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Laser Beam Machining (LBM) Formulas

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List of 25 Laser Beam Machining (LBM) Formulas

Laser Beam Machining (LBM)

Cutting Rate in LBM

1) Area of Laser Beam at Focal Point

Open Calculator

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

$$2.09999\text{mm}^2 = \frac{0.408 \cdot 10.397\text{W}}{9.999998\text{W/mm}^3 \cdot 10.10\text{mm/min} \cdot 1.199999\text{m}}$$

2) Constant Dependent of Material

Open Calculator

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

$$0.408002 = 10.10\text{mm/min} \cdot \frac{9.999998\text{W/mm}^3 \cdot 2.099999\text{mm}^2 \cdot 1.199999\text{m}}{10.397\text{W}}$$

3) Cutting Rate

Open Calculator

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

$$10.09996\text{mm/min} = \frac{0.408 \cdot 10.397\text{W}}{9.999998\text{W/mm}^3 \cdot 2.099999\text{mm}^2 \cdot 1.199999\text{m}}$$

4) Laser Power Incident on Surface

Open Calculator

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

$$10.39704\text{W} = 10.10\text{mm/min} \cdot \frac{9.999998\text{W/mm}^3 \cdot 2.099999\text{mm}^2 \cdot 1.199999\text{m}}{0.408}$$

5) Thickness of Material

Open Calculator

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

ex $$1.199994\text{m} = \frac{0.408 \cdot 10.397\text{W}}{9.999998\text{W/mm}^3 \cdot 2.099999\text{mm}^2 \cdot 10.10\text{mm/min}}$$

6) Vaporisation Energy of Material

Open Calculator

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

ex $$9.999957\text{W/mm}^3 = \frac{0.408 \cdot 10.397\text{W}}{10.10\text{mm/min} \cdot 2.099999\text{mm}^2 \cdot 1.199999\text{m}}$$

Energy Requirements in LBM

7) Ambient Temperature during LBM

Open Calculator

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

ex $$55.01959^\circ\text{C} = 1499.999^\circ\text{C} - \frac{\frac{4200\text{J} \cdot (1-0.50)}{2.4 \cdot 0.04\text{m}^3 \cdot 4.2} - 4599.997\text{J/kg}}{0.421\text{J/kg*}^\circ\text{C}}$$

8) Energy Required to Melt Metal in LBM

Open Calculator

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

ex $$4200\text{J} = \frac{10.08\text{kg/m}^3 \cdot 0.04\text{m}^3 \cdot (0.421\text{J/kg*}^\circ\text{C} \cdot (1499.999^\circ\text{C} - 55.02^\circ\text{C}) + 4599.997\text{J/kg})}{1 - 0.50}$$

9) Latent Heat of Fusion of Metal

Open Calculator

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

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

10) Melting Temperature of Metal

Open Calculator

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

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

11) Reflectivity of Material

Open Calculator

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

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

12) Specific Gravity of given Metal

Open Calculator

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

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

13) Specific Heat Capacity of Metal

Open Calculator

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

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

14) Volume of Metal Melted

Open Calculator

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

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

Metal Diffusivity

15) Diffusivity of Metal

Open Calculator

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

$$0.053647 m^2/s = \frac{0.38 \cdot (1.199999 m)^2}{10.20 s}$$

16) Minimum Thickness of Metal

Open Calculator

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

$$1.199999 m = \sqrt{\frac{0.053647 m^2/s \cdot 10.20 s}{0.38}}$$

17) Time Duration of Laser Beam

Open Calculator

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

$$10.19999\text{s} = \frac{0.38 \cdot (1.199999\text{m})^2}{0.053647\text{m}^2/\text{s}}$$

Power Density of Laser Beam

18) Beam Divergence

Open Calculator

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

$$0.001232\text{rad} = \sqrt{\frac{4 \cdot 10.39\text{W}}{\pi \cdot (3.00\text{m})^2 \cdot 9.49\text{W/cm}^2 \cdot 10.20\text{s}}}$$

19) Beam Divergence given Diameter of Spot

Open Calculator

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

$$0.001233\text{rad} = \frac{0.0037\text{m}}{3.00\text{m}}$$

20) Diameter of Spot Produced by Laser

Open Calculator

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

$$0.003696\text{m} = 3.00\text{m} \cdot 0.001232\text{rad}$$

21) Focal Length given Diameter of Spot

Open Calculator

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

$$3.003247\text{m} = \frac{0.0037\text{m}}{0.001232\text{rad}}$$

22) Focal Length of Lens

Open Calculator

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

$$3.000675\text{m} = \sqrt{\frac{4 \cdot 10.39\text{W}}{\pi \cdot 9.49\text{W/cm}^2 \cdot (0.001232\text{rad})^2 \cdot 10.20\text{s}}}$$

23) Laser Energy Output

Open Calculator

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

$$10.38533\text{W} = \frac{9.49\text{W/cm}^2 \cdot \pi \cdot (3.00\text{m})^2 \cdot (0.001232\text{rad})^2 \cdot 10.20\text{s}}{4}$$

24) Power Density of Laser Beam

Open Calculator

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

$$9.49427\text{W/cm}^2 = \frac{4 \cdot 10.39\text{W}}{\pi \cdot (3.00\text{m})^2 \cdot (0.001232\text{rad})^2 \cdot 10.20\text{s}}$$

25) Pulse Duration of Laser

Open Calculator

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

$$10.20459\text{s} = \frac{4 \cdot 10.39\text{W}}{\pi \cdot (3.00\text{m})^2 \cdot (0.001232\text{rad})^2 \cdot 9.49\text{W/cm}^2}$$

Variables Used

- 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

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Function: **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 (m^3)
  Volume Unit Conversion
- Measurement: **Area** in Square Millimeter (mm^2)
  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/cm^2)
  Heat Flux Density Unit Conversion
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m^3)
  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/mm^3)
  Power Density Unit Conversion

- Measurement: **Diffusivity** in Square Meter Per Second (m²/s)
  Diffusivity Unit Conversion

Check other formula lists

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

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