Important Laser Beam Machining (LBM) Formulas PDF

Formulas
Examples
with Units

List of 25
Important Laser Beam Machining (LBM) Formulas

1) Cutting Rate in LBM Formulas

1.1) Area of Laser Beam at Focal Point Formula

Evaluate Formula

Formula

$$A_{beam} = \frac{A_0 \cdot P_{out}}{E \cdot V_c \cdot t}$$

Example with Units

$$2.1\,\text{mm}^2 = \frac{0.408 \cdot 10.397\,\text{W}}{9.999998\,\text{W/mm}^3 \cdot 10.10\,\text{mm/min} \cdot 1.199999\,\text{m}}$$

1.2) Constant Dependent of Material Formula

Evaluate Formula

Formula

$$A_0 = V_c \cdot \frac{E \cdot A_{beam} \cdot t}{P_{out}}$$

Example with Units

$$0.408 = 10.10\,\text{mm/min} \cdot \frac{9.999998\,\text{W/mm}^3 \cdot 2.099999\,\text{mm}^2 \cdot 1.199999\,\text{m}}{10.397\,\text{W}}$$

1.3) Cutting Rate Formula

Evaluate Formula

Formula

$$V_c = \frac{A_0 \cdot P_{out}}{E \cdot A_{beam} \cdot t}$$

Example with Units

$$10.1\,\text{mm/min} = \frac{0.408 \cdot 10.397\,\text{W}}{9.999998\,\text{W/mm}^3 \cdot 2.099999\,\text{mm}^2 \cdot 1.199999\,\text{m}}$$

1.4) Laser Power Incident on Surface Formula

Evaluate Formula

Formula

$$P_{out} = V_c \cdot \frac{E \cdot A_{beam} \cdot t}{A_0}$$

Example with Units

$$10.397\,\text{W} = 10.10\,\text{mm/min} \cdot \frac{9.999998\,\text{W/mm}^3 \cdot 2.099999\,\text{mm}^2 \cdot 1.199999\,\text{m}}{0.408}$$

1.5) Thickness of Material Formula

Evaluate Formula

Formula

$$t = \frac{A_0 \cdot P_{out}}{E \cdot A_{beam} \cdot V_c}$$

Example with Units

$$1.2\,\text{m} = \frac{0.408 \cdot 10.397\,\text{W}}{9.999998\,\text{W/mm}^3 \cdot 2.099999\,\text{mm}^2 \cdot 10.10\,\text{mm/min}}$$

1.6) Vaporisation Energy of Material Formula

Evaluate Formula

Formula

$$E = \frac{A_0 \cdot P_{out}}{V_c \cdot A_{beam} \cdot t}$$

Example with Units

$$10\,\text{W/mm}^3 = \frac{0.408 \cdot 10.397\,\text{W}}{10.10\,\text{mm/min} \cdot 2.099999\,\text{mm}^2 \cdot 1.199999\,\text{m}}$$

2) Energy Requirements in LBM Formulas

2.1) Ambient Temperature during LBM Formula

Evaluate Formula

Formula

$$\theta_{ambient} = T_m - \frac{\frac{Q \cdot (1 - R)}{s \cdot V \cdot 4.2} - L_{fusion}}{c}$$

Example with Units

$$55.0196\,^\circ\text{C} = 1499.999\,^\circ\text{C} - \frac{\frac{4200\,\text{J} \cdot (1 - 0.50)}{2.4 \cdot 0.04\,\text{m}^3 \cdot 4.2} - 4599.997\,\text{J/kg}}{0.421\,\text{J/kg*°C}}$$

2.2) Energy Required to Melt Metal in LBM Formula

Evaluate Formula

Formula

$$Q = \frac{\rho_m \cdot V \cdot \left(c \cdot \left(T_m - \theta_{ambient}\right) + L_{fusion}\right)}{1 - R}$$

Example with Units

$$4199.9999\,\text{J} = \frac{10.08\,\text{kg/m}^3 \cdot 0.04\,\text{m}^3 \cdot \left(0.421\,\text{J/kg*°C} \cdot \left(1499.999\,^\circ\text{C} - 55.02\,^\circ\text{C}\right) + 4599.997\,\text{J/kg}\right)}{1 - 0.50}$$

2.3) Latent Heat of Fusion of Metal Formula

Evaluate Formula

Formula

$$L_{fusion} = \frac{Q \cdot (1 - R)}{s \cdot V \cdot 4.2} - c \cdot \left(T_m - \theta_{ambient}\right)$$

Example with Units

$$4599.9972\,\text{J/kg} = \frac{4200\,\text{J} \cdot (1 - 0.50)}{2.4 \cdot 0.04\,\text{m}^3 \cdot 4.2} - 0.421\,\text{J/kg*°C} \cdot \left(1499.999\,^\circ\text{C} - 55.02\,^\circ\text{C}\right)$$

2.4) Melting Temperature of Metal Formula

Evaluate Formula

Formula

$$T_m = \frac{\frac{Q \cdot (1 - R)}{s \cdot V \cdot 4.2} - L_{fusion}}{c} + \theta_{ambient}$$

Example with Units

$$1499.9994\,°C = \frac{\frac{4200\,J \cdot (1 - 0.50)}{2.4 \cdot 0.04\,m^3 \cdot 4.2} - 4599.997\,J/kg}{0.421\,J/kg*°C} + 55.02\,°C$$

2.5) Reflectivity of Material Formula

Evaluate Formula

Formula

$$R = 1 - \frac{s \cdot V \cdot \left(c \cdot \left(T_m - \theta_{ambient}\right) + L_{fusion}\right) \cdot 4.2}{Q}$$

Example with Units

$$0.5 = 1 - \frac{2.4 \cdot 0.04\,m^3 \cdot \left(0.421\,J/kg*°C \cdot \left(1499.999\,°C - 55.02\,°C\right) + 4599.997\,J/kg\right) \cdot 4.2}{4200\,J}$$

2.6) Specific Gravity of given Metal Formula

Evaluate Formula

Formula

$$s = \frac{Q \cdot (1 - R)}{V \cdot \left(c \cdot \left(T_m - \theta_{ambient}\right) + L_{fusion}\right) \cdot 4.2}$$

Example with Units

$$2.4 = \frac{4200\,J \cdot (1 - 0.50)}{0.04\,m^3 \cdot \left(0.421\,J/kg*°C \cdot \left(1499.999\,°C - 55.02\,°C\right) + 4599.997\,J/kg\right) \cdot 4.2}$$

2.7) Specific Heat Capacity of Metal Formula

Evaluate Formula

Formula

$$c = \frac{\frac{Q \cdot (1 - R)}{s \cdot V \cdot 4.2} - L_{fusion}}{T_m - \theta_{ambient}}$$

Example with Units

$$0.421\,J/kg*°C = \frac{\frac{4200\,J \cdot (1 - 0.50)}{2.4 \cdot 0.04\,m^3 \cdot 4.2} - 4599.997\,J/kg}{1499.999\,°C - 55.02\,°C}$$

2.8) Volume of Metal Melted Formula

Evaluate Formula

Formula

$$V = \frac{Q \cdot (1 - R)}{s \cdot \left(c \cdot \left(T_m - \theta_{ambient}\right) + L_{fusion}\right) \cdot 4.2}$$

Example with Units

$$0.04\,\text{m}^3 = \frac{4200\,\text{J} \cdot (1 - 0.50)}{2.4 \cdot \left(0.421\,\text{J/kg*°C} \cdot \left(1499.999\,\text{°C} - 55.02\,\text{°C}\right) + 4599.997\,\text{J/kg}\right) \cdot 4.2}$$

3) Metal Diffusivity Formulas

3.1) Diffusivity of Metal Formula

Evaluate Formula

Formula

$$D = \frac{0.38 \cdot t^2}{\Delta T}$$

Example with Units

$$0.0536\,\text{m}^2\text{/s} = \frac{0.38 \cdot 1.199999\,\text{m}^2}{10.20\,\text{s}}$$

3.2) Minimum Thickness of Metal Formula

Evaluate Formula

Formula

$$t = \sqrt{\frac{D \cdot \Delta T}{0.38}}$$

Example with Units

$$1.2\,\text{m} = \sqrt{\frac{0.053647\,\text{m}^2\text{/s} \cdot 10.20\,\text{s}}{0.38}}$$

3.3) Time Duration of Laser Beam Formula

Evaluate Formula

Formula

$$\Delta T = \frac{0.38 \cdot t^2}{D}$$

Example with Units

$$10.2\,\text{s} = \frac{0.38 \cdot 1.199999\,\text{m}^2}{0.053647\,\text{m}^2\text{/s}}$$

4) Power Density of Laser Beam Formulas

4.1) Beam Divergence Formula

Evaluate Formula

Formula

$$\alpha = \sqrt{\frac{4 \cdot P}{\pi \cdot f_{lens}^2 \cdot \delta_p \cdot \Delta T}}$$

Example with Units

$$0.0012\,\text{rad} = \sqrt{\frac{4 \cdot 10.39\,\text{W}}{3.1416 \cdot 3.00\,\text{m}^2 \cdot 9.49\,\text{W/cm}^2 \cdot 10.20\,\text{s}}}$$

4.2) Beam Divergence given Diameter of Spot Formula

Evaluate Formula

Formula

$$\alpha = \frac{d_{spot}}{f_{lens}}$$

Example with Units

$$0.0012\,\text{rad} = \frac{0.0037\,\text{m}}{3.00\,\text{m}}$$

4.3) Diameter of Spot Produced by Laser Formula

Evaluate Formula

Formula

$$d_{spot} = f_{lens} \cdot \alpha$$

Example with Units

$$0.0037\,\text{m} = 3.00\,\text{m} \cdot 0.001232\,\text{rad}$$

4.4) Focal Length given Diameter of Spot Formula

Evaluate Formula

Formula

$$f_{lens} = \frac{d_{spot}}{\alpha}$$

Example with Units

$$3.0032\,\text{m} = \frac{0.0037\,\text{m}}{0.001232\,\text{rad}}$$

4.5) Focal Length of Lens Formula

Evaluate Formula

Formula

$$f_{lens} = \sqrt{\frac{4 \cdot P}{\pi \cdot \delta_p \cdot \alpha^2 \cdot \Delta T}}$$

Example with Units

$$3.0007\,\text{m} = \sqrt{\frac{4 \cdot 10.39\,\text{W}}{3.1416 \cdot 9.49\,\text{W/cm}^2 \cdot 0.001232\,\text{rad}^2 \cdot 10.20\,\text{s}}}$$

4.6) Laser Energy Output Formula

Evaluate Formula

Formula

$$P = \frac{\delta_p \cdot \pi \cdot f_{lens}^2 \cdot \alpha^2 \cdot \Delta T}{4}$$

Example with Units

$$10.3853\,\text{W} = \frac{9.49\,\text{W/cm}^2 \cdot 3.1416 \cdot 3.00\,\text{m}^2 \cdot 0.001232\,\text{rad}^2 \cdot 10.20\,\text{s}}{4}$$

4.7) Power Density of Laser Beam Formula

Evaluate Formula

Formula

$$\delta_p = \frac{4 \cdot P}{\pi \cdot f_{lens}^2 \cdot \alpha^2 \cdot \Delta T}$$

Example with Units

$$9.4943\,\text{W/cm}^2 = \frac{4 \cdot 10.39\,\text{W}}{3.1416 \cdot 3.00\,\text{m}^2 \cdot 0.001232\,\text{rad}^2 \cdot 10.20\,\text{s}}$$

4.8) Pulse Duration of Laser Formula

Evaluate Formula

Formula

$$\Delta T = \frac{4 \cdot P}{\pi \cdot f_{lens}^2 \cdot \alpha^2 \cdot \delta_p}$$

Example with Units

$$10.2046\,\text{s} = \frac{4 \cdot 10.39\,\text{W}}{3.1416 \cdot 3.00\,\text{m}^2 \cdot 0.001232\,\text{rad}^2 \cdot 9.49\,\text{W/cm}^2}$$

Variables used in list of Laser Beam Machining (LBM) Formulas above

- A_0 Empirical Constant
- A_{beam} Laser Beam Area at Focal Point *(Square Millimeter)*
- **c** Specific Heat Capacity *(Joule per Kilogram per Celcius)*
- **D** Metal Diffusivity *(Square Meter Per Second)*
- d_{spot} Spot Diameter *(Meter)*
- **E** Vaporisation Energy of Material *(Watt Per Cubic Millimeter)*
- f_{lens} Focal Length of Lens *(Meter)*
- L_{fusion} Latent Heat of Fusion *(Joule per Kilogram)*
- **P** Laser Energy Output *(Watt)*
- P_{out} Laser Energy during Cut Rate *(Watt)*
- **Q** Heat Energy *(Joule)*
- **R** Material Reflectivity
- **s** Specific Gravity of Material
- **t** Thickness *(Meter)*
- T_m Melting Temperature of Base Metal *(Celsius)*
- **V** Volume of Metal Melted *(Cubic Meter)*
- V_c Cutting Rate *(Millimeter per Minute)*
- **α** Beam Divergence *(Radian)*
- δ_p Power Density of Laser Beam *(Watt per Square Centimeter)*
- **ΔT** Laser Beam Duration *(Second)*
- $\theta_{ambient}$ Ambient Temperature *(Celsius)*
- ρ_m Metal Density *(Kilogram per Cubic Meter)*

Constants, Functions, Measurements used in list of Laser Beam Machining (LBM) Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- 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 Meter (m) *Length Unit Conversion*
- Measurement: **Time** in Second (s) *Time Unit Conversion*
- Measurement: **Temperature** in Celsius (°C) *Temperature Unit Conversion*
- Measurement: **Volume** in Cubic Meter (m³) *Volume Unit Conversion*
- Measurement: **Area** in Square Millimeter (mm²) *Area Unit Conversion*
- Measurement: **Speed** in Millimeter per Minute (mm/min) *Speed Unit Conversion*
- Measurement: **Energy** in Joule (J) *Energy Unit Conversion*
- Measurement: **Power** in Watt (W) *Power Unit Conversion*
- Measurement: **Angle** in Radian (rad) *Angle Unit Conversion*
- Measurement: **Specific Heat Capacity** in Joule per Kilogram per Celcius (J/kg*°C) *Specific Heat Capacity Unit Conversion*
- Measurement: **Heat Flux Density** in Watt per Square Centimeter (W/cm²) *Heat Flux Density Unit Conversion*
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³) *Density Unit Conversion*
- Measurement: **Latent Heat** in Joule per Kilogram (J/kg) *Latent Heat Unit Conversion*

- Measurement: **Power Density** in Watt Per Cubic Millimeter (W/mm³)
  Power Density Unit Conversion
- Measurement: **Diffusivity** in Square Meter Per Second (m²/s)
  Diffusivity Unit Conversion

Download other Important Unconventional machining processes PDFs

- **Important Laser Beam Machining (LBM) Formulas**

Try our Unique Visual Calculators

- **Percentage growth**
- **LCM calculator**
- **Divide fraction**

Please SHARE this PDF with someone who needs it!

This PDF can be downloaded in these languages

English Spanish French German Russian Italian Portuguese Polish Dutch

7/8/2024 | 9:20:00 AM UTC