DVS SLV HALLE

RESEARCH AND DEVELOPMENT

REDCOFAL

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Development of a descriptive model and a user-oriented manual for the exchange of laser sources for laser beam welding of metallic materials

Motivation

- CO_2-lasers will be substituted by solid state lasers like fiber lasers for welding of metallic materials.
- Reasons:
  - higher power efficiency
  - compact lasers sources with low maintenance effort
  - increased absorption in metallic materials
  - simple beam guiding with optical fiber cables
- Retrofitting of laser machines → Task for operators:

constant welding task	⟷ parameter transfer	changed circumstances
material joint type welding position welding seam geometry	welding velocity laser power focal position	wavelength absorption laser beam quality focussing intensity profile

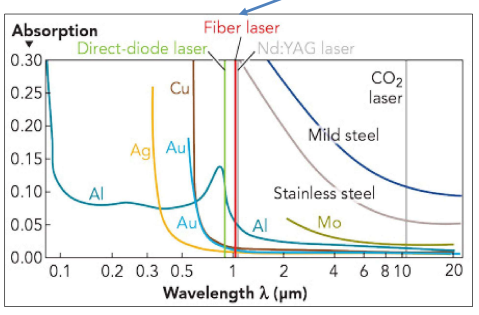
- **Aim: Algorithm for a simple parameter transfer for the laser deep welding with high power lasers in cw-mode**

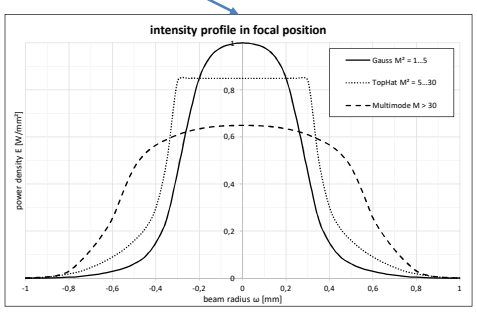
Implementation

TRUMPF · FEHA LASERTEC · rofin · IPG LASER · laserline

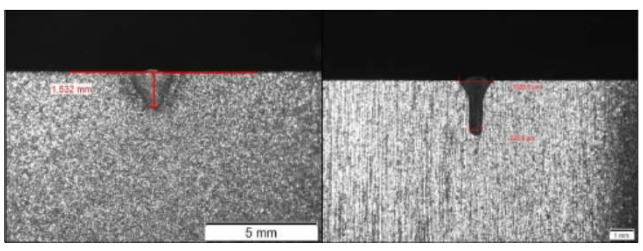
- Beam quality measurements of different laser sources regarding EN ISO 11146-1:2005 by using renowned technology:
  - PRIMES FocusMonitor FM+
  - PRIMES PowerMonitor PM
- Focussing of real laser beams:

$$2\omega_0 = \frac{2 \cdot \lambda \cdot f'}{\pi \cdot 2\omega_L} \cdot M^2$$





- Welding tests in mild steel (1.0038) and stainless steel (1.4571)
- Macro-sections → seam width b and depth t



Results

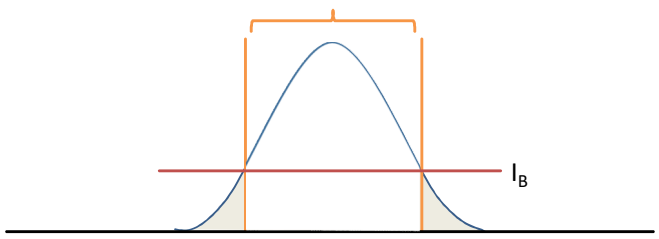
- Mathematical description of laser beam profiles by using Origin Pro software

$$y = A \cdot \frac{1}{1 + e^{-\frac{x + \frac{w_1}{2}}{w_2}}} \cdot \left(1 - \frac{1}{1 + e^{-\frac{x - \frac{w_1}{2}}{w_3}}}\right)$$

- Approach for use of the intensity profiles:
  - from Hügel & Graf: “Laser in der Fertigung”
  - vaporization temperature T_B in the center of the laser beam
  - effective beam diameter on the surface d_f
  - threshold intensity I_B
  - absorption coefficient A
  - thermal conductivity λ_{th}

$$I_B = \frac{T_B \cdot \lambda_{th}}{A \cdot d_f} \cdot \sqrt{\frac{32}{\pi}}$$

- Integration of the usable laser power P_{Nutz} within the lateral borders



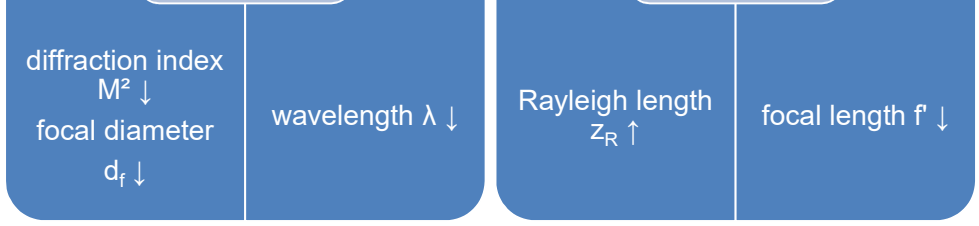
- Definition of deep welding efficiency η

$$\eta = \frac{P_{Nutz}}{P}$$

- 1st algorithm to determine the beam welding efficiency η
  - generation of a steady course y = f(A,T_B,λ_{th},M^2,d_f,λ) by using proportionalities (auxiliary quantity)
  - deduction of function to describe η(y)

$$y = \sqrt{\frac{A \cdot 10^9}{T_B \cdot \sqrt[6]{\lambda_{th}} \cdot \lambda \cdot M^2 \cdot d_f}}$$

$$\eta = -0{,}356 \cdot y^2 + 1{,}3953 \cdot y - 0{,}37935$$



- 2nd algorithm to determine the weld seam geometry
  - generation of a steady course x = f(v,PNutz,zR,f') by using proportionalities (auxiliary quantity)
  - deduction of functions to describe b(x) und t(x)

$$x = \frac{P_{Nutz}}{v} \cdot e^{\frac{z_R^2}{f'}}$$

$$b = 0{,}495 \cdot \ln(x) - 0{,}45125$$

$$t = 0{,}9183 \cdot e^{0{,}0255 \cdot x}$$

- Tolerances for quantities: η ± 0,1, t ± 0,5 mm, b ± 0,3 mm
- Validity limits of the algorithm at bad beam quality M^2 > 60 or beam parameter product BPP > 25