

Important Cutting Force and Surface Roughness Formulas PDF



Formulas
Examples
with Units

List of 21 Important Cutting Force and Surface Roughness Formulas

1) Area of Contact given Frictional Force Formula ↻

Formula

$$A_c = \frac{F_f}{(\gamma_m \cdot \tau_1) + ((1 - \gamma_m) \cdot \tau_2)}$$

Evaluate Formula ↻

Example with Units

$$1250 \text{ mm}^2 = \frac{25 \text{ N}}{(0.5 \cdot 0.03 \text{ N/mm}^2) + ((1 - 0.5) \cdot 0.01 \text{ N/mm}^2)}$$

2) Corner Radius given Roughness value Formula ↻

Formula

$$r_c = 0.0321 \cdot \frac{(f)^2}{R}$$

Example with Units

$$1.5235 \text{ mm} = 0.0321 \cdot \frac{(0.9 \text{ mm})^2}{0.017067 \text{ mm}}$$

Evaluate Formula ↻

3) Cutting Force given Rate of Energy Consumption during Machining Formula ↻

Formula

$$F_c = \frac{Q_c}{V_c}$$

Example with Units

$$900 \text{ N} = \frac{1.8 \text{ W}}{2 \text{ mm/s}}$$

Evaluate Formula ↻

4) Cutting Force given Specific Cutting Energy in Machining Formula ↻

Formula

$$F_c = Q_{sc} \cdot A_{cs}$$

Example with Units

$$900 \text{ N} = 2000 \text{ MJ/m}^3 \cdot 0.45 \text{ mm}^2$$

Evaluate Formula ↻

5) Diameter of Cutter given Roughness Value Formula ↻

Formula

$$d_t = \frac{0.0642 \cdot (V_f)^2}{R \cdot (\omega_c)^2}$$

Example with Units

$$41.7961 \text{ mm} = \frac{0.0642 \cdot (100 \text{ mm/s})^2}{0.017067 \text{ mm} \cdot (30 \text{ Hz})^2}$$

Evaluate Formula ↻



6) Feed given Roughness value Formula

Formula

$$f = 4 \cdot (\cot(\theta) + \cot(\theta')) \cdot R$$

Evaluate Formula 

Example with Units

$$0.9 \text{ mm} = 4 \cdot (\cot(45.17097^\circ) + \cot(4.69^\circ)) \cdot 0.017067 \text{ mm}$$

7) Feed given Roughness Value and corner radius Formula

Formula

$$f = \left(R \cdot \frac{r_c}{0.0321} \right)^{\frac{1}{2}}$$

Example with Units

$$0.9 \text{ mm} = \left(0.017067 \text{ mm} \cdot \frac{1.523466 \text{ mm}}{0.0321} \right)^{\frac{1}{2}}$$

Evaluate Formula 

8) Feed Speed given Roughness Value Formula

Formula

$$V_f = \sqrt{R \cdot \frac{d_t}{0.0642}} \cdot \omega_c$$

Example with Units

$$100.0047 \text{ mm/s} = \sqrt{0.017067 \text{ mm} \cdot \frac{41.8 \text{ mm}}{0.0642}} \cdot 30 \text{ Hz}$$

Evaluate Formula 

9) Force required to remove Chip and Acting on Tool Face Formula

Formula

$$F_r = F_{rc} - F_p$$

Example with Units

$$500 \text{ N} = 647.55 \text{ N} - 147.55 \text{ N}$$

Evaluate Formula 

10) Frictional Force required to continuously Shear Junction between Surfaces Formula

Formula

$$F_f = A_c \cdot \left((\gamma_m \cdot \tau_1) + ((1 - \gamma_m) \cdot \tau_2) \right)$$

Evaluate Formula 

Example with Units

$$25 \text{ N} = 1250 \text{ mm}^2 \cdot \left((0.5 \cdot 0.03 \text{ N/mm}^2) + ((1 - 0.5) \cdot 0.01 \text{ N/mm}^2) \right)$$

11) Proportion of Area in which Metallic Contact occurs given Frictional Force Formula

Formula

$$\gamma_m = \frac{\left(\frac{F_f}{A_c} \right) - \tau_2}{\tau_1 - \tau_2}$$

Example with Units

$$0.5 = \frac{\left(\frac{25 \text{ N}}{1250 \text{ mm}^2} \right) - 0.01 \text{ N/mm}^2}{0.03 \text{ N/mm}^2 - 0.01 \text{ N/mm}^2}$$

Evaluate Formula 

12) Resultant Cutting Force using Force required to remove Chip Formula

Formula

$$F_{rc} = F_r + F_p$$

Example with Units

$$647.55 \text{ N} = 500 \text{ N} + 147.55 \text{ N}$$

Evaluate Formula 



13) Rotational Frequency of Cutter given Roughness Value Formula

Formula

$$\omega_c = \sqrt{\frac{0.0642}{R \cdot d_t}} \cdot V_f$$

Example with Units

$$29.9986 \text{ Hz} = \sqrt{\frac{0.0642}{0.017067 \text{ mm} \cdot 41.8 \text{ mm}}} \cdot 100 \text{ mm/s}$$

Evaluate Formula 

14) Roughness Value Formula

Formula

$$R = \frac{f}{4 \cdot (\cot(\theta) + \cot(\theta'))}$$

Example with Units

$$0.0171 \text{ mm} = \frac{0.9 \text{ mm}}{4 \cdot (\cot(45.17097^\circ) + \cot(4.69^\circ))}$$

Evaluate Formula 

15) Roughness value given corner radius Formula

Formula

$$R = 0.0321 \cdot \frac{(f)^2}{r_c}$$

Example with Units

$$0.0171 \text{ mm} = 0.0321 \cdot \frac{(0.9 \text{ mm})^2}{1.523466 \text{ mm}}$$

Evaluate Formula 

16) Roughness value given feed speed Formula

Formula

$$R = \frac{0.0642 \cdot (V_f)^2}{d_t \cdot (\omega_c)^2}$$

Example with Units

$$0.0171 \text{ mm} = \frac{0.0642 \cdot (100 \text{ mm/s})^2}{41.8 \text{ mm} \cdot (30 \text{ Hz})^2}$$

Evaluate Formula 

17) Roughness Value of Tool Formula

Formula

$$R = 0.0321 \cdot \frac{(f)^2}{r_c}$$

Example with Units

$$0.0171 \text{ mm} = 0.0321 \cdot \frac{(0.9 \text{ mm})^2}{1.523466 \text{ mm}}$$

Evaluate Formula 

18) Shear Strength of Softer Lubricant Layer given Frictional force Formula

Formula

$$\tau_2 = \frac{\left(\frac{F_f}{A_c}\right) - (\gamma_m \cdot \tau_1)}{1 - \gamma_m}$$

Example with Units

$$0.01 \text{ N/mm}^2 = \frac{\left(\frac{25 \text{ N}}{1250 \text{ mm}^2}\right) - (0.5 \cdot 0.03 \text{ N/mm}^2)}{1 - 0.5}$$

Evaluate Formula 



19) Shear Strength of Softer Metal given Frictional force Formula

Formula

$$\tau_1 = \frac{\left(\frac{F_f}{A_c} \right) - (1 - \gamma_m) \cdot \tau_2}{\gamma_m}$$

Example with Units

$$0.03 \text{ N/mm}^2 = \frac{\left(\frac{25 \text{ N}}{1250 \text{ mm}^2} \right) - (1 - 0.5) \cdot 0.01 \text{ N/mm}^2}{0.5}$$

Evaluate Formula 

20) Working Major Cutting Edge Angle given Roughness Value Formula

Formula

$$\theta = \left(\operatorname{acot} \left(\left(\frac{f}{4 \cdot R} \right) - \cot(\theta') \right) \right)$$

Example with Units

$$45.171^\circ = \left(\operatorname{acot} \left(\left(\frac{0.9 \text{ mm}}{4 \cdot 0.017067 \text{ mm}} \right) - \cot(4.69^\circ) \right) \right)$$

Evaluate Formula 

21) Working Minor Cutting Edge Angle given Roughness Value Formula

Formula

$$\theta' = \left(\operatorname{acot} \left(\left(\frac{f}{4 \cdot R} \right) - \cot(\theta) \right) \right)$$

Example with Units

$$4.69^\circ = \left(\operatorname{acot} \left(\left(\frac{0.9 \text{ mm}}{4 \cdot 0.017067 \text{ mm}} \right) - \cot(45.17097^\circ) \right) \right)$$

Evaluate Formula 



Variables used in list of Cutting Force and Surface Roughness Formulas above

- **A_c** Real Area of Contact (Square Millimeter)
- **A_{cs}** Cross Sectional Area of Uncut Chip (Square Millimeter)
- **d_t** Diameter of Cutter (Millimeter)
- **f** Feed (Millimeter)
- **F_c** Cutting Force (Newton)
- **F_f** Force of Friction (Newton)
- **F_p** Plowing Force (Newton)
- **F_r** Force required to Remove Chip (Newton)
- **F_{rc}** Resultant Cutting Force (Newton)
- **Q_c** Rate of Energy Consumption during Machining (Watt)
- **Q_{sc}** Specific Cutting Energy in Machining (Megajoule per Cubic Meter)
- **R** Roughness Value (Millimeter)
- **r_c** Corner Radius of Tool (Millimeter)
- **V_c** Cutting Speed (Millimeter per Second)
- **V_f** Feed Speed (Millimeter per Second)
- **γ_m** Proportion of Area of Metallic Contact
- **θ** Working Major Cutting Edge Angle (Degree)
- **θ'** Working Minor Cutting Edge (Degree)
- **T_1** Shear Strength of Softer Metal (Newton per Square Millimeter)
- **T_2** Shear Strength of Softer Lubricant Layer (Newton per Square Millimeter)
- **ω_c** Rotational Frequency of Cutter (Hertz)

Constants, Functions, Measurements used in list of Cutting Force and Surface Roughness Formulas above

- **Functions:** **acot**, acot(Number)
The ACOT function calculates the arccotangent of a given number which is an angle given in radians from 0 (zero) to pi.
- **Functions:** **cot**, cot(Angle)
Cotangent is a trigonometric function that is defined as the ratio of the adjacent side to the opposite side in a right triangle.
- **Functions:** **sqrt**, sqrt(Number)
A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- **Measurement:** **Length** in Millimeter (mm)
Length Unit Conversion 
- **Measurement:** **Area** in Square Millimeter (mm²)
Area Unit Conversion 
- **Measurement:** **Speed** in Millimeter per Second (mm/s)
Speed Unit Conversion 
- **Measurement:** **Power** in Watt (W)
Power Unit Conversion 
- **Measurement:** **Force** in Newton (N)
Force Unit Conversion 
- **Measurement:** **Angle** in Degree (°)
Angle Unit Conversion 
- **Measurement:** **Frequency** in Hertz (Hz)
Frequency Unit Conversion 
- **Measurement:** **Energy Density** in Megajoule per Cubic Meter (MJ/m³)
Energy Density Unit Conversion 
- **Measurement:** **Stress** in Newton per Square Millimeter (N/mm²)
Stress Unit Conversion 



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