	24.00
400063	16.0	32.0	16	92	28.70
400064	18.0	32.0	16	92	35.80
400065	20.0	38.0	20	104	46.70
400066	22.0	38.0	20	104	51.60
400067	25.0	45.0	25	121	69.00

 Finishing	Ø End mill D	1 – 3	4 – 7	8 – 10	12 – 16	18 – 25
	Feed rate fz	0.01 – 0.02	0.02 – 0.025	0.05 – 0.07	0.07 – 0.08	0.08 – 0.09
	Ae = 0.05 x D	0.05 – 0.15	0.20 – 0.35	0.40 – 0.50	0.60 – 0.80	0.90 – 1.25
	Ap = 1.5 x D	1.50 – 4.50	6.0 – 10.5	12.0 – 15.0	18.0 – 24.0	27.0 – 37.5
 Roughing	Ø End mill D	1 – 3	4 – 7	8 – 10	12 – 16	18 – 25
	Feed rate fz	0.008 – 0.015	0.015 – 0.025	0.04 – 0.06	0.06 – 0.07	0.07 – 0.08
	Ae = 0.3 x D	0.30 – 0.90	1.20 – 2.10	2.40 – 3.00	3.60 – 4.80	5.40 – 7.50
	Ap = 1.0 x D	1.0 – 3.0	4.0 – 7.0	8.0 – 10.0	12.0 – 16.0	18.0 – 25.0
 Slotting	Ø End mill D	1 – 3	4 – 7	8 – 10	12 – 16	18 – 25
	Feed rate fz	0.006 – 0.012	0.012 – 0.02	0.03 – 0.045	0.05 – 0.06	0.06 – 0.07
	Ae = 1.0 x D	1.0 – 3.0	4.0 – 7.0	8.0 – 10.0	12.0 – 16.0	18.0 – 25.0
	Ap = 0.5 x D	0.50 – 1.50	2.0 – 3.50	4.0 – 5.0	6.00 – 8.0	9.0 – 12.5
 3 axis simultaneous	Ø End mill D	1 – 3	4 – 7	8 – 10	12 – 16	18 – 25
	Feed rate fz	0.008 – 0.015	0.015 – 0.025	0.04 – 0.06	0.06 – 0.07	0.07 – 0.08
	Ae = 1.0 x D	1.00 – 3.00	4.00 – 7.00	8.00 – 10.0	12.0 – 16.0	18.0 – 25.0
	Ap = 0.1 x D	0.10 – 0.30	0.40 – 0.70	0.80 – 1.00	1.20 – 1.60	1.80 – 2.50

40000 L 30 Series

DIN 844 L, 4 cutting edges, right hand, 30° helix, DIN 1835 B shank, AlCrN coating

Article number	Cutting diameter [-0.03/0]	Cutting length	Shank diameter [h6]	O.A.L.	Price [in € / piece]
400071	2.0	10.0	6	54	11.80
400072	3.0	12.0	6	56	11.80
400073	4.0	19.0	6	63	11.80
400074	5.0	24.0	6	68	11.80
400075	6.0	24.0	6	68	11.80
400076	7.0	30.0	10	80	18.60
400077	8.0	38.0	10	88	18.60
400078	9.0	38.0	10	88	18.60
400079	10.0	45.0	10	95	18.60
400080	12.0	53.0	12	110	27.00
400081	14.0	53.0	12	110	31.80
400082	16.0	63.0	16	123	39.00
400083	18.0	63.0	16	123	49.80
400084	20.0	75.0	20	141	64.80
400085	22.0	75.0	20	141	70.90
400086	25.0	90.0	25	166	105.50

 Finishing	Ø End mill D	2 – 3	4 – 7	8 – 10	12 – 16	18 – 25
	Feed rate fz	0.01 – 0.02	0.02 – 0.025	0.05 – 0.07	0.07 – 0.08	0.08 – 0.09
	Ae = 0.05 x D	0.05 – 0.15	0.20 – 0.35	0.40 – 0.50	0.60 – 0.80	0.90 – 1.25
	Ap = 2.5 x D	2.50 – 7.50	10.0 – 17.5	20.0 – 25.0	30.0 – 40.0	45.0 – 62.5
 Roughing	Ø End mill D	2 – 3	4 – 7	8 – 10	12 – 16	18 – 25
	Feed rate fz	0.008 – 0.015	0.015 – 0.025	0.04 – 0.06	0.06 – 0.07	0.07 – 0.08
	Ae = 0.2 x D	0.40 – 0.60	0.80 – 1.40	1.60 – 2.0	2.40 – 3.20	3.60 – 5.0
	Ap = 2.0 x D	4.0 – 6.0	8.0 – 14.0	16.0 – 20.0	24.0 – 32.0	36.0 – 50.0
 Peripheral	Ø End mill D	2 – 3	4 – 7	8 – 10	12 – 16	18 – 25
	Feed rate fz	0.01 – 0.02	0.02 – 0.025	0.05 – 0.07	0.07 – 0.08	0.08 – 0.09
	Ae = 0.05 x D	0.05 – 0.15	0.20 – 0.35	0.40 – 0.50	0.60 – 0.80	0.90 – 1.25
	Ap = 2.5 x D	2.50 – 7.50	10.0 – 17.5	20.0 – 25.0	30.0 – 40.0	45.0 – 62.5

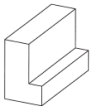
41000 K 30 Series

DIN 844 K, 3 - 5 cutting edges, right hand, 30° helix, DIN 1835 B shank, AlCrN coating

Fine roughing profile

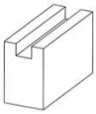
Number of teeth / diameter end mill Ø 6 – 9 => z = 3 Ø 10 – 20 => z = 4 Ø 22 -25 => z = 5

Article number	Cutting diameter [js12]	Cutting length	Shank diameter [h6]	O.A.L.	Price [in € / piece]
410001	6.0	13.0	6	57	15.40
410002	7.0	16.0	10	66	20.70
410003	8.0	19.0	10	69	20.70
410004	9.0	19.0	10	69	21.30
410005	10.0	22.0	10	72	21.30
410006	12.0	26.0	12	83	27.60
410007	14.0	26.0	12	83	34.10
410008	16.0	32.0	16	92	38.40
410009	18.0	32.0	16	92	42.80
410010	20.0	38.0	20	104	53.80
410011	22.0	38.0	20	104	66.30
410012	25.0	45.0	25	121	79.20



Roughing

Ø End mill D	6 – 8	9 – 10	12 – 14	16 – 20	22 – 25
Feed rate fz	0.02 – 0.03	0.035 – 0.05	0.055 – 0.07	0.075 – 0.09	0.1 – 0.12
Ae = 0.3 x D	1.80 – 2.40	2.70 – 3.0	3.60 – 4.20	4.80 – 6.0	6.60 – 7.50
Ap = 1.0 x D	6.0 – 8.0	9.0 – 10.0	12.0 – 14.0	16.0 – 20.0	22.0 – 25.0



Slotting

Ø End mill D	6 – 8	9 – 10	12 – 14	16 – 20	22 – 25
Feed rate fz	0.015 – 0.02	0.025 – 0.035	0.04 – 0.05	0.055 – 0.06	0.065 – 0.08
Ae = 1.0 x D	6.0 – 8.0	9.0 – 10.0	12.0 – 14.0	16.0 – 20.0	22.0 – 25.0
Ap = 0.5 x D	3.0 – 4.0	4.50 – 5.0	6.0 – 7.0	8.0 – 10.0	11.0 – 12.5

Peripheral

Ø End mill D	6 – 8	9 – 10	12 – 14	16 – 20	22 – 25
Feed rate fz	0.02 – 0.03	0.035 – 0.05	0.055 – 0.07	0.075 – 0.09	0.1 – 0.12
Ae = 0.3 x D	1.80 – 2.40	2.70 – 3.0	3.60 – 4.20	4.80 – 6.0	6.60 – 7.50
Ap = 1.0 x D	6.0 – 8.0	9.0 – 10.0	12.0 – 14.0	16.0 – 20.0	22.0 – 25.0

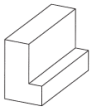
41000 L 30 Series

DIN 844 L, 3 - 5 cutting edges, right hand, 30° helix, DIN 1835 B shank, AlCrN coating

Fine roughing profile

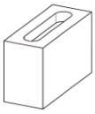
Number of teeth / diameter end mill Ø 6 - 9 => z = 3 Ø 10 - 20 => z = 4 Ø 22 - 25 => z = 5

Article number	Cutting diameter [js12]	Cutting length	Shank diameter [h6]	O.A.L.	Price [in € / piece]
410021	6.0	24.0	6	68	24.00
410022	7.0	30.0	10	80	29.80
410023	8.0	38.0	10	88	29.80
410024	9.0	38.0	10	88	29.80
410025	10.0	45.0	10	95	29.80
410026	12.0	53.0	12	110	36.50
410027	14.0	53.0	12	110	48.20
410028	16.0	63.0	16	123	52.60
410029	18.0	63.0	16	123	63.00
410030	20.0	75.0	20	141	76.40
410031	22.0	75.0	20	141	99.80
410032	25.0	90.0	25	166	122.20



Roughing

Ø End mill D	6 – 8	9 – 10	12 – 14	16 – 20	22 – 25
Feed rate fz	0.02 – 0.03	0.035 – 0.05	0.055 – 0.07	0.075 – 0.09	0.1 – 0.12
Ae = 0.15 x D	0.90 – 1.20	1.35 – 1.50	1.80 – 2.10	2.40 – 3.0	3.30 – 3.75
Ap = 2.0 x D	12.0 – 16.0	18.0 – 20.0	24.0 – 28.0	32.0 – 40.0	44.0 – 50.0



Peripheral

Ø End mill D	6 – 8	9 – 10	12 – 14	16 – 20	22 – 25
Feed rate fz	0.02 – 0.03	0.035 – 0.05	0.055 – 0.07	0.075 – 0.09	0.1 – 0.12
Ae = 0.15 x D	1.80 – 2.40	2.70 – 3.0	3.60 – 4.20	4.80 – 6.0	6.60 – 7.50
Ap = 2.0 x D	6.0 – 8.0	9.0 – 10.0	12.0 – 14.0	16.0 – 20.0	22.0 – 25.0

41000 K 45 Series

DIN 844 K, 3 - 6 cutting edges, right hand, 45° helix, DIN 1835 B shank, AlCrN coating

Fine roughing profile

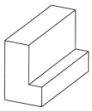
Number of teeth / diameter end mill Ø 4 => z = 3 Ø 5 - 12 => z = 4 Ø 14 - 16 => z = 5 Ø 18 - 25 => z = 6

Article number	Cutting diameter [js12]	Cutting length	Shank diameter [h6]	O.A.L.	Price [in € / piece]
410039	4.0	11.0	6	57	19.80
410040	5.0	13.0	6	57	19.80
410041	6.0	13.0	6	57	19.80
410042	7.0	16.0	10	66	26.40
410043	8.0	19.0	10	69	26.40
410044	9.0	19.0	10	69	27.00
410045	10.0	22.0	10	72	27.00
410046	12.0	26.0	12	83	33.60
410047	14.0	26.0	12	83	39.60
410048	16.0	32.0	16	92	45.60
410049	18.0	32.0	16	92	49.80
410050	20.0	38.0	20	104	63.00
410051	25.0	45.0	25	121	93.00

End mills with neck: Ø 10, 12, 16, 20 and 25 mm

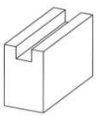
€ 225.00

Set dimensions Ø 4 / 5 / 6 / 8 / 10 / 12 / 16 / 20 mm



Roughing

Ø End mill D	4 – 5	6 – 8	9 – 10	12 – 16	18 – 25
Feed rate fz	0.025 – 0.03	0.04 – 0.05	0.055 – 0.065	0.08 – 0.10	0.11 – 0.14
Ae = 0.4 x D	1.60 – 2.0	2.40 – 3.20	3.60 – 4.0	4.80 – 5.60	7.20 – 10.0
Ap = 1.5 x D	6.0 – 7.50	9.0 – 12.0	13.50 – 15.0	18.0 – 24.0	27.0 – 37.5



Slotting

Ø End mill D	4 – 5	6 – 8	9 – 10	12 – 16	18 – 25
Feed rate fz	0.02 – 0.025	0.03 – 0.035	0.04 – 0.045	0.055 – 0.075	0.08 – 0.11
Ae = 1.0 x D	4.0 – 5.0	6.0 – 8.0	9.0 – 10.0	12.0 – 16.0	18.0 – 25.0
Ap = 0.75 x D	3.0 – 3.75	4.50 – 6.0	6.75 – 7.50	9.0 – 12.0	13.5 – 18.75

3 axis simultaneous

Ø End mill D	4 – 5	6 – 8	9 – 10	12 – 16	18 – 25
Feed rate fz	0.02 – 0.025	0.03 – 0.035	0.04 – 0.045	0.055 – 0.075	0.08 – 0.11
Ae = 1.0 x D	4.0 – 5.0	6.0 – 8.0	9.0 – 10.0	12.0 – 16.0	18.0 – 25.0
Ap = 0.1 x D	0.40 – 0.50	0.60 – 0.80	0.90 – 1.0	1.20 – 1.60	1.80 – 2.50

Complementary end mill types on request

Square end mill DIN 844 short

Square end mill DIN 844 long

Square end mill DIN 327
extrem short

Square end mill DIN 844 long

Ball nose end mill DIN 327 short

Ball nose end mill DIN 1889 long

Roughing end mill DIN 844 short

Roughing end mill DIN 844 long

Cutting speed Vc

Carbon steel	Examples [DIN/W.Nr]	Vc
< 450 N/mm²	C15 C22 Ck15 St37-3 9SMn28	60 - 70 m/min
< 850 N/mm²	St50-2 16CrMo4 12CrMo19 5	50 - 60 m/min
< 1100 N/mm²	St60-2 St70-2 42CrV6 51CrMoV4	40 - 50 m/min
Low alloyed steel		
< 600 N/mm²	100Cr6 42Cr4 51CrV4	45 - 60 m/min
< 1000 N/mm²	31NiCr14 100Cr2 36NiCr6	40 - 50 m/min
< 1300 N/mm²	40CrMn7 35NiCr18 42CrMo4	30 - 40 m/min
High alloyed steel		
< 700 N/mm²	X40CrMoV5 X155CrVMo12 1	35 - 45 m/min
< 1200 N/mm²	S-12-1-4-5 S-6-5-2	25 - 30 m/min

Stainless steel	Examples [DIN/W.Nr]	Vc
Ferritic/martensitic	1.4021 1.4305 1.4448 1.4762	25 - 35 m/min
Martensitic	1.4034 1.4057 1.4125	25 - 30 m/min
Austenitic	1.4301 1.4311 1.4404 1.4462	25 - 35 m/min

Cast iron	Examples [DIN/W.Nr]	Vc
Grey cast iron [<180-HB]	EN-GJL-110 EN-GJL-150	50 - 60 m/min
Grey cast iron [<260HB]	EN-GJL-250 EN-GJL-400	40 - 50 m/min
Nodular cast iron [<160HB]	EN-GJS-350 EN-GJS-400	30 - 40 m/min
Nodular cast iron [<250HB]	EN-GJS-500 EN-GJS-700	25 - 35 m/min

Non ferretic materials	Examples [DIN/W.Nr]	Vc
Aluminium alloys		
< 250 N/mm²	Al99.5 AlMg1	80 - 120 m/min
< 300 N/mm²/ < 12% Si	G-AlSi12 G-AlSi10Mg	50 - 70 m/min
Copper alloys		
Brass	CuZn15 CuZn30 G-CuPb20Sn	40 - 60 m/min
Electrolytic copper	CuAl10Ni5Fe4 G-CuAl10Ni	60 - 80 m/min
Plastics		
Duroplastics	Resonal / Novodur	80 - 100 m/min
Thermoplastics	Bakelit / Pertinax	70 - 90 m/min

Heat resistant alloys	Tensile strength Rm in N/mm²	Vc
Iron based	800 - 1200	20 - 25 m/min
Nickel based	1000 - 1450	25 - 30 m/min
Cobalt based	1000 - 1450	25 - 30 m/min
Titanium alloys	900 - 1600	30 - 35 m/min

Hardened materials	Examples [DIN/W.Nr]	Vc
Tool steel [40-48 HRc]	-	15 - 25 m/min
Tool steel [48-52 HRc]	-	10 - 20 m/min
Hardened cast iron	G-X260NiCr4 2	15 - 25 m/min
	[< 48 HRc]	

Troubles versus counter measures

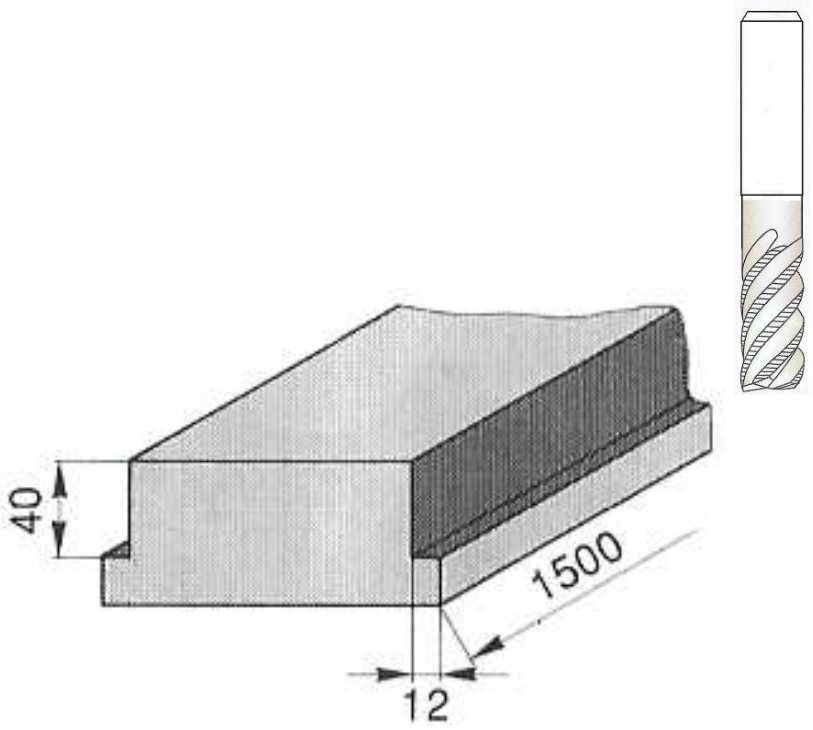
Trouble	Situation and cause	Counter measures
Breakage of tool	engaging workpiece	decrease feed rate Vf
	leaving workpiece	decrease feed rate Vf
	during cutting	decrease feed rate Vf
	excessive wear	earlier tool change
	run out	replace adapter
	to narrow pitch of teeth	utilize coarse pitch end mill
	dry machining	change to wet machining
	changing direction of feed movement	circulair interpolation decrease feed rate Vf
Fracture of cutting edge	fracture of corners	choose bigger T land
	notching of cutting edge	decrease feed rate Vf from down cut machining to up cut machining
	chipping of the cutting edge	increase feed rate Vf decrease cutting speed Vc replace adapter from dry to wet machining
	large fracture of the cutting edge	decrease feed rate Vf decrease cutting speed Vc utilize coarse pitch end mill increase coolant supply

Troubles versus counter measures

Trouble	Situation and cause	Counter measures
Rapid worn out tool	cutting speed Vc	decrease cutting speed Vc from up cut machining to down cut machining increase feed rate Vf utilize coolant check regrinded tool
Inferior surface roughness	coarse and good surface	decrease feed rate Vf utilize fine pitch end mill
	chip welding	increase cutting speed Vc increase coolant supply from up cut to down cut machining fine honing on the cutting edge increase feed rate Vf
	excessive cutting parameters	decrease D.O.C./Ap decrease W.O.C./Ae increase cutting speed Vc decrease feed rate Vf
Poor machining accuracy	critical minus stock removal	from up cut to down cut machining decrease D.O.C./Ap replace adapter increase cutting speed Vc decrease feed rate Vf
Chattering	fixture / workpiece	increase feed rate Vf change of cutting speed Vc from down cut to up cut machining

Machining example

Workpiece:	Guide fork-lift truck
Material:	DIN St 52.3 / 1.0570
Operation:	Roughing
Machining center:	Vertical
Opname:	SK50 MAS-BT/JIS to DIN 1835 B
Coolant:	8 % emulsion; 20 bar presure; externally
Tool:	410051 DIN 844 K



Chipform

Cutting speed Vc:	60 m/min
Revolutions n:	764 r.p.m.
Depth of cut D.O.C./Ap:	40.0 mm
Width of cut W.O.C./Ae:	6.0 mm [2 x]
Feed rate fz:	0.14 mm [z = 6]
Feed rate Vf:	642 mm/min
Chip volume Q:	154 cm³/min
Specific cutting force kc:	≈ 2600 N/mm²
Power Pc:	≈ 7.9 kW
Torque Mc:	≈ 3.4 Nm
Time in cut Tc:	Lc : Vf = 6000 : 642 = 9. 35 min

Formulas and symbols

$$\text{Cutting speed } Vc = \frac{D \times \pi \times n}{1000} \text{ in m/min}$$

Vc: cutting speed in m/min
D: cutting diameter in mm
π: value pí; ≈ 3.14
n: number of revolutions/min

$$\text{Revolutions } n = \frac{Vc \times 1000}{D \times \pi} \text{ in r.p.m.}$$

n: number of revolutions/min
D: cutting diameter in mm
π: value pí; ≈ 3.14
Vc: cutting speed in m/min

Table feed rate Vf = fz x z x n in mm/min

Vf: table feed rate in mm/min
fz: feed rate/tooth in mm
z: number of teeth
n: number of revolutions/min

$$\text{Feed rate/tooth } fz = \frac{Vf}{z \times n} \text{ in mm}$$

fz: feed rate/tooth in mm
Vf: table feed in mm/min
z: number of teeth
n: number of revolutions/min

$$\text{Chip volume } Q = \frac{Ap \times Ae \times Vf}{1000} \text{ in } cm^3/min$$

Q: chip volume in cm^3/min
D.O.C./Ap: depth of cut in mm
W.O.C./Ae: width of cut in mm
Vf: feed rate in mm/min

$$\text{Surf. roughness } Rth = [D : 2] - \frac{\sqrt{[D^2 - Ae^2]}}{4} \text{ in } \mu m$$

Rth: theoretical surface roughness in μm
D: cutting diameter in mm
W.O.C./Ae: width of cut in mm

$$\text{Power } Pc = \frac{[Ap \times Ae \times Vf \times kc]}{60000 \times 10^3 \times \eta} \text{ in } cm^3/min$$

Pc: power requirement in kW
D.O.C./Ap: depth of cut in mm
W.O.C./Ae: width of cut in mm
Kc: specific cutting forces
η: spindel efficiency [factor 0.85]

$$\text{Torque } Mc = \frac{[D : 2] \times fz \times z \times kc}{8000} \text{ in Nm}$$

Mc: torque in Nm
fz: feed rate/tooth in mm
z: number of teeth
Kc: specific cutting force

Approximate values specific cutting forces

Carbon steel	fz = 0.05	0.1	0.16	0.2	0.25	0.3
< 450 N/mm²	2900	2600	2400	2300	2250	2200
< 850 N/mm²	4350	3600	3200	3000	2850	2700
< 1100 N/mm²	3500	3400	3100	2900	2600	2550
Low alloyed steel						
< 600 N/mm²	4500	3400	2800	2600	2500	2400
< 1000 N/mm²	3800	3200	2800	2600	2500	2400
< 1300 N/mm²	5400	4500	4000	3800	3600	3400
High alloyed steel						
< 700 N/mm²	4000	3300	2900	2800	2600	2500
< 1200 N/mm²	4000	3300	2900	2800	2600	2500

Stainless steel	fz = 0.05	0.1	0.16	0.2	0.25	0.3
Ferrit./martensit.	4000	3600	3300	2900	2750	2600
Martensitic	4000	3600	3300	2900	2750	2600
Austenitic	4600	4000	3700	3500	3400	3300

Cast iron	fz = 0.05	0.1	0.16	0.2	0.25	0.3
Grey cast iron	2500	2400	1850	1750	1650	1600
Nodular cast iron	2150	1800	1600	1500	1400	1350
Malleable c. iron	3650	3200	2900	2800	2700	2600

Aluminium alloys	fz = 0.05	0.1	0.16	0.2	0.25	0.3
< 250 N/mm²	1550	1300	1200	1100	1050	1000
< 12% Si	1650	1400	1300	1200	1150	1100
Copper alloys						
Pb > 1%	1350	1150	1000	950	900	850
Electrolitic copper	1750	1500	1350	1300	1200	1150

Heat resistant all.	fz = 0.05	0.1	0.16	0.2	0.25	0.3
Iron based	4600	4100	4000	3800	3400	3200
Nickel based	5000	4100	4000	3800	3100	2900
Cobalt based	5000	4100	4000	3800	3200	2900
Titanium alloys	2600	2200	2100	2000	1800	1700

Hardened steel	fz = 0.05	0.1	0.16	0.2	0.25	0.3
48 – 52 HRc	5500	4750	4300	4100	4000	3800
52 – 60 HRc	6400	5550	5050	4800	4600	4450
60 – 68 HRc	7300	6350	5800	5500	5300	5100

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