Basic calculations of machine time, speed, power and cutting forces for machining.

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Basic calculation of machining time

$$t_c = t_a + t_b$$

t_c – total time,

t_a – main time,

t_b – batch time (time to prepare dose),

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Main time for turning and drilling

$$t_a = \frac{l}{n \cdot s} \quad [\text{min}]$$

l – length of machined surface (drill hole) [mm],

n – number of rotations [rpm],

s – feed per revolution [mm / rev]

Main time for milling

$$t_a = \frac{A}{b \cdot n \cdot s_z \cdot z} \text{ [min]}$$

A – milling surface [mm^2],

b – width of cutters [mm],

n – revolutions of cutter [rpm],

s_z – feed per tooth [mm / tooth],

z – number of cutter teeth [teeth]

Calculation of the cutting speed during turning

$$v_c = \frac{\pi \cdot D \cdot n}{1000} \quad [m / min]$$

D – workpiece diameter [mm],

n – spindle speed [rpm]

Calculation of the cutting force during turning

$$F_z = p \cdot S \text{ [N]}$$

p – specific cutting resistance - see table below [MPa],

S – chip cross section [mm^2]:

$$S = h \cdot s \text{ [}mm^2\text{]}$$

h – cutting depth [mm],

s – feed per revolution [mm / rev]

Power required during turning

$$P = \frac{F_z \cdot v_c}{60 \cdot 1000} \text{ [kW]}$$

F_z – cutting force [N],

v_c – cutting speed [m / min]

Specific cutting resistance of selected materials

Material	Specific cutting resistance [MPa]		
	turning	milling	drilling
steel σ_{pt}=450 – 700 MPa (11, 12)	2100 - 2450	3650 - 4950	2700 – 4000
steel Cr, σ_{pt}=500 – 800 MPa	2500 - 2800	5050 - 5400	4300 – 5200
cast iron 180 – 200 HB	1380 - 1580	2650 - 3050	1750 - 2500
Cu alloys σ_{pt}=200 – 500 MPa	1100 - 1400	1750 - 2100	1500 – 1800
Al alloys σ_{pt}=180 – 350 MPa	850 - 1150	1300 - 1450	1150 - 1300

Calculation of cutting speed during drilling

$$v_c = \frac{\pi \cdot D \cdot n}{1000} \quad [m / min]$$

D – diameter of drill [mm],

n – revolutions of drill [rpm]

Calculation of force feed (axial force) during drilling

$$F_a = 0{,}5 \cdot p \cdot \frac{D}{2} \cdot s \cdot \sin \varkappa \ \ [\mathrm{N}]$$

p – specific cutting resistance - see table [MPa],

D – diameter of drill [mm],

s – feed per revolution [mm / rev],

$\varkappa$ – adjustment angle, the angle between the edge and the feed direction (φ / 2)

Calculation of cutting forces during drilling (per cutting edge)

$$F_z = p \cdot S \ [N]$$

p – specific cutting resistance - see table [MPa],

S – chip cross section on one edge [mm^2]:

$$S = \frac{s}{i} \cdot \frac{D}{2} \ [mm^2]$$

i – number of cutting edges,

s – feed per revolution [mm / rev],

D – diameter of drill [mm]

The torque needed during drilling

$$M = i \cdot F_z \cdot \frac{D}{4 \cdot 1000} \ [Nm]$$

i – number of cutting edges,

F_z – cutting force [N],

D – diameter of drill [mm]

Power requirement during drilling

$$P = \frac{F_z \cdot v_c}{60 \cdot 1000} \text{ [kW]}$$

F_z – cutting force [N],

v_c – cutting speed [m / min]

$$P = M \cdot \frac{2 \cdot \pi \cdot n}{60} \text{ [kW]}$$

M – torque [Nm],

n – revolutions of drill [rpm]

Feed speed for milling

$$f = s_z \cdot n \cdot z \ \text{[mm / min]}$$

s_z – feed per tooth [mm / tooth],

n – revolutions of cutter [rev / min],

z – Number of cutter teeth [teeth]

The volume of material removed during milling

$$Q = b \cdot h \cdot f \ [mm^3 / min]$$

b – width of cut [mm],

h – cutting depth [mm],

f – feed speed for milling [mm / min]

Power required during milling

$$P = Q \cdot p \cdot \frac{1}{60 \cdot 1000 \cdot 1000} \; [kW]$$

Q – the volume of material removed [mm^3 / min],

p – specific cutting resistance - see table [MPa]

References

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