Important Sheet Metal Operations Formulas PDF

Formulas
Examples
with Units

List of 26
Important Sheet Metal Operations Formulas

1) Bending Operation Formulas

1.1) Bend Allowance Formula

Evaluate Formula

Formula

$$B_{al} = \theta \cdot \left(r_c + \lambda \cdot t_{bar} \right)$$

Example with Units

$$0.0261\,\text{mm} = 3.14\,\text{rad} \cdot \left(0.007\,\text{mm} + 0.44 \cdot 0.003\,\text{mm} \right)$$

1.2) Bending Force Formula

Evaluate Formula

Formula

$$F_B = \frac{K_{bd} \cdot L_b \cdot \sigma_{ut} \cdot t_{blank}^{2}}{w}$$

Example with Units

$$32.5425\,\text{N} = \frac{0.031 \cdot 1.01\,\text{mm} \cdot 450\,\text{N/mm}^2 \cdot 8.99\,\text{mm}^{2}}{34.991620\,\text{mm}}$$

1.3) Clearance between Two Shears Formula

Evaluate Formula

Formula

$$C_s = 0.0032 \cdot t_b \cdot \left(\tau \right)^{0.5}$$

Example with Units

$$51.138\,\text{mm} = 0.0032 \cdot 1.13\,\text{mm} \cdot \left(200\,\text{N/mm}^2 \right)^{0.5}$$

1.4) Length of Bent Part in Bending Operation Formula

Evaluate Formula

Formula

$$L_b = \frac{F_B \cdot w}{K_{bd} \cdot \sigma_{ut} \cdot t_{stk}^{2}}$$

Example with Units

$$1.0078\,\text{mm} = \frac{32.5425\,\text{N} \cdot 34.991620\,\text{mm}}{0.031 \cdot 450\,\text{N/mm}^2 \cdot 9\,\text{mm}^{2}}$$

1.5) Stock Thickness used in Bending Operation Formula

Evaluate Formula

Formula

$$t_{stk} = \sqrt{\frac{F_B \cdot w}{K_{bd} \cdot L_b \cdot \sigma_{ut}}}$$

Example with Units

$$8.99\,\text{mm} = \sqrt{\frac{32.5425\,\text{N} \cdot 34.991620\,\text{mm}}{0.031 \cdot 1.01\,\text{mm} \cdot 450\,\text{N/mm}^2}}$$

1.6) Width between Contact Points during Bending Formula

Evaluate Formula

Formula

$$w = \frac{K_{bd} \cdot L_b \cdot \sigma_{ut} \cdot t_{blank}^{2}}{F_B}$$

Example with Units

$$34.9916\,\text{mm} = \frac{0.031 \cdot 1.01\,\text{mm} \cdot 450\,\text{N/mm}^2 \cdot 8.99\,\text{mm}^{2}}{32.5425\,\text{N}}$$

2) Drawing Operation Formulas

2.1) Blank Diameter from Percent Reduction Formula

Evaluate Formula

Formula

$$D_b = d_s \cdot \left(1 - \frac{PR_{\%}}{100}\right)^{-1}$$

Example with Units

$$84.2105\,\text{mm} = 80\,\text{mm} \cdot \left(1 - \frac{5}{100}\right)^{-1}$$

2.2) Blank Size for Drawing Operation Formula

Evaluate Formula

Formula

$$D_b = \sqrt{d_s^{\,2} + 4 \cdot d_s \cdot h_{shl}}$$

Example with Units

$$84.1903\,\text{mm} = \sqrt{80\,\text{mm}^{\,2} + 4 \cdot 80\,\text{mm} \cdot 2.15\,\text{mm}}$$

2.3) Drawing Force for Cylindrical Shells Formula

Evaluate Formula

Formula

$$P_d = \pi \cdot d_s \cdot t_b \cdot \sigma_y \cdot \left(\frac{D_b}{d_s} - C_f\right)$$

Example with Units

$$0.0045\,\text{N/mm}^2 = 3.1416 \cdot 80\,\text{mm} \cdot 1.13\,\text{mm} \cdot 35\,\text{N/mm}^2 \cdot \left(\frac{84.2\,\text{mm}}{80\,\text{mm}} - 0.6\right)$$

2.4) Percent Reduction after Drawing Formula

Evaluate Formula

Formula

$$PR_{\%} = 100 \cdot \left(1 - \frac{d_s}{D_b}\right)$$

Example with Units

$$4.9881 = 100 \cdot \left(1 - \frac{80\,\text{mm}}{84.2\,\text{mm}}\right)$$

2.5) Shell Diameter from Percent Reduction Formula

Evaluate Formula

Formula

$$d_s = D_b \cdot \left(1 - \frac{PR_{\%}}{100}\right)$$

Example with Units

$$79.99\,\text{mm} = 84.2\,\text{mm} \cdot \left(1 - \frac{5}{100}\right)$$

3) Ironing Operation Formulas

3.1) Average of Tensile Strength before and after Ironing Formula

Evaluate Formula

Formula

$$S_{avg} = \frac{F}{\pi \cdot d_1 \cdot t_f \cdot \ln\left(\frac{t_0}{t_f}\right)}$$

Example with Units

$$0.1819\,\text{N/mm}^2 = \frac{8.01\,\text{N}}{3.1416 \cdot 2.5\,\text{mm} \cdot 13\,\text{mm} \cdot \ln\left(\frac{20.01\,\text{mm}}{13\,\text{mm}}\right)}$$

3.2) Ironing Force after Drawing Formula

Evaluate Formula

Formula

$$F = \pi \cdot d_1 \cdot t_f \cdot S_{avg} \cdot \ln\left(\frac{t_0}{t_f}\right)$$

Example with Units

$$8.0093\,\text{N} = 3.1416 \cdot 2.5\,\text{mm} \cdot 13\,\text{mm} \cdot 0.181886\,\text{N/mm}^2 \cdot \ln\left(\frac{20.01\,\text{mm}}{13\,\text{mm}}\right)$$

3.3) Mean Diameter of Shell after Ironing Formula

Evaluate Formula

Formula

$$d_1 = \frac{F}{\pi \cdot S_{avg} \cdot t_f \cdot \ln\left(\frac{t_0}{t_f}\right)}$$

Example with Units

$$2.5002\,\text{mm} = \frac{8.01\,\text{N}}{3.1416 \cdot 0.181886\,\text{N/mm}^2 \cdot 13\,\text{mm} \cdot \ln\left(\frac{20.01\,\text{mm}}{13\,\text{mm}}\right)}$$

3.4) Thickness of Shell before Ironing Formula

Evaluate Formula

Formula

$$t_0 = t_f \cdot \exp\left(\frac{F}{\pi \cdot d_1 \cdot t_f \cdot S_{avg}}\right)$$

Example with Units

$$20.0108\,\text{mm} = 13\,\text{mm} \cdot \exp\left(\frac{8.01\,\text{N}}{3.1416 \cdot 2.5\,\text{mm} \cdot 13\,\text{mm} \cdot 0.181886\,\text{N/mm}^2}\right)$$

4) Punch Operation Formulas

4.1) Blank Size when there is Corner Radius on Punch Formula

Evaluate Formula

Formula

$$d_{bl} = \sqrt{d_s^2 + 4 \cdot d_s \cdot h_{shl}} - 0.5 \cdot r_{cn}$$

Example with Units

$$84.1813\,\text{mm} = \sqrt{80\,\text{mm}^2 + 4 \cdot 80\,\text{mm} \cdot 2.15\,\text{mm}} - 0.5 \cdot 0.003001\,\text{mm}$$

4.2) Maximum Shear Force given Shear Applied to Punch or Die Formula

Evaluate Formula

Formula

$$F_s = L_{ct} \cdot t_{stk} \cdot \frac{t_{stk} \cdot p}{t_{sh}}$$

Example with Units

$$0.0156\,\mathrm{N} = 615.66\,\mathrm{m} \cdot 9\,\mathrm{mm} \cdot \frac{9\,\mathrm{mm} \cdot 0.499985\,\mathrm{mm}}{1.599984\,\mathrm{mm}}$$

4.3) Penetration of Punch as Fraction Formula

Evaluate Formula

Formula

$$p = \frac{F_s \cdot t_{sh}}{L_{ct} \cdot t_{stk}^{2}}$$

Example with Units

$$0.4996\,\mathrm{mm} = \frac{0.015571\,\mathrm{N} \cdot 1.599984\,\mathrm{mm}}{615.66\,\mathrm{m} \cdot 9\,\mathrm{mm}^{2}}$$

4.4) Perimeter of Cut when Shear is Applied Formula

Evaluate Formula

Formula

$$L_{ct} = \frac{F_s \cdot t_{sh}}{p \cdot t_{stk}^{2}}$$

Example with Units

$$615.1629\,\mathrm{m} = \frac{0.015571\,\mathrm{N} \cdot 1.599984\,\mathrm{mm}}{0.499985\,\mathrm{mm} \cdot 9\,\mathrm{mm}^{2}}$$

4.5) Punch Load Formula

Evaluate Formula

Formula

$$L_p = L_{ct} \cdot t_{bar} \cdot S_c$$

Example with Units

$$16.8306\,\mathrm{N} = 615.66\,\mathrm{m} \cdot 0.003\,\mathrm{mm} \cdot 9112.5$$

4.6) Punching Force for Holes Smaller than Sheet Thickness Formula

Evaluate Formula

Formula

$$P = \frac{d_{rm} \cdot t_b \cdot \varepsilon}{\left(\frac{d_{rm}}{t_b}\right)^{\frac{1}{3}}}$$

Example with Units

$$178.3896\,\mathrm{N} = \frac{13.3\,\mathrm{mm} \cdot 1.13\,\mathrm{mm} \cdot 27\,\mathrm{N/mm^2}}{\left(\frac{13.3\,\mathrm{mm}}{1.13\,\mathrm{mm}}\right)^{\frac{1}{3}}}$$

4.7) Shear on Punch or Die Formula

Evaluate Formula

Formula

$$t_{sh} = L_{ct} \cdot t_{stk} \cdot \frac{t_{stk} \cdot p}{F_s}$$

Example with Units

$$1.6013\,\mathrm{mm} = 615.66\,\mathrm{m} \cdot 9\,\mathrm{mm} \cdot \frac{9\,\mathrm{mm} \cdot 0.499985\,\mathrm{mm}}{0.015571\,\mathrm{N}}$$

4.8) Stock Thickness when Shear used on Punch Formula

Evaluate Formula

Formula

$$t_{stk} = \sqrt{\frac{F_s \cdot t_{sh}}{L_{ct} \cdot p}}$$

Example with Units

$$8.9964\,\mathrm{mm} = \sqrt{\frac{0.015571\,\mathrm{N} \cdot 1.599984\,\mathrm{mm}}{615.66\,\mathrm{m} \cdot 0.499985\,\mathrm{mm}}}$$

5) Stripping Operation Formulas

5.1) Perimeter of Cut given Stripper Force Formula

Evaluate Formula

Formula

$$L_{cut} = \frac{P_s}{K \cdot t_{blank}}$$

Example with Units

$$617.3526\,\text{mm} = \frac{0.000111\,\text{N}}{0.02 \cdot 8.99\,\text{mm}}$$

5.2) Stripping Force Formula

Evaluate Formula

Formula

$$P_s = K \cdot L_{cut} \cdot t_{blank}$$

Example with Units

$$0.0001\,\text{N} = 0.02 \cdot 616.6667\,\text{mm} \cdot 8.99\,\text{mm}$$

5.3) Thickness of Stock given Stripper Force Formula

Evaluate Formula

Formula

$$t_{blank} = \frac{P_s}{K \cdot L_{cut}}$$

Example with Units

$$9\,\text{mm} = \frac{0.000111\,\text{N}}{0.02 \cdot 616.6667\,\text{mm}}$$

Variables used in list of Sheet Metal Operations Formulas above

- B_{al} Bend Allowance *(Millimeter)*
- C_f Cover Friction Constant
- C_s Clearance between Two Shears *(Millimeter)*
- d_1 Mean Shell Diameter after Ironing *(Millimeter)*
- D_b Sheet Diameter *(Millimeter)*
- d_{bl} Blank Diameter *(Millimeter)*
- d_{rm} Punch or Ram Diameter *(Millimeter)*
- d_s Outer Diameter of Shell *(Millimeter)*
- F Ironing Force *(Newton)*
- F_B Bending Force *(Newton)*
- F_s Maximum Shear Force *(Newton)*
- h_{shl} Shell Height *(Millimeter)*
- K Stripping Constant
- K_{bd} Bending Die Constant
- L_b Bent Part Length *(Millimeter)*
- L_{ct} Cutting Perimeter *(Meter)*
- L_{cut} Perimeter of Cut *(Millimeter)*
- L_p Punch Load *(Newton)*
- p Punch Penetration *(Millimeter)*
- P Punching Force or Load *(Newton)*
- P_d Drawing Force *(Newton per Square Millimeter)*
- P_s Stripper Force *(Newton)*
- $PR_{\%}$ Percent Reduction after Drawing
- r_c Radius *(Millimeter)*
- r_{cn} Corner Radius on Punch *(Millimeter)*
- S_{avg} Average Tensile Strength Before & After Ironing *(Newton per Square Millimeter)*
- S_c Strength Coefficient
- t_0 Shell Thickness before Ironing *(Millimeter)*
- t_b Sheet Thickness *(Millimeter)*

Constants, Functions, Measurements used in list of Sheet Metal Operations Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **exp**, exp(Number) *n an exponential function, the value of the function changes by a constant factor for every unit change in the independent variable.*
- Functions: **ln**, ln(Number) *The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.*
- 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), Meter (m) *Length Unit Conversion*
- Measurement: **Pressure** in Newton per Square Millimeter (N/mm²) *Pressure Unit Conversion*
- Measurement: **Force** in Newton (N) *Force Unit Conversion*
- Measurement: **Angle** in Radian (rad) *Angle Unit Conversion*

- t_{bar} Bar Thickness *(Millimeter)*
- t_{blank} Blank Thickness *(Millimeter)*
- t_f Shell Thickness after Ironing *(Millimeter)*
- t_{sh} Shear on Punch *(Millimeter)*
- t_{stk} Thickness of Stock *(Millimeter)*
- **w** Width between Contact Points *(Millimeter)*
- **ε** Tensile Strength *(Newton per Square Millimeter)*
- **θ** Subtended Angle in Radians *(Radian)*
- **λ** Stretch Factor
- σ_{ut} Ultimate Tensile Strength *(Newton per Square Millimeter)*
- σ_y Yield Strength *(Newton per Square Millimeter)*
- **τ** Shear Strength of Material *(Newton per Square Millimeter)*

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