Revolutionizing Laser Cutting: Harnessing Tunable Laser Beam Technology

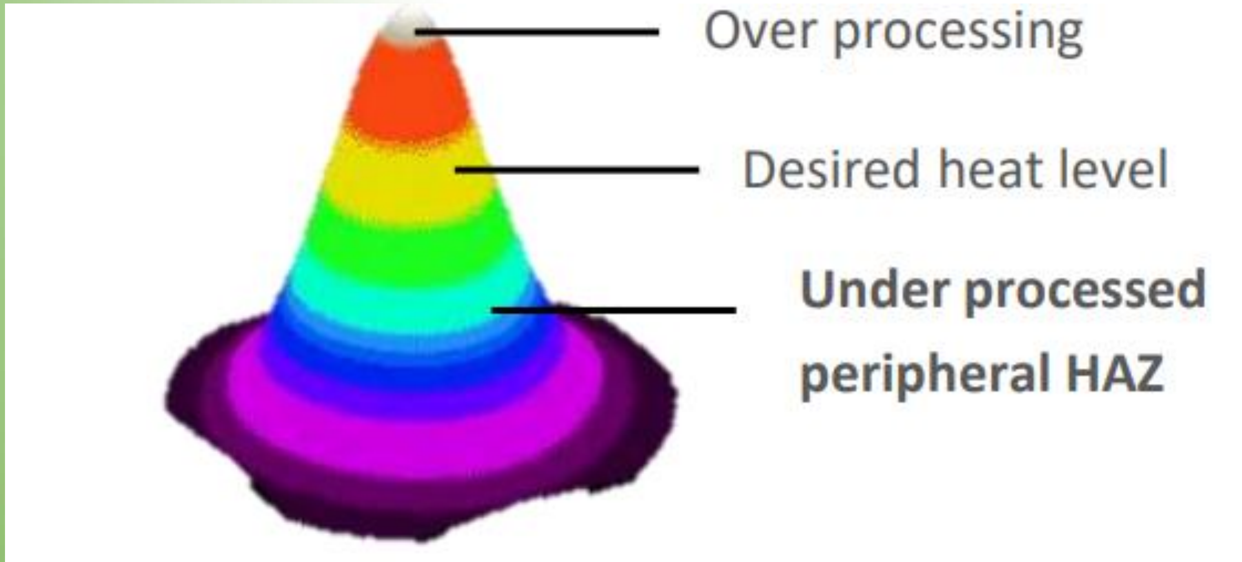
PROTECK

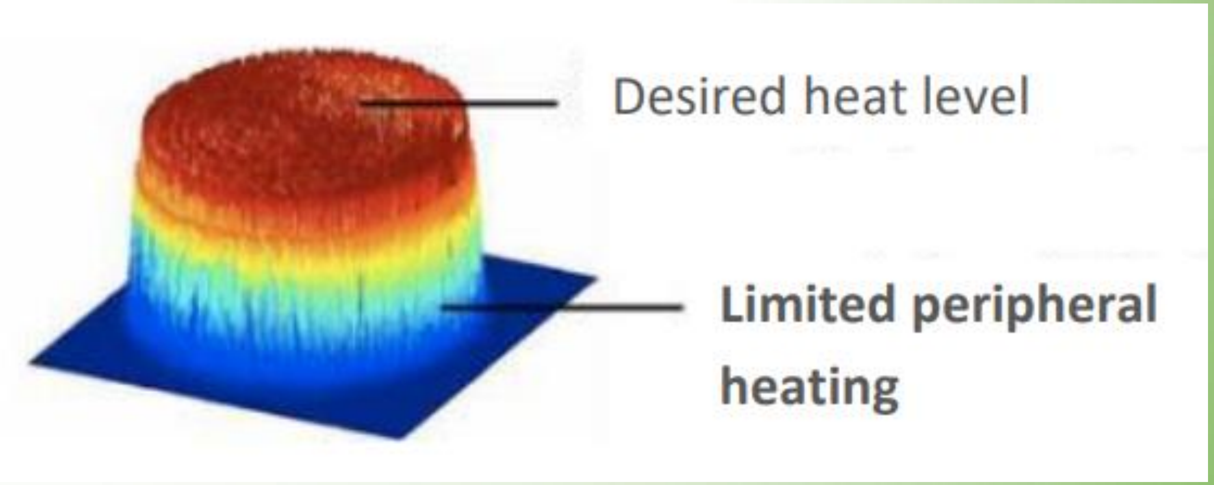
...Innovation and Industrial Excellence Embedded

Cutting Process - Optimization

- The important parameters related to Laser Beam in context of Laser cutting, apart from Laser power are:
  1. Laser Beam Quality (Expressed as BPP OR M2)
  2. Laser spot diameter (Depends on machine configuration)
  3. Radial intensity distribution (Flat Top, Ring Beam and Saddle beams)
- It has been observed that rapid tuning of the above parameters for each step of the cutting process, not just for cutting of different material types Or thicknesses, offers max. advantage in optimizing the process. For, example different beam quality setting can be used during the piercing sequence versus cutting Or during straight cutting versus cornering.
- A system that offers beam quality tunability feature is a key to maximize machine performance. And the reliability of such a system is crucial to industry acceptance.

Intensity Distribution – Profound Influence On Material Interaction





Gaussian Profile **Flat top Profile**

Tunable Beam Quality: Significant Feature in Material Processing Application

- **The ability to automatically tune the Beam Quality and laser spot size would greatly extend the applicability, productivity and process window for Fiber laser machines. Prevalent approaches depend on motorized free-space optics.**

- **Such as Zoom cutting heads, fiber-to-fiber or free-space-to-fiber couplers that vary the launch conditions in the fiber, or fiber-to-fiber switches with two to four outputs coupled to independent process fibers.**

- **Such free-space optical approaches entail significant cost and complexity and can degrade tool performance and reliability. They are sensitive to mis-alignment, contamination, and environment condition(Temperature, Vibration), introduce power dependence (thermal lensing) and optical loss, and/or slow switching speed.**

Key Aspects in Optimizing Laser Cutting Systems

- **Understanding Optimization**:
  - **Definition: The strategic selection and design of various sub-systems in a laser cutting system.**
  - **Objective: Achieving the desired balance between productivity and quality output.**

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- **Critical Interplay of Sub-systems:**
  - **Importance: Highlighting the need for seamless compatibility among sub-systems.**
  - **Example Scenario:**
    - **Utilizing a high beam quality(low BPP) from the fiber laser source necessitates effective configuration of:**
      - **Gantry design**
      - **Control system design**
      - **Optical system design**

Key Aspects in Optimizing Laser Cutting Systems (cont..)

- **Realizing Enhanced Performance:**
  - **Attaining High Dynamic Performance:**
  - **Outcome of effective sub-systems' configuration.**

  - **Precision in Spot Size:**
  - **Resulting from optimized optical configuration.**

Key Aspects in Optimizing Laser Cutting Systems (cont..)

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  - **Precision in Spot Size.**
  - **Resulting from optimized optical configuration.**

- **Ultimate Goal:**

  Crafting an Optimal Process:
  - **Addressing specific material types and thicknesses for distinct applications**

Key Aspects in Optimizing Laser Cutting Systems (cont..)

- **System design challenges**

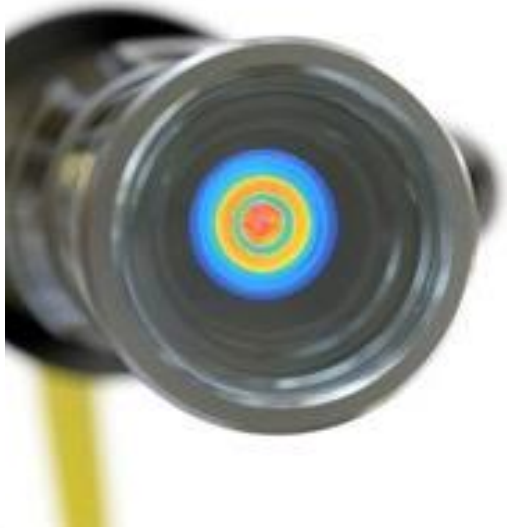
  - **R&D team development**
    - **Establishing a competent R&D team with expertise in associated technologies poses a challenge in system design.**

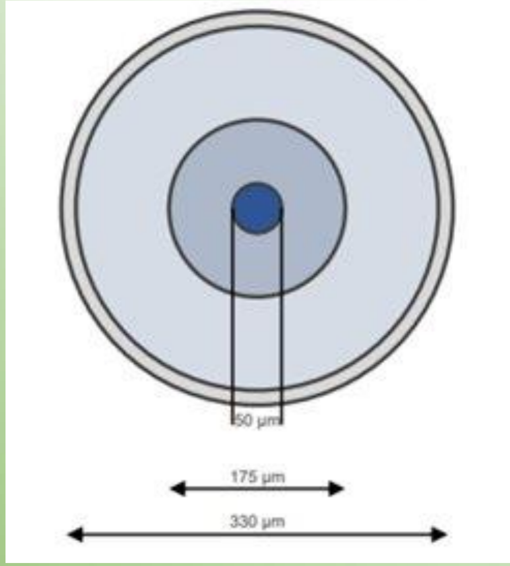
  - **Pricing control challenge**
    - **Manufacturers face the challenge of controlling system pricing while justifying its value.**

Fiber Laser Source – Desired Features

Proteck machine features a Laser source that is a BREAKTHROUGH in fiber laser technology.

Fiber Laser Source – Desired Features





- **It utilizes a novel, all-fiber technology, "Corona", that enables rapid tunning of the laser spot directly from the feeding fiber over a range of more than 3X without any of the drawbacks of free-space approaches.**

- **Thereby maintaining all the perform ance, stability, efficiency and reliability advantages of fiber lasers.**

Corona VS Others Beam Shaping Technologies

Desired Feature	Corona	Zoom lens	Comp 1	Comp 2	Comp 3
All fiber (no free space optics)	✓	✗	✗	✗	✓
Variable spot size (with fixed Mag. Cutting head)	✓	✗	✓	✗	✓
Integrated into Laser	✓	✗	✗	✗	✓
Full power Available	✓	✓	✓	✓	✗
Optimized power distributions	✓	✗	✓	✓	✗
Fast switching on-the-fly	✓	✓	✗	✓	✓

LASER BEAM PROPERTIES

- **As we will see in our next section, below laser beam properties determine how best the laser cutting process can be optimized:**

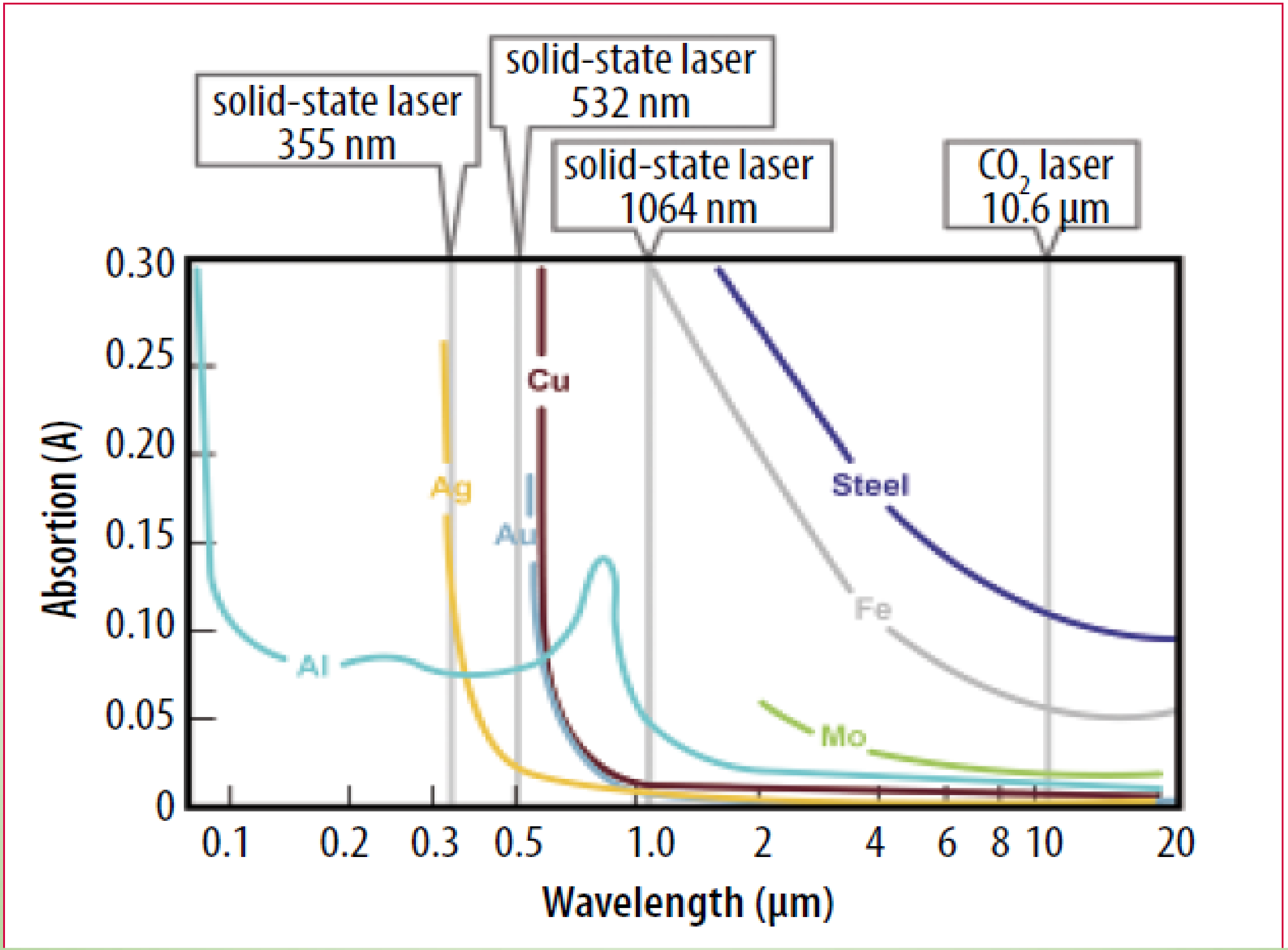
➢ **Wavelength**
➢ **Polarization**
➢ **Beam Quality**

WAVELENGTH

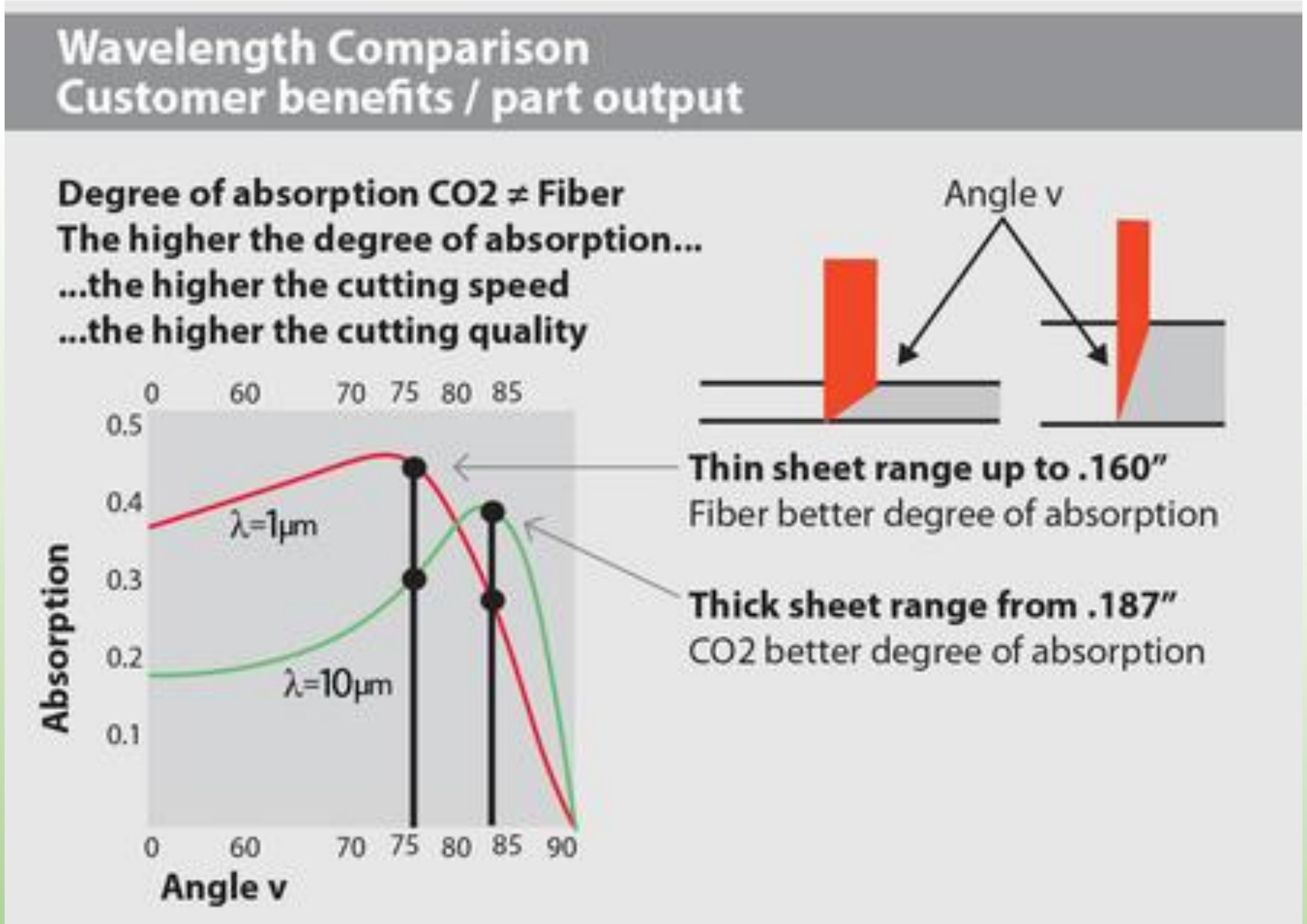
The wavelength determines the physics of beam propagation and focusing but also the absorptivity of the work-piece:

10600 nm	CO_2 Laser
1080 nm	fiber laser (Yb)
1060 nm	Nd:YAG laser rode laser
1030 nm	Yb:YAG disc laser
980 nm	
940 nm	Diode
808 nm	

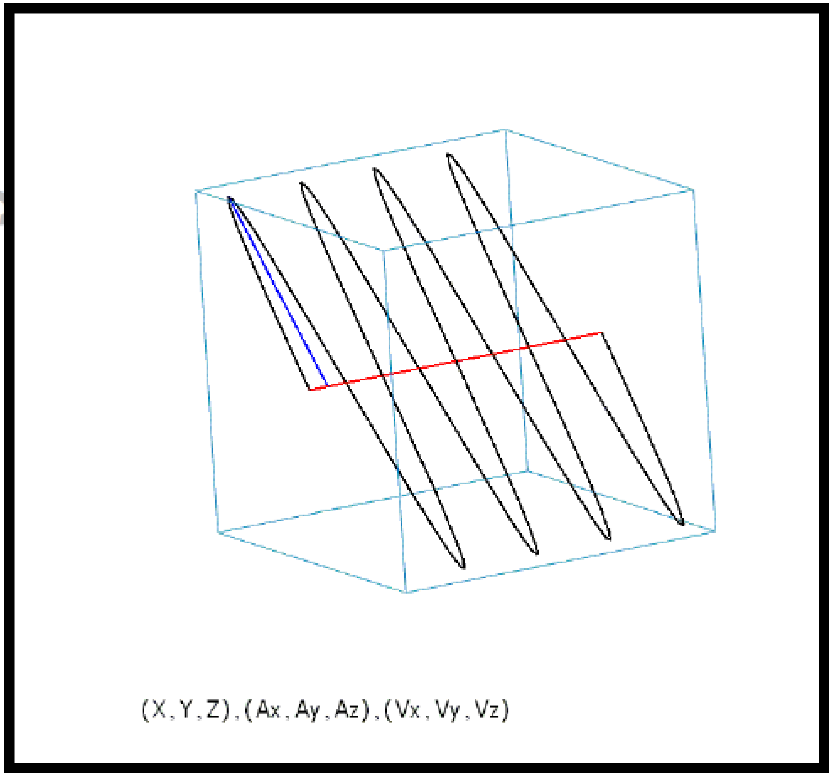
Absorption coefficient of typical laser-processed materials at different wavelengths



ABSORPTION COMPARISON – CO2 VS FIBER



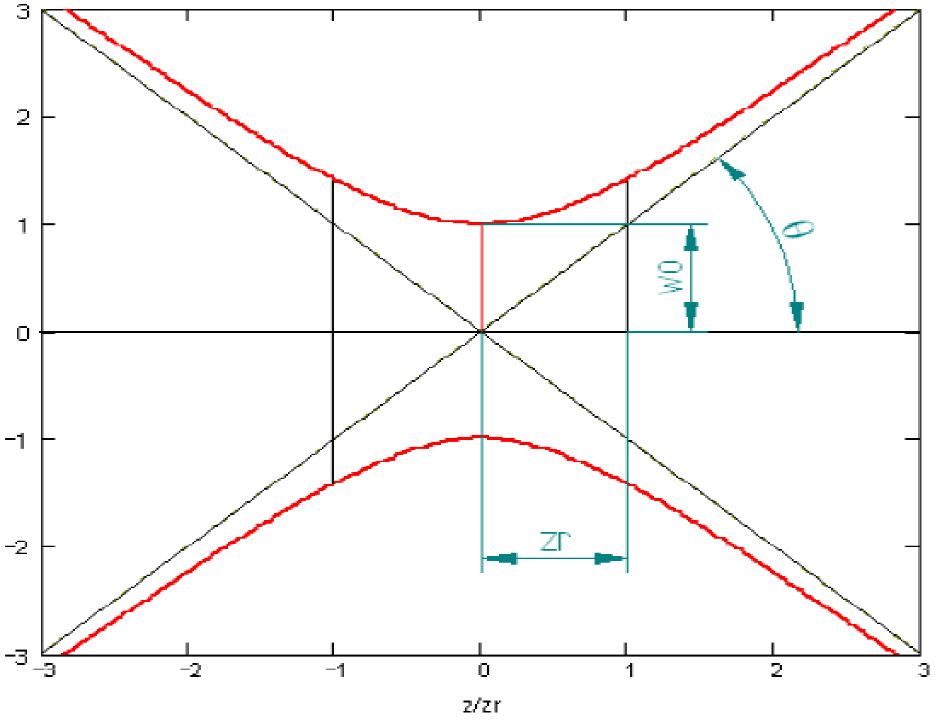
POLARIZATION



- electromagnetic wave
- direction of E-Field vector

Animation:
The electric field of an electromagnetic wave propagating along the (red) z- Axes. The polarisation (blue) is oriented at 45° to the horizontal plane.

BEAM QUALITY/PROPAGATION



Beam propagation (red)

θ :far field divergence angle

w_o : beam waist radius

z_r : Rayleigh length at this position the beam radius is enlarged by $\sqrt{2}$

Beam quality:

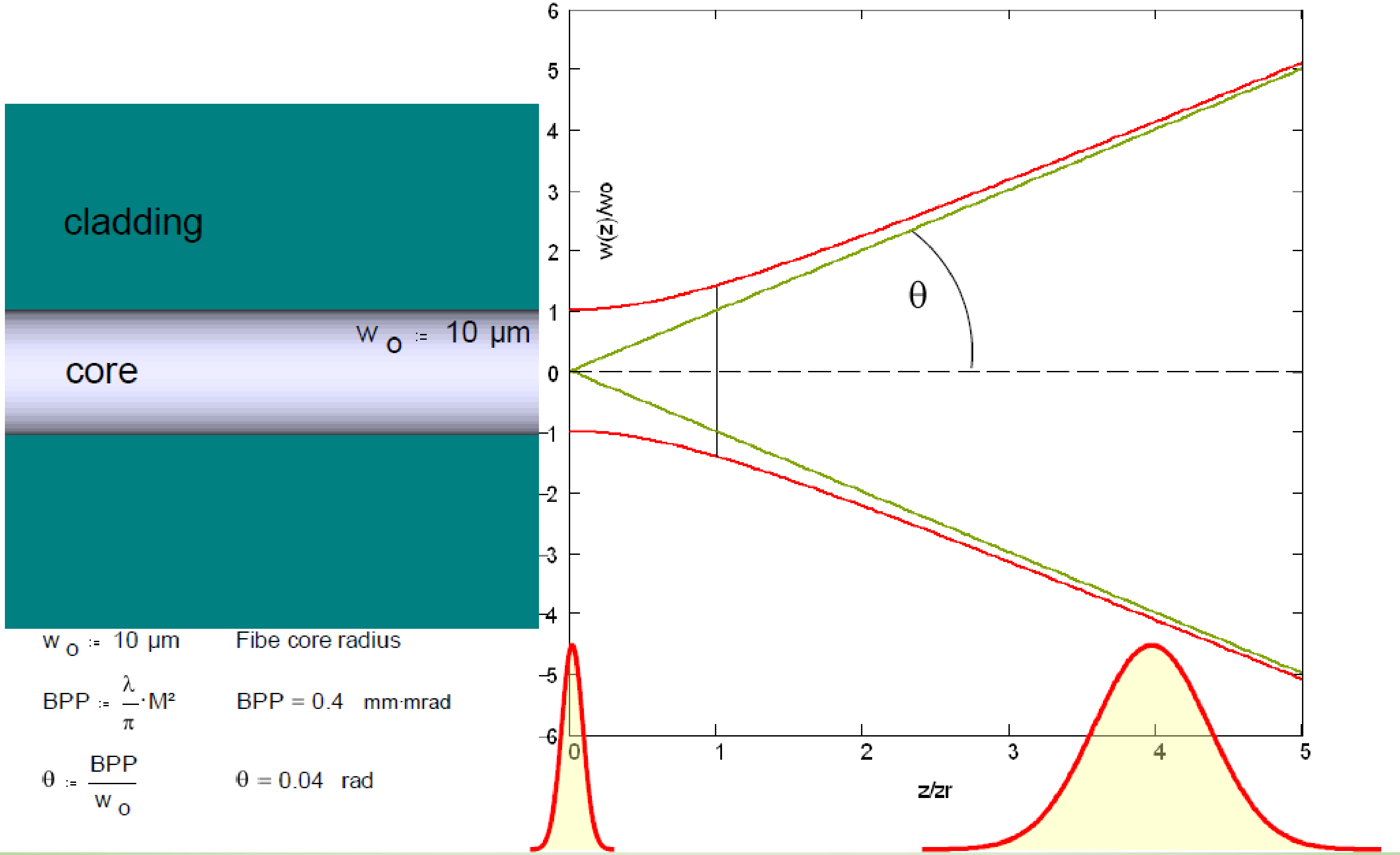
$$w_o \cdot \theta \geq \frac{\lambda}{\pi} \qquad M^2 = \frac{w_o \cdot \theta}{\frac{\lambda}{\pi}} \qquad K = \frac{1}{M^2}$$

$$BPP := w_o \cdot \theta$$

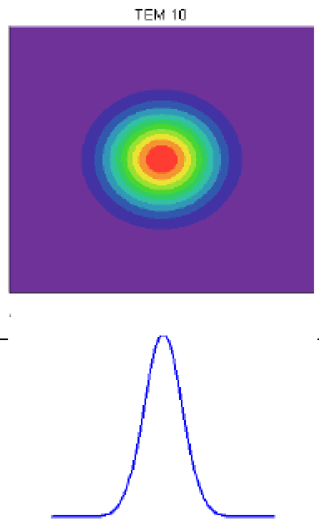
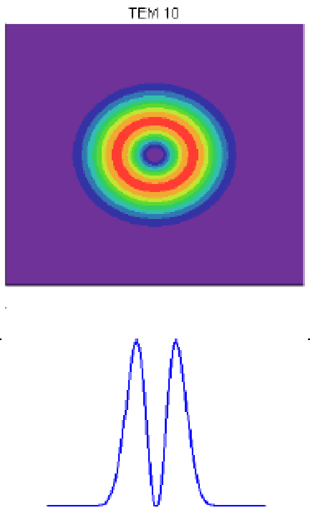
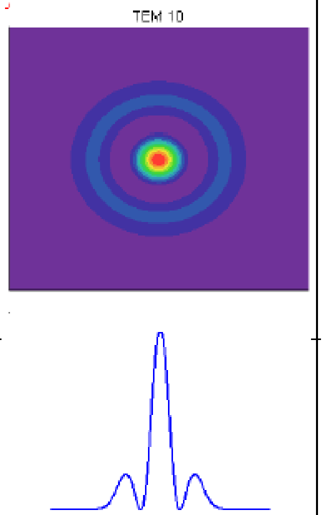
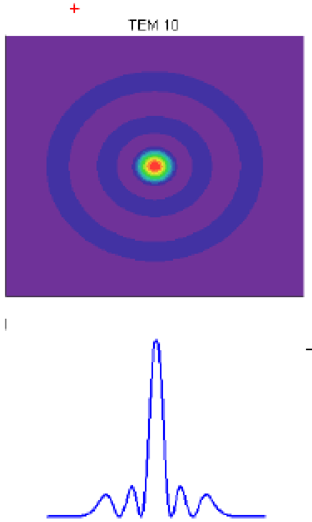
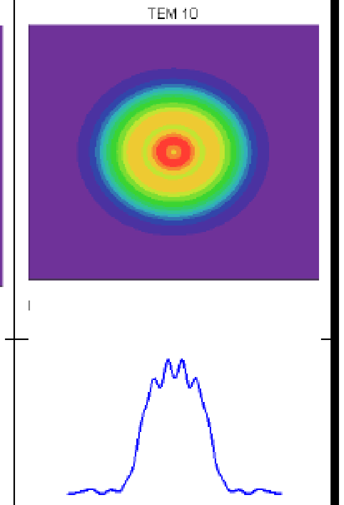
$$z_r := w_o^2 \cdot \frac{1}{BPP}$$

$$z_r := \frac{w_o}{\theta}$$

SINGLE MODE FIBER M2 = 1.2

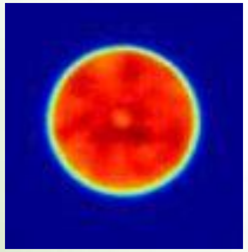


CO2 LASER – M2

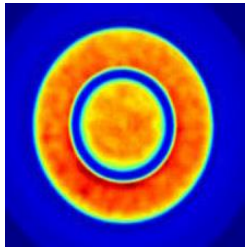
				
TEM 00	TEM 01*	TEM 10	TEM 20	Multi
K = 1 M² = 1 BPP=3.5 *)BPP mm.mrad	K = 0.5 M² = 2 BPP=7	K = 0.33 M² = 3 BPP=10	K = 0.2 M² = 5 BPP=17	K = 0.15 M² = 6. BPP=23

FIBER LASER – M2

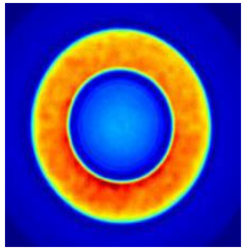
Different beam mode index for different cutting conditions.



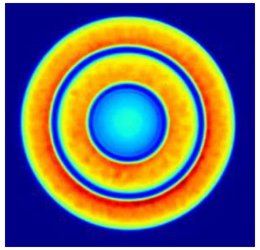
BPP = 3.4
M2 = 9.98



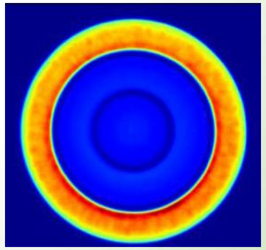
BPP = 11.1
M2 = 32.59



BPP = 10.6
M2 = 31.12



BPP = 17.9
M2 = 52.56



BPP = 16.1
M2 = 47.27

FIBER LASER TECHNOLOGY VS CO2

- **Comprehensive Analysis**

Advantages of Fiber Laser Cutting Technology

1. Monolithic Design

2. Fiber-Fiber Design

3. Compact solid state design configuration that is maintenance free

4. Provides a lower cost of operation than can be achieved with comparable CO2 lasers

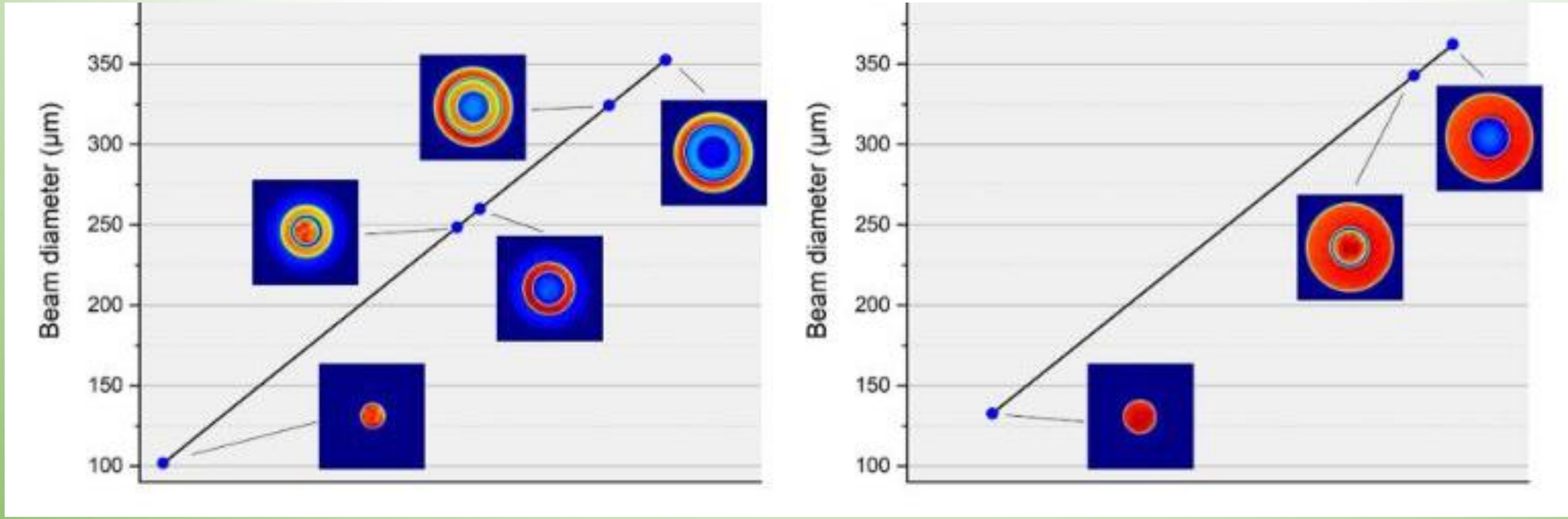
5. Fiber laser beam characteristics also provide for much faster cutting speeds than CO2 as we will explore below.

6. For certain, for processing stainless, aluminum, brass or copper materials, Fiber laser technology is the fastest and most economical regardless of thickness.

Process Fiber : Two Core and Three Core Fiber

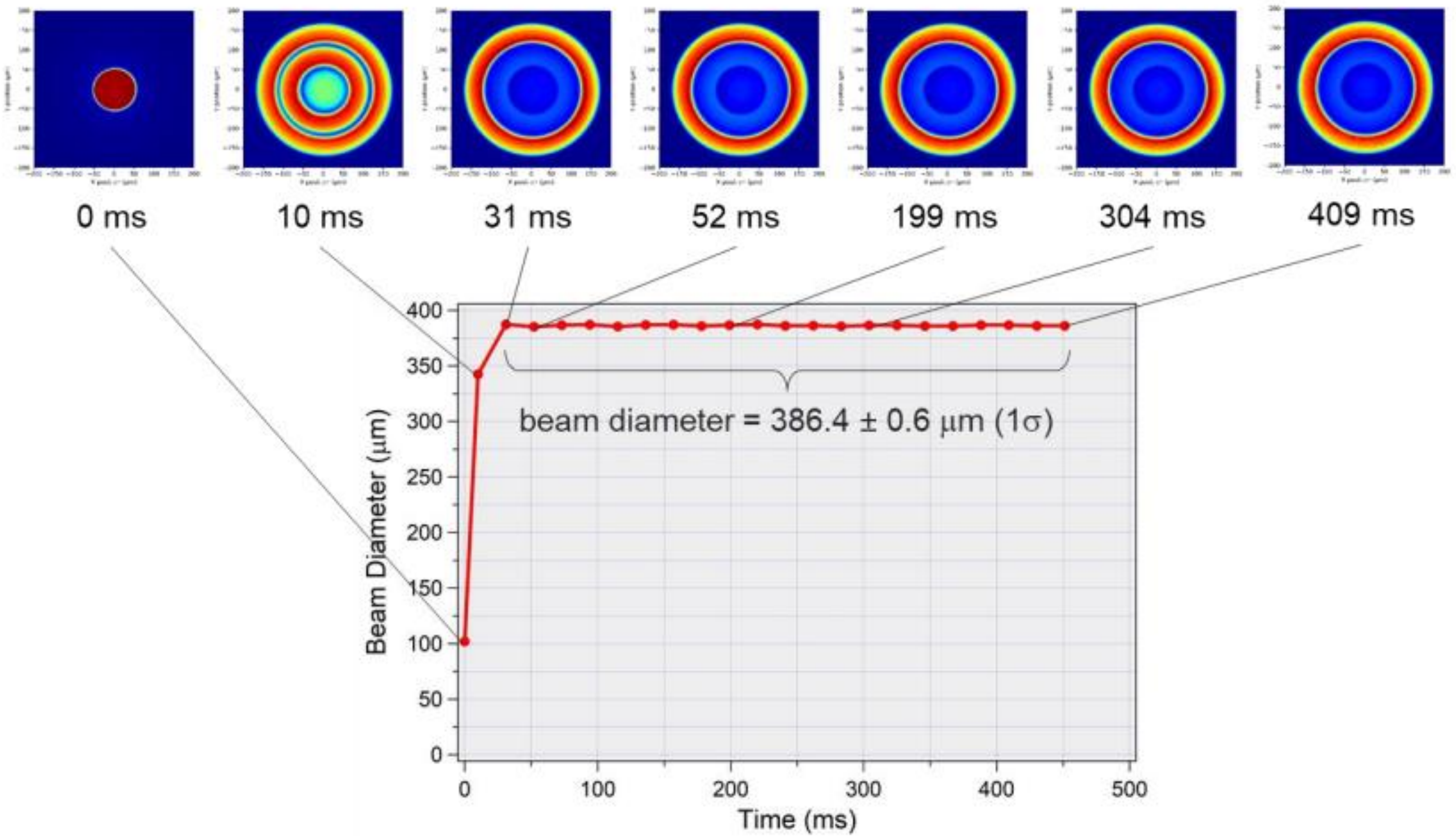
- NLight Corona fiber lasers provide beam shapes that have shown improved cutting quality for various metals, including flat top and annular ("donut") beams.
- The Machine’s 8kW power coupled with tunable beam quality enables optimized cutting of thin and thick metal.

Three Core fiber, 5 kW output | **Two Core fiber, 8 kW output**



CORONA BEAM SWITCHING :THREE ZONE FIBER 100/215/330 FEEDING FIBER

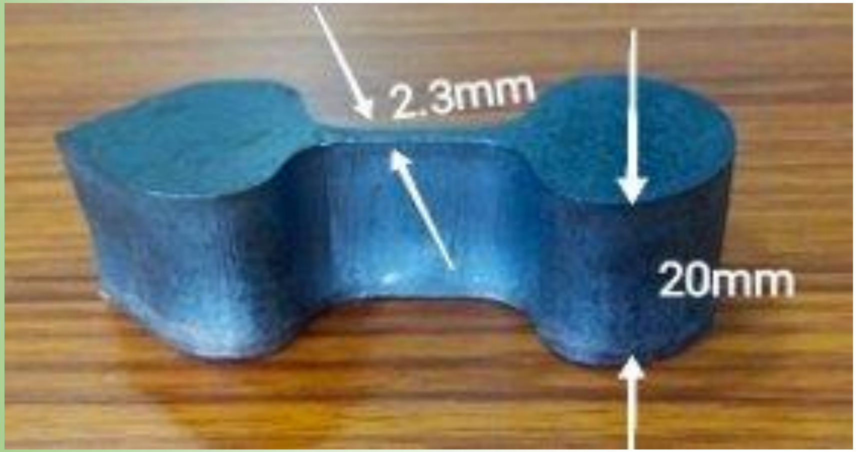
These beam-switching and accelerated life tests show that Corona fiber lasers maintain the exceptional stability and reproducibility of conventional fiber lasers with fixed beam characteristics, and this performance pertains to all Index settings.

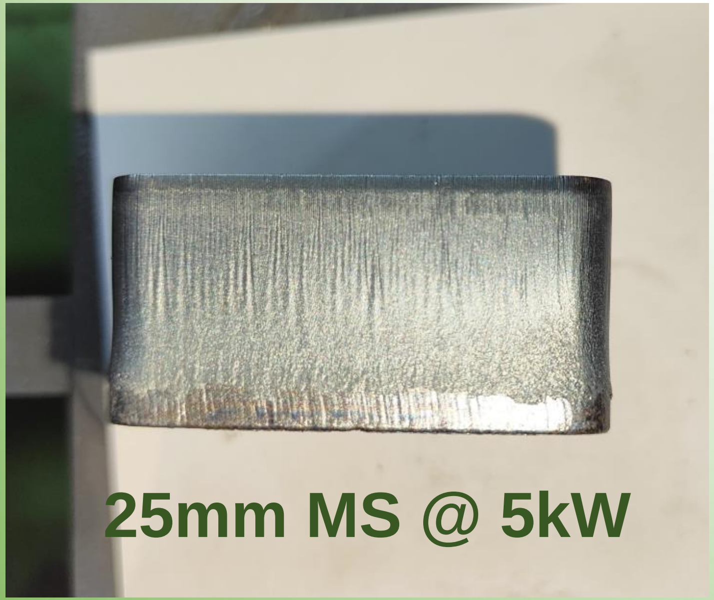


Cutting Results: ProLaser Blaze (Corona 50/175/330 Feeding Fiber)

Cutting Speed with Corona 5kW(50micron) is equivalent to 8kW fixed beam quality laser

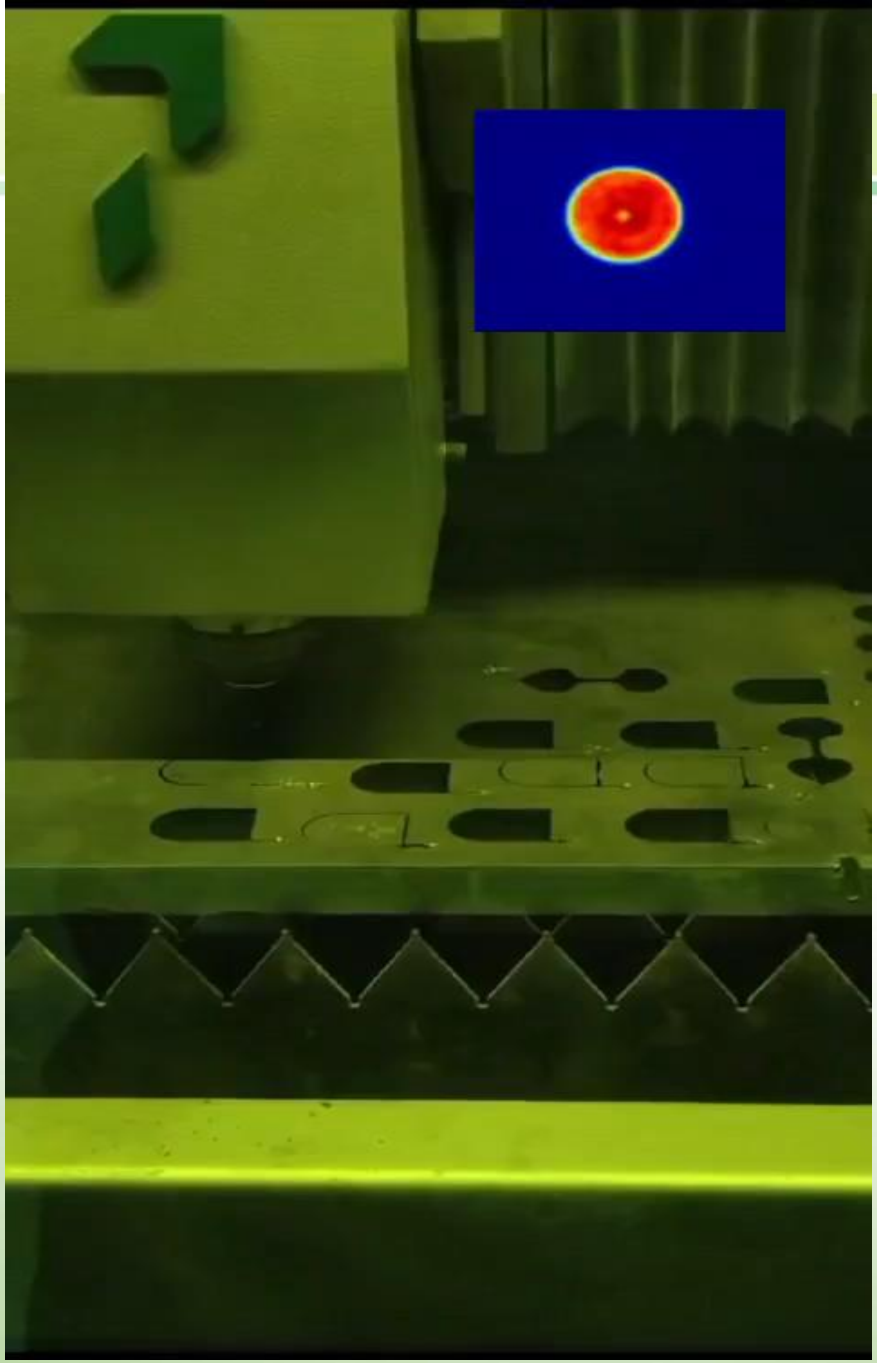
Cutting Edge Quality: Application Results



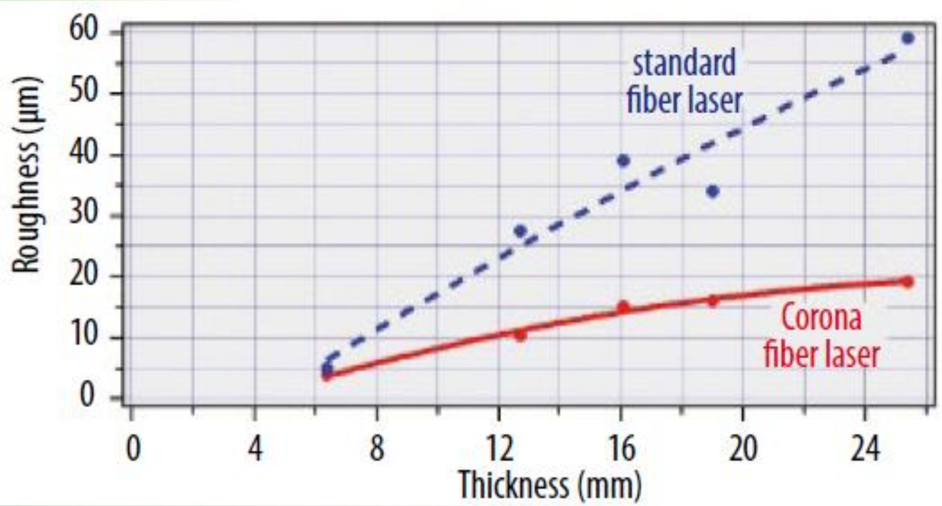


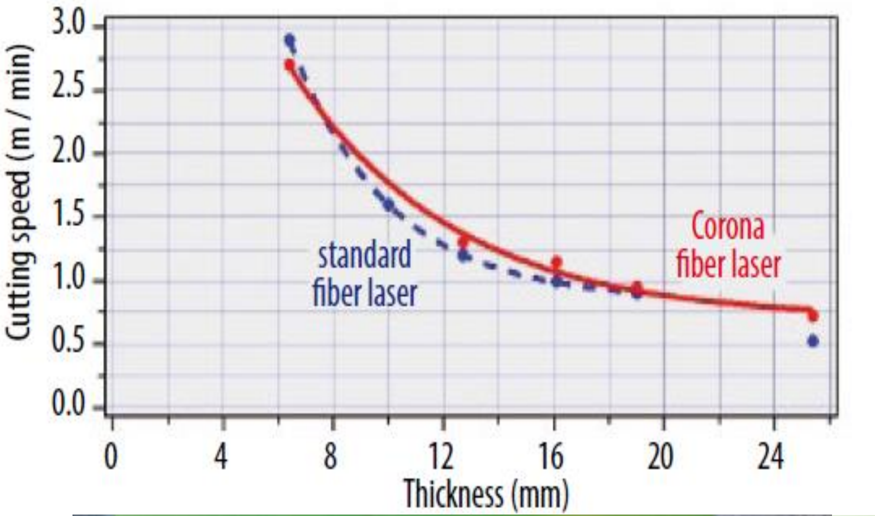
- **With the laser power at 5kW, It is capable of consistently cutting thick Mild Steel up to 25mm with excellent cut quality, with greatly reduced piercing times that enhances productivity. It also improves cut finish in SS and AL with N2 cutting due to its Beam Quality Tunability feature.**

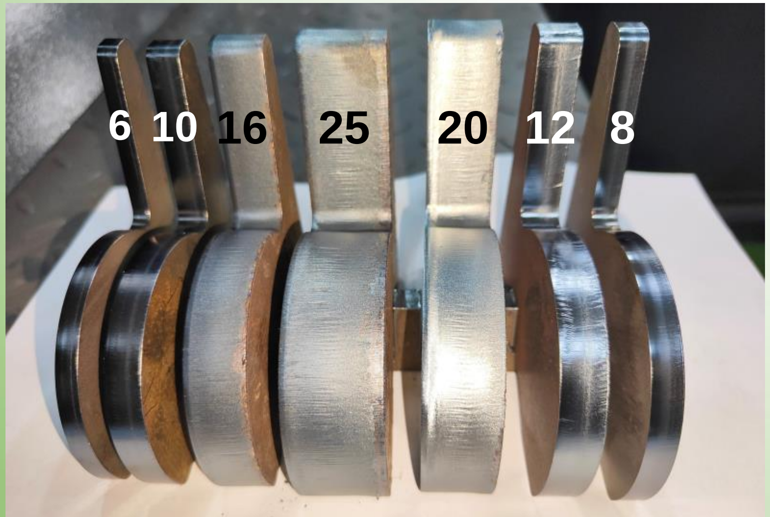
- **The results obtained at 5kW Power are almost equal to that obtained with a 8kW fixed beam quality system in terms of achievable feed-rate. 5kW Edge- quality is still superior.**



Standard fiber Laser vs Corona fiber Laser : Application Results

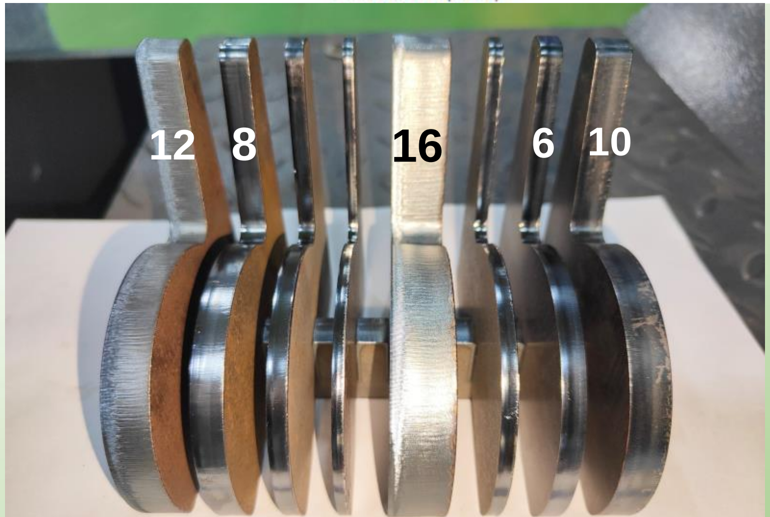






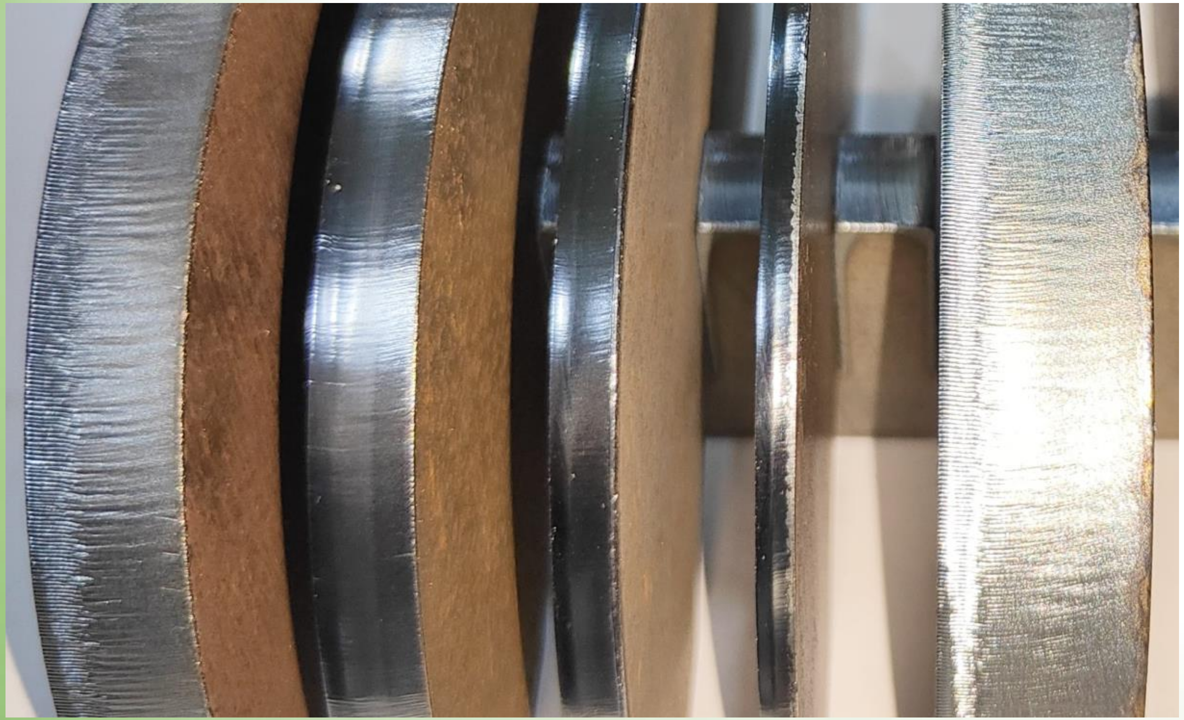
Corona Fiber Laser

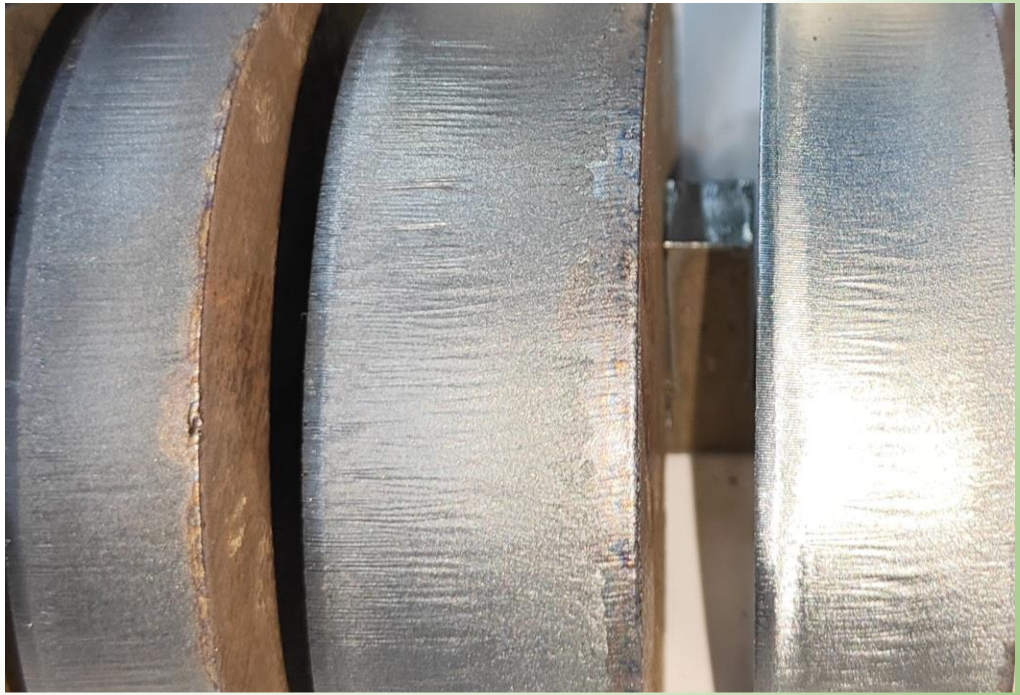
Power:
4kW



Standard Fiber Laser

ROUGHNESS COMPARISON



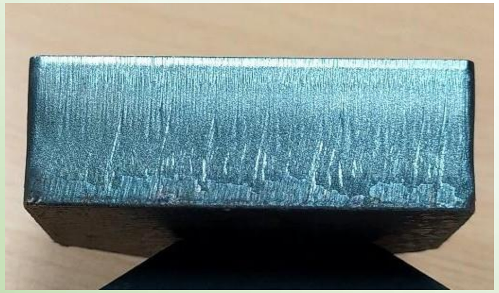


It is evident that there is marked difference in edge quality in MS O2 cutting thickness > 10 mm with the fixed beam quality Laser cutting system (BPP = 2.5 - 3.5) VS Optimimized beam quality Laser system.

nLIGHT CFX (Index 4) vs nLIGHT CFL(Standard Beam Quality) – 20mm

Laser	Beam Quality (mm* mRad)	Spot Diameter	Power (w)	Material (IS 2062)	Thickness (mm)	Taper per side (mm)	Taper angle (deg)	Gas (O2) Pressure (bar)	Nozzle dia (mm)	Gas Consumption
nLIGHT CFX Corona	Ring Mode (BPP = 17)	650 µ	4000	MS	20	~0.18	~0.5	0.45	2.5D	71 LPM
nLIGHT CFL	Standard Mode (BPP = 2.6 @ 100 µ fiber)	150 µ	4000	MS	20	~0.3	~0.85	0.5	5.0D	284 LPM

nLIGHT CFX Corona



1. Smooth edge finish (Top to bottom)
2. Less visible concavity
3. Minimum taper

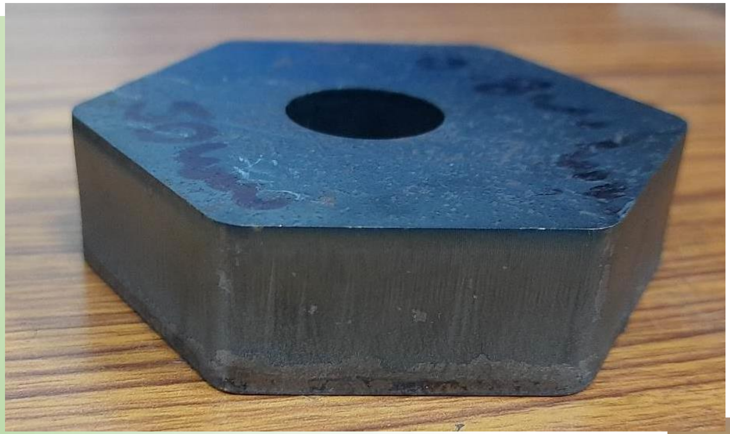
nLIGHT CFL

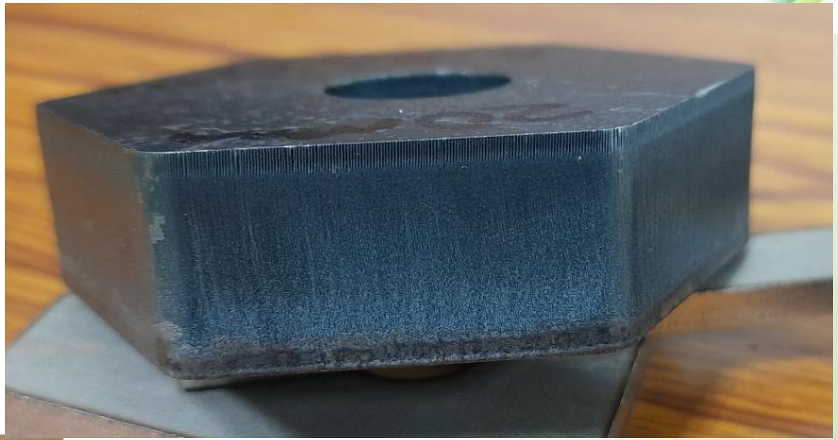
1. Roughness at cutting edge
2. Visible concavity
3. More taper compared with nLight CFX Corona

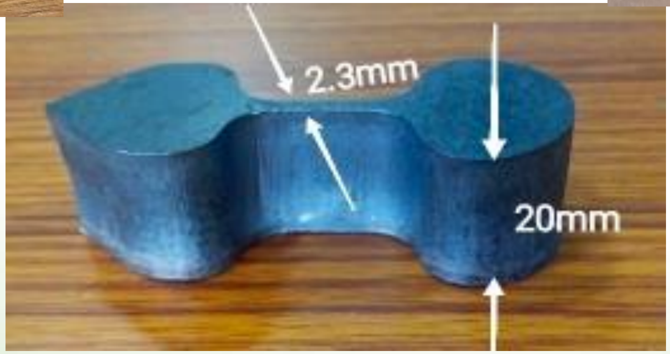
nLIGHT Corona Mild Steel - 10mm

Nozzle	Power	Beam Index no	Feed Rate	Gas Pressure	Taper	Surface Roughness
1.2D	5000	3	2200	0.4	~0.03 µ	~10µ

nLIGHT Corona Mild Steel - 20mm

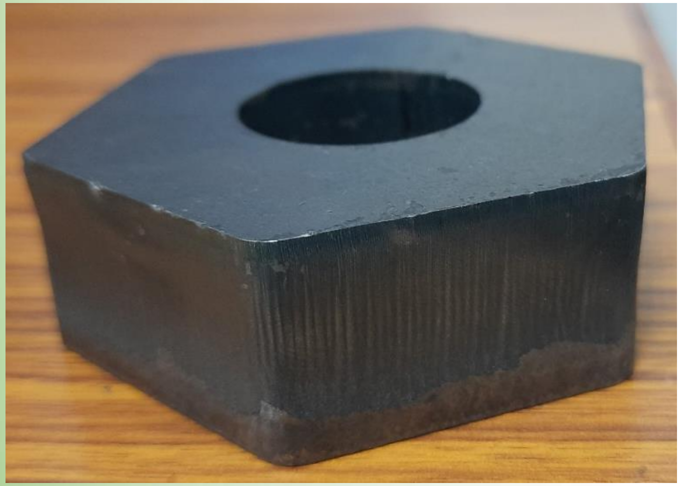


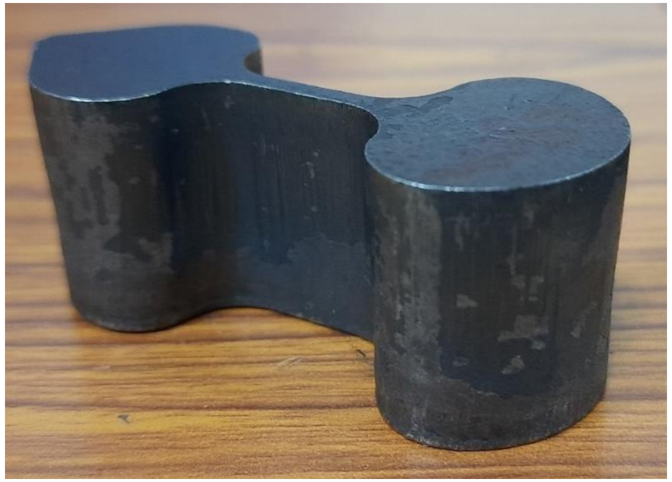


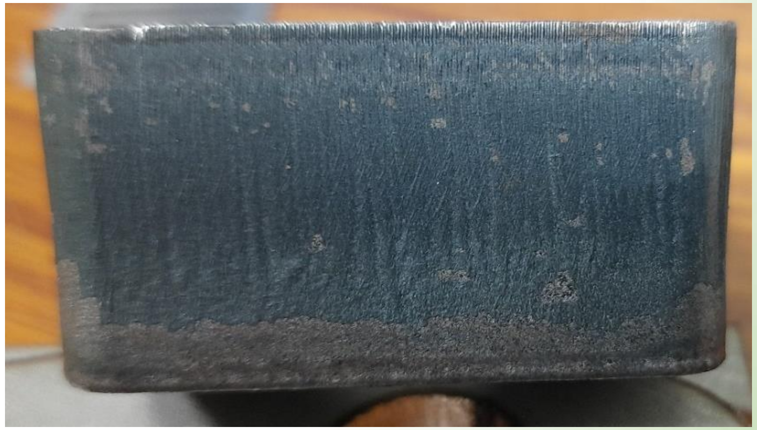


Nozzle	Power	Beam Index no	Feed Rate	Gas Pressure	Taper	Surface Roughness
2.5	4000	4	800	0.45	~200µ	17µ

MS - 25mm







Nozzle	Power	Beam Index no	Feed Rate	Gas Pressure	Taper	Surface Roughness
3.5	4000	4	650	0.45	~250µ	25µ

Customer Benefit – Excellent Quality With Max Productivity

MS 25mm at 4 KW With Beam quality optimization

Conclusion

- **Intensity profiles have profound influence on material interaction.**
- **Programmability feature of Beam Parameters offers max. flexibility and control for optimizing the process for cutting of various materials such as MS, SS, AL, CU etc.**
- **Beam Transformation directly inside the laser source than utilizing free space optics maximizes performance by enhancing the stability and reliability of the system.**
- **Real time Beam Quality switching accompanied by rapid tuning of the spot diameter, achieved directly through the feeding fiber.**
- **Above features when in perfect synergy with the other sub-systems of the Laser cutting system offers the complete package for realizing Max. Customer benefit .**
- **We at Proteck are committed to developing such innovative products that gives an edge to our customers in setting the benchmark in quality and productivity.**

About Proteck

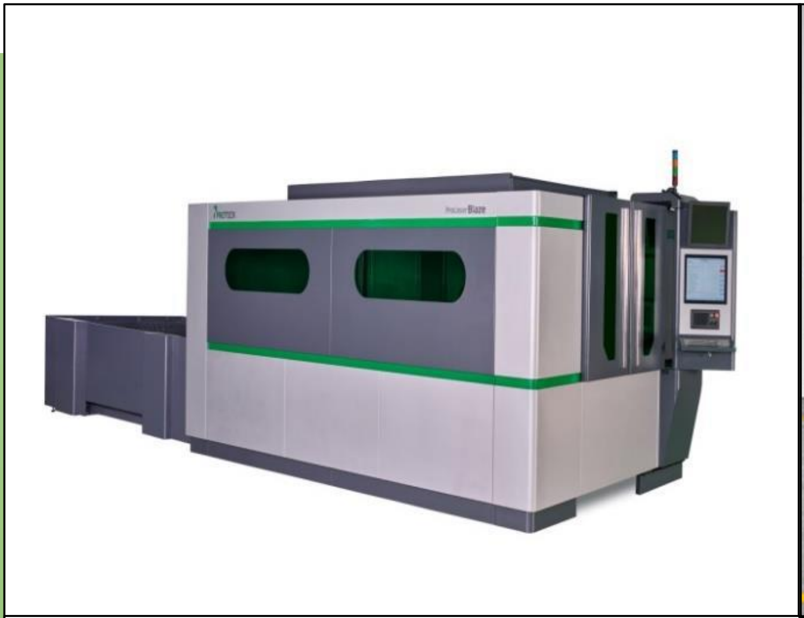
Founded by a group of IIT ians in the year 1985, Proteck is focused on delivering market leading technology and innovative systems with a focus on exceeding customer expectations.

ORAGADAM FACTORY, CHENNAI

OUR MISSION

“We are committed to growth by embedding excellence and innovative application of technology in our products and services, and evolving continuously as a valued and responsible corporate citizen in our businesses while contributing to society ”

OUR PRODUCTS



SPECIAL PURPOSE MACHINE

ESTEEMED CUSTOMER LIST

Thank You

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