University of technology
Laser and optoelectronics eng. Dept.

LASER APPLICATION COURSE
4^{TH} YEAR
LEC.6

LASER CUTTING

- Industrial laser cutting is done with CW or pulsed CO_2 & high-repetition pulsed Nd-YAG lasers. The processes is a gas-assist technique in which, under pressure, forces molten from the Kerf , Oxygen is used with oxidizable material to increase cutting speed

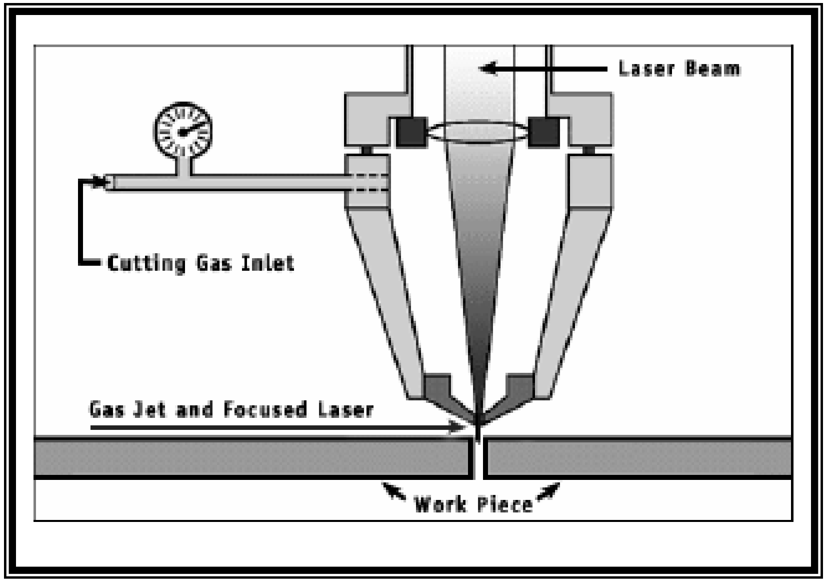


Figure 2.1 Laser cutting

- ***Advantage*[2]**
- Ease of automation. سهولة الأتمتة (تشغيل الجهاز أوتوماتيكياً)
- Small **H**eat **A**ffect **Z**one (***HAZ***). صغر حجم المساحة المتعرضة للحرارة
- Narrow & high-precision Kerf. القطع ضيق وبالغ الدقة
- Frequently higher speed than other methods. القطع بالليزر أسرع من الطرق الأخرى
- When the laser beam is focused on the material, the speed of cutting will be:

$$V_C = \frac{dH}{Z\rho(CT_V + L_V)} \quad \text{..(2.5)}$$

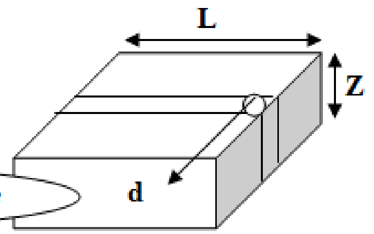
- Where:
- ***: Cutting Speed (mm/s).***
- ***d: Focused beam diameter (mm).***
- ***H: Heat flow or Intensity (w/m²).***
- ***Z: Cutting depth (mm) or thickness.***
- ***: Density (kg/m³).***
- ***C: Specific heat capacity (Jkg⁻¹.k⁻¹).***
- ***T_V: Boiling point (k).***
- ***L_V: Latent heat of vaporization (J.kg⁻¹).***

- Most materials can be readily cut using a CO_2 laser with the exception of those such as brass, copper & aluminum which have high reflectance at 10.6 μm. However, since the reflectances are much lower at 1.06 μm ***Nd:YAG*** lasers can be used instead[4].
- ***Question: Proof*** that cutting speed (V_c) equal to:

$$V_C = \frac{dH}{Z\rho(CT_V + L_V)}$$

Answer:

By assuming that the ***cutting is a limited number of drilling***, from the figure below we get:



L: Cutting length

d: Drilling or focused diameter

t_d: Drilling time

t_C: Cutting time

n: number of holes

Speed = displacement / time

$$t_C = n t_d \quad \text{...(1)}$$

$$V_C = \frac{L}{t_C} \quad \text{...(2)}$$

From (1 & 2) $$t_d = \frac{L}{n V_C} \quad \text{...(3)}$$

$$V_P = \frac{Z}{t_d} \quad \text{...(4)}$$

From (3 & 4) $$V_C = \frac{L}{n}\frac{V_P}{Z} \quad \text{...(5)}$$

Cutting length = n × Drilling diameter

$$L = nd \quad \text{...(6)}$$

From (5 & 6) $$V_C = \frac{d V_P}{Z} \quad \text{...(7)}$$

Penetration Speed $$V_P = \frac{H}{\rho(C T_V + L_V)} \quad \text{...(8)}$$

From (7 & 8) $$V_C = \frac{dH}{Z\rho(C T_V + L_V)}$$

*****The end*****

Example-7:

As an example of metal for which we have the required thermal constant:

$C = 435$ $L_V = 6.8x10^6$ $\rho = 7870$ $T_V = 316$

And we suppose the laser beam to have a power of (1 Kw) and to be focused down to a spot diameter of (0.25 mm). ***Find the cutting speed*** at thickness of (2.5 mm).

Solution:

$$H = \frac{P}{A} = \frac{P}{\pi r^2} = \frac{1\times 10^3}{\pi(\frac{0.25}{2}\times 10^{-3})^2} = 2\times 10^{10} \quad \textit{(w/m}^2\textit{)}$$

$$V_P = \frac{H}{\rho(CT_V + L_V)} = \frac{2\times 10^{10}}{7870(435\times 316 + 6.8\times 10^6)} = 366 \quad \textit{(mm/s)}$$

$$V_C = \frac{dV_P}{Z} = \frac{0.25\times 310}{2.5} = 36.6 \quad \textit{(mm/s)}$$