The Right Laser For The Right Application

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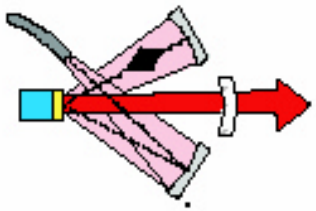
Content

- State of the Art of CO_2, Nd:YAG, Diode and Fiber Laser
- Features and Costs of Each Laser System
- Application Guides the Laser of Choice
- Production and Management Specify the Laser
- Case Studies for Successful Laser Integration

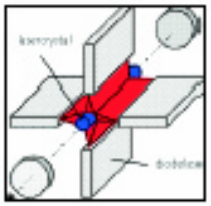
Finding the key to fit the lock

Application Defines Beam Quality

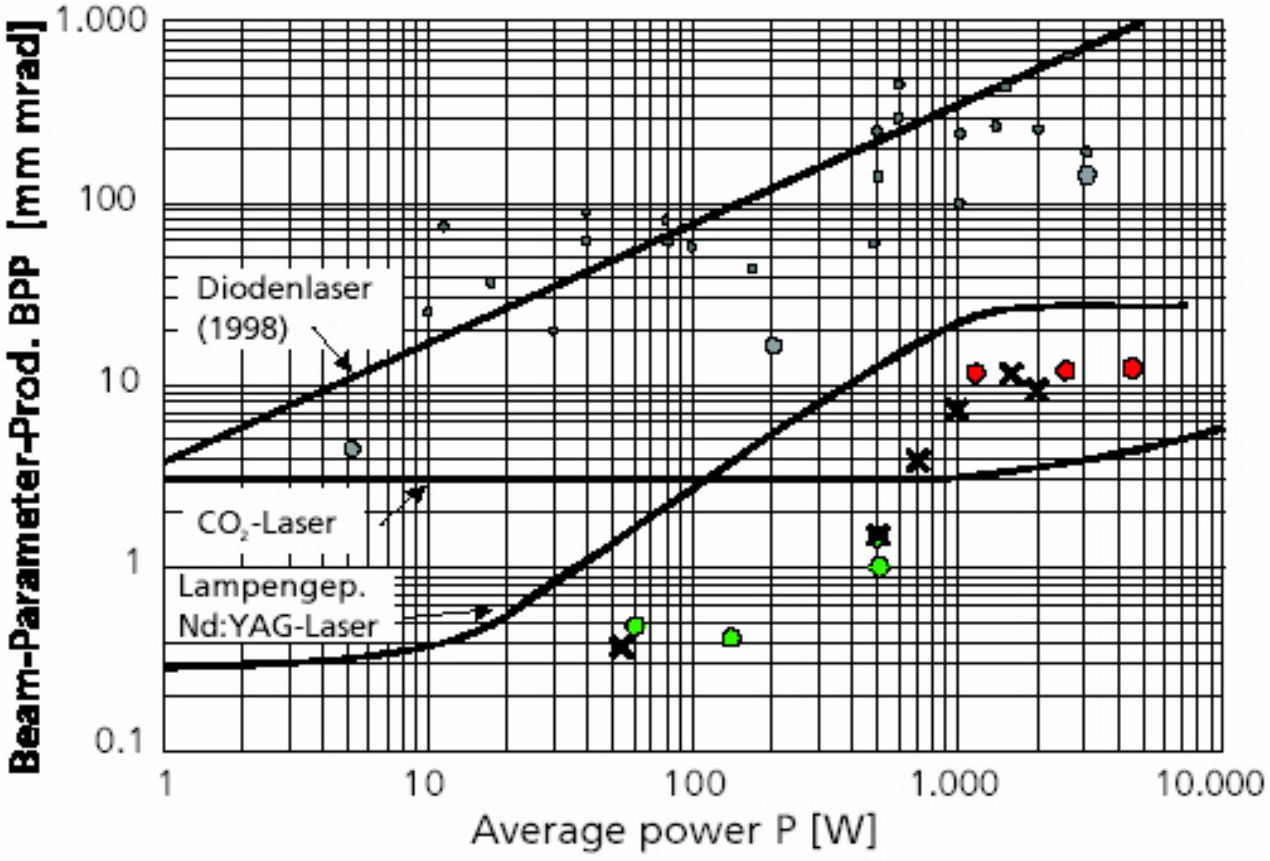
INNOSLAB



Disc Laser



Rod Laser



Source: Fraunhofer ILT

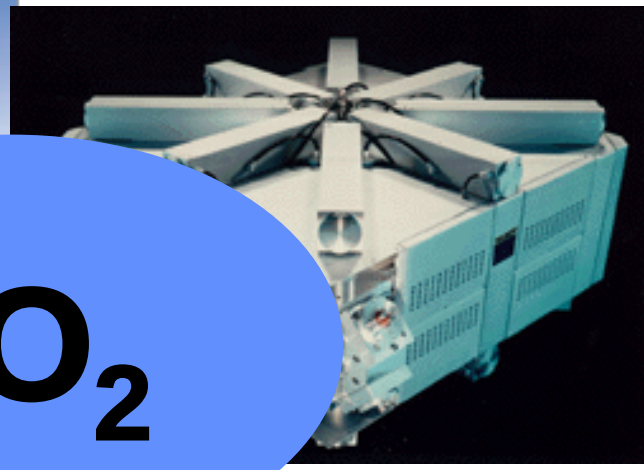
Characteristics of Different Lasers

	CO2	Nd:YAG	Fiber Laser	Diode Laser
Capital [$ / W]	40 - 80	120 - 400	120 - 500	10 - 140
Hourly Cost (4 kW, 4,000 hrs)	$5	$10 - $15	$2	$2
Maintenance Cycle	1,000 hrs	1,000 hrs	> 20,000 hrs	10,000 hrs
Footprint	20 cft	20 cft	5 cft	4 cft
Wall Plug Efficiency	10%	2 % to 10%	20%	25%
Average Power Density	10 MW/cm2	10 MW/cm2	100 MW/cm2	0.1 MW/cm2
Wavelength	10 μm	1 μm	1 μm to 2μm	0.9 μm
Beam Guidance	Mirror	Fiber	Fiber	Fiber / Integrated

Absorptivity

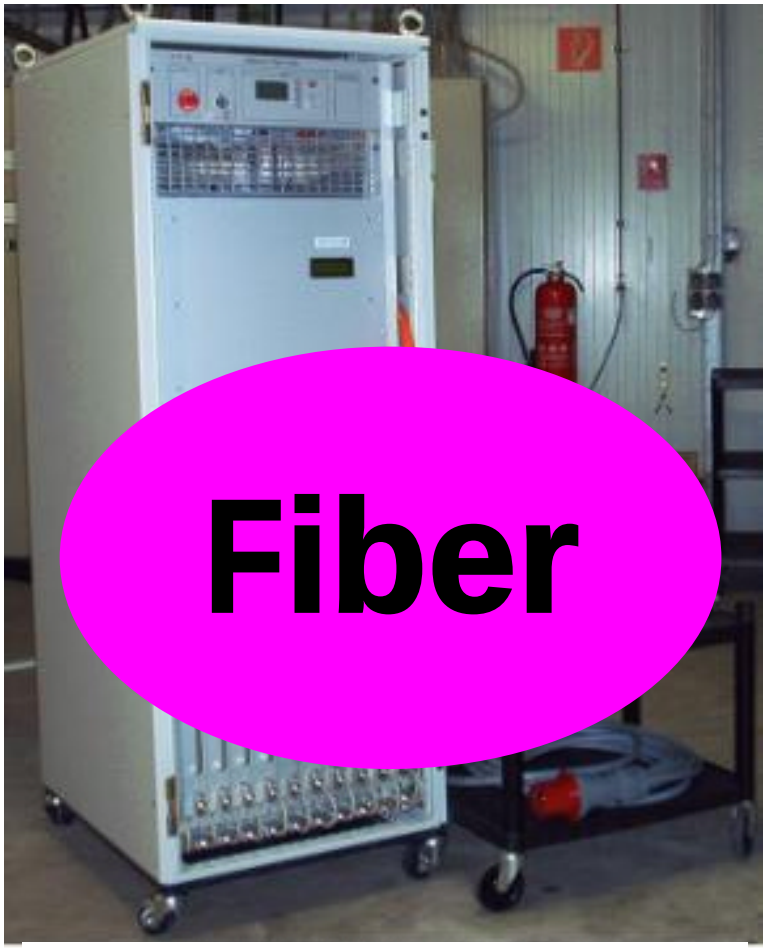
Metal	8%	20%	20%	25%
Glass	100%	0%	0%	0%
Composites	100%	50%	50%	50%

Representative Industrial Lasers



CO_2

Representative Next Generation Lasers



Courtesy of IPG Photonics
2 kW air cooled fiber laser system

4 kW
line focus

500W
Fiber coupled

Courtesy of Visotek

Perspective of Engineering I

Laser parameters are defined by the application

• Part Design	Is it laser weldable?
• **Output Power:**	**Watt to kilowatt**
• **Mode of Operation:**	**Pulsed or continuous**
• **Wavelength:**	**0.3 μm to 10 μm**
• **Beam Quality:**	**5 mm*mrad to ?? mm*mrad**
• **Focusing Optic:**	**50 mm to 250 mm**
• **Spot Size:**	**10 μm to 1,000 μm**
• **Intensity Profile:**	**Top hat, Gaussian or custom**

Impact of Laser Parameters

- **Output Power:** Feed rate and penetration depth
- **Mode of Operation:** - Continuous for welding & cutting
  - Pulsed for cutting & drilling
- **Wavelength:** Material and plasma plume
- **Beam Quality:** Focusing optic
- **Focusing Optic:** - Spot size, stand off & tolerance in focal posit.
  - Raleigh length / processing depth
- **Spot Size:** - Intensity
  - width of treated area
- **Intensity Profile:** - Interface width and integrity
  - Strength (width) and fatigue (shape)
  - Fit-up tolerances

Perspective of Engineering II

Auxiliary components are defined by the manufacturing process

- **Beam Switching:**
  - **None**
  - **Sharing of time or energy**
- **Beam Delivery:** **Fiber or hard optic**
- **Focusing Optic:** **Remote – scanner – flying optic**
- **Tooling:** **Flexible or part dedicated**
- **Assist Gas:** **Yes or No**
- **Quality Monitoring:** **Real time process monitor**
- **Hybrid Processes**
  - **Cold & hot wire feed**
  - **Plasma plus laser**
  - **GMAW plus laser**

Impact of Auxiliary Components

- **Beam Switching:**
  - Single or multiple work stations
  - Single joint or multiple joints per part
- **Beam Delivery:**
  - Intensity profile in spot
  - Flexibility in shape & number of welds
- **Focusing Optic:** Remote – scanner – flying optic
- **Tooling:**
  - flexible or part dedicated
  - Tolerances and force
- **Assist Gas:** Prevention of Oxidation
- **Quality Monitor:**
  - Quality control procedure
- **Hybrid Processes**
  - Metallurgy & geometry of weld nugget
  - strength and fatigue
  - Fit-up tolerance

Perspective of Production

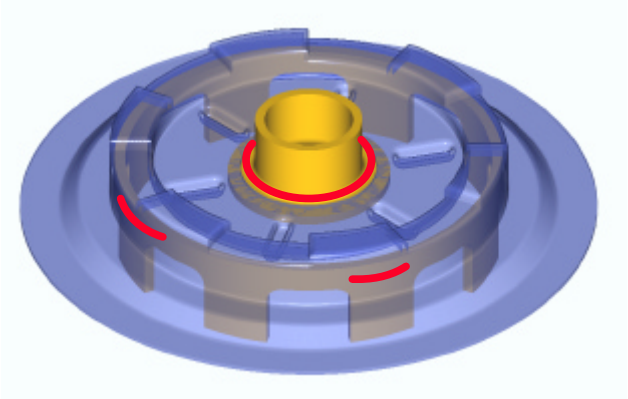
- Work Flow:
  - Number of stations
  - Number of operators
- Throughput:
  - Cycle time
  - Load / unload cycle (beam sharing for multiple stations)
  - High machine uptime
- Maintenance:
  - How much and what skill level?
- Quality Monitoring:
  - Reliable real-time device
  - Consistent and superior quality
  - Reduced destructive testing, PM and part testing
  - Data management
- Laser Safety: Plexiglas (CO_2) vs. light tight enclosure (Nd:YAG)
- Technology: Familiarity to leapfrog

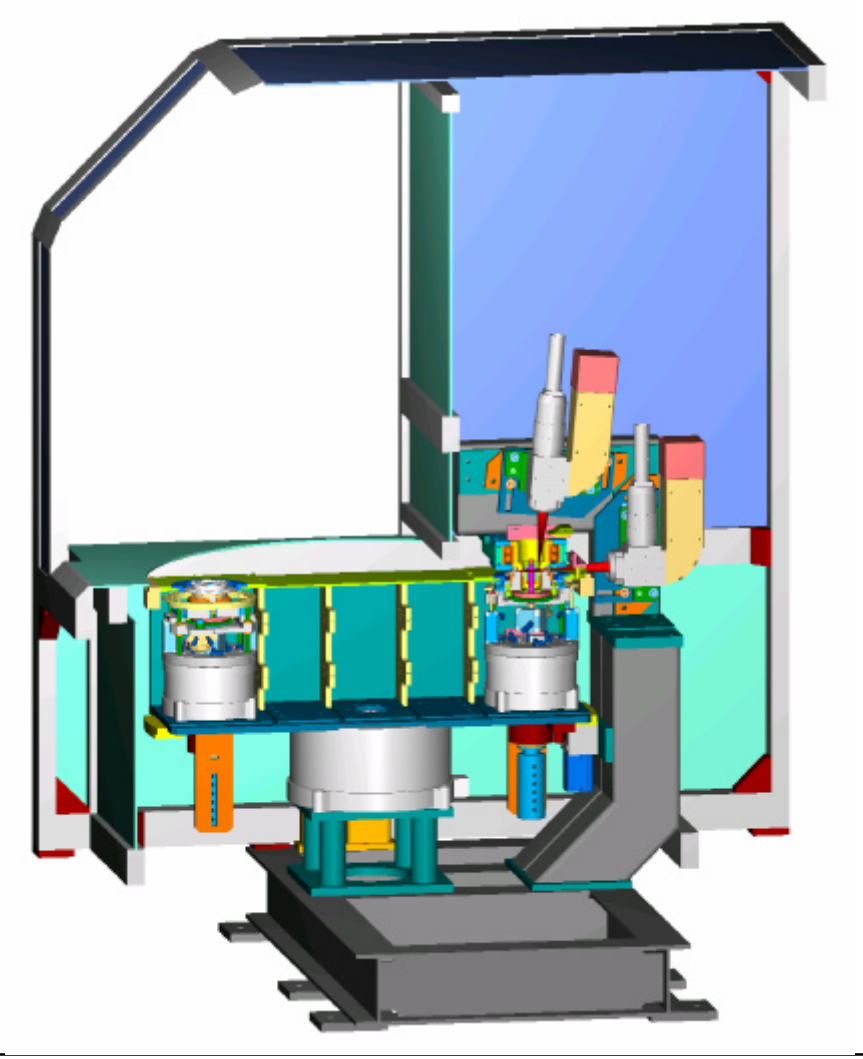
Perspective of Management

Management determines cost target

- ROI:
  - Capital
  - Tooling
  - Variable cost (electricity, gases, etc.)
  - Floorspace
- Secondary ROI:
  - Part consolidation
  - Leaner manufacturing process
- Equipment: retrofit or all-new
- Technology: Familiarity to leapfrog

Electronic Fan Clutch





Perspective of Engineering I – Fan Clutch

- Design — Part designed for laser welding
- **Output Power: 1.5 kW**
  - **Feed rate to meet cycle time**
  - **Penetration depth not critical**
- **Mode of Operat.:** — **Continuous and long pulses**
- **Wavelength: Nd:YAG**
  - **Material not critical**
  - **Control of plasma plume without assist gas**
- **Focusing Optic:**
  - **Spot size must be large to meet fatigue requirements**
  - **Stand off must be >200mm due to accessibility**
  - **Tolerance in focal position & processing depth uncritical**
- **Intensity Profile:**
  - **Top hat for uniform interface width**
  - **Interface width maximum for high fatigue (shape)**
  - **Strength (width) & fit-up tolerances not critical**

Perspective of Engineering II – Fan Clutch

- **Beam Switching:** **Yes**
  - Single work station meets cycle time (14 sec)
  - Multiple joints per part
- **Beam Delivery:** **Fiber**
  - Intensity profile in spot should be top hat
  - Flexibility in shape & number of welds (2)
- **Focusing Optic:**
  - Remote – scanner – flying optic (stationary)
- **Tooling:**
  - flexible or part dedicated
  - Tolerances (tight) and force
- **Assist Gas:**
  - Prevention of Oxidation (not critical)
  - Eliminated for cost reasons
- **Quality Monitor:**
  - Real time (quantity of parts)
  - Back tracing of parts
- **Hybrid Processes** No

Perspective of Production – Fan Clutch

- Work Flow: - Number of stations / operators: 1
- Throughput:
  - Cycle time: 14 sec
  - Load / unload cycle (beam sharing for multiple stations): no
  - High machine uptime: >97%
- Maintenance: - How much and what skill level?
- Quality Monitoring:
  - Reliable real-time device
  - Consistent and superior quality
  - Reduced destructive testing, PM and part testing
  - Data management
  - Back up PM
- Laser Safety: Plexiglas vs. light tight enclosure (small part)
- Technology: Familiarity to leapfrog

Laser Welding of Powertrain Components I

Requirements:

- Maximum torsional stiffness
  → tubular design
- High wear resistance
  → hardenable steel
- High fatigue strength
  → Mn alloyed tube steel
- Crack-free welds of
  - heat treatable steels
  - quenched annealed components
  - induction hardened components
  - case-hardened components
  - cast iron / steel joints

Source: Fraunhofer IWS

Laser Welding of Powertrain Components II

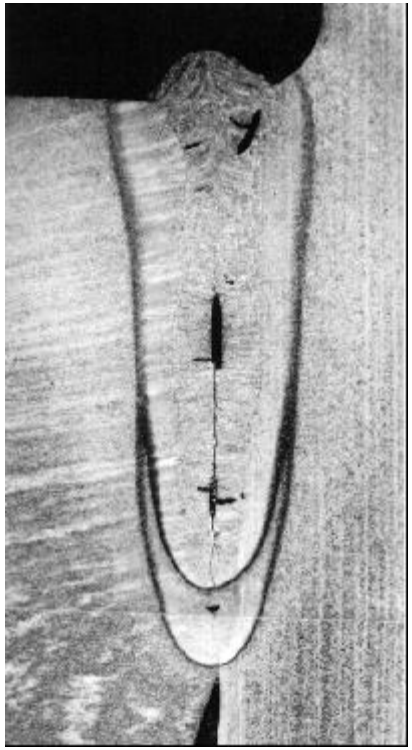
Solution:

- Hybrid Laser Welding
  - Induction assisted
  - Filler wire
- Synchronized welding and heat-treatment cycle

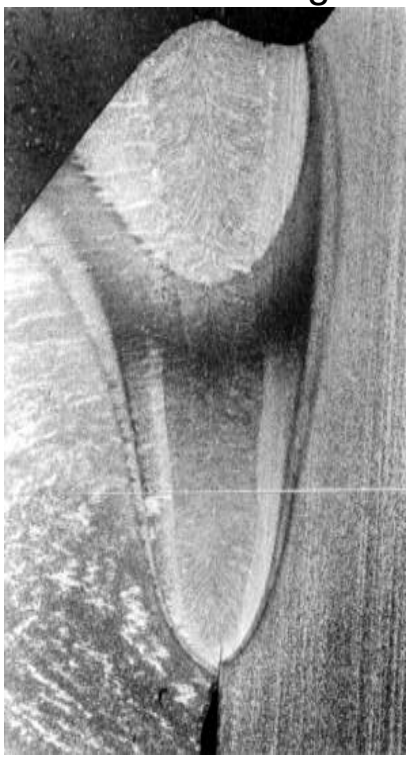
Result:

- Reduced CTE mismatch of shaft and gear
- Reduced hardness of weld
- Minimized distortion
- Shorter cycle time
- Reduced costs through new design and production strategies for wear loaded components

Autogenus Laser Welding



Induction Assisted Laser Welding



Source: Fraunhofer IWS

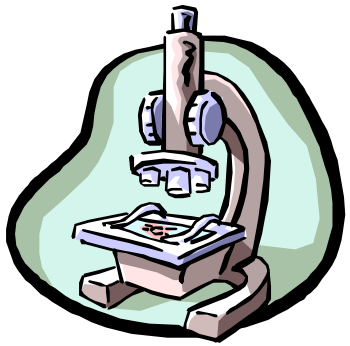
Lasers in Shipbuilding

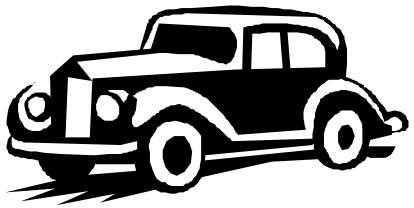
- **Product:** Sandwich panels: 3/8” to 1” thick
- **Output Power - Maximum:**
  Reasonable feed rate at high penetration depth
- **Wavelength – CO_2:**
  Laser safety (large product) and highest power
- **End effector:**
  - Typical 8” to 10”, flying optic
  - GMAW integrated for gap bridging
- **Equipment: All new**
- **Technology: Leapfrog**
- **Benefits:**
  - Increased production rate
  - Reduced rework though less distortion

Source: Industrial Laser Solutions

Conclusion

CO_2 Nd:YAG Diode Fiber





Wide variety of lasers offer

- Potential for confusion

- The key to fit the lock