Application Note
Issued: 2015-08-27

Steel cutting with a 500 W direct diode laser

SUMMARY

The performance of the 500 W DirectProcess 900 direct diode laser in flat sheet metal cutting experiments is discussed for its application to steel. Cutting results were analyzed for mild steel and stainless steel samples with thicknesses of up to 6.4 mm and 3.4 mm, respectively. The cutting speed and the cut quality can compete with the performance of current fiber lasers.

The DirectProcess 900 achieved fast cutting speeds for both mild steel and stainless steel that are very similar to those achieved by a standard fiber laser. With regard to cut quality, whilst yielding a slightly rougher surface of the cut edges, the 500 W DirectProcess 900 outperformed a 1.5 kW test fiber laser in edge angularity for mild steel. These results demonstrate how direct diode lasers are becoming an alternative on a complete par with fiber lasers for such cutting applications. At the same time, they offer typical advantages like compactness, high efficiency, usability and easy maintenance.

The DirectProcess 900 laser can also be employed for cutting other metals such as aluminium, copper and brass. In this case, however, operation requires a higher laser power[1)] to cut above a certain thickness, since compensation has to be made for power losses due to the higher thermal conductivity. The topic of cutting these materials will be addressed in a separate Application Note.

PRODUCT LINE / APPLICATION

Product	DirectProcess 900-500-200-01 by DirectPhotonics Industries
Application	Direct diode laser material processing at 500 W
Process	Cutting
Material	Mild steel; stainless steel

Table 1

The ultra-high brightness of the DirectProcess 900 laser system is perfectly suited for direct diode laser material processing in demanding industrial environments.

1) Using the technology of wavelength division multiplexing, the DirectProcess 900 can be operated at a higher output power without losses in beam quality [1].

SETUP

Cutting parameters

All cutting tests were performed according to ISO9013:2002(E). The DirectProcess 900 direct diode laser was operated with the following settings:

	Mild steel	Stainless steel
Output power, fiber coupled	500 W	
Core diameter of delivery fiber	200 µm	
Collimator	f = 100 mm	
Cutting lens (plano-convex)	f = 160 mm	f = 125 mm
Focal spot size	320 µm	250 µm
Sample thickness (range in mm)	0.9 – 6.4	0.6 – 3.4
Assist gas	Oxygen	Nitrogen

Table 2: Cutting conditions for DirectProcess 900

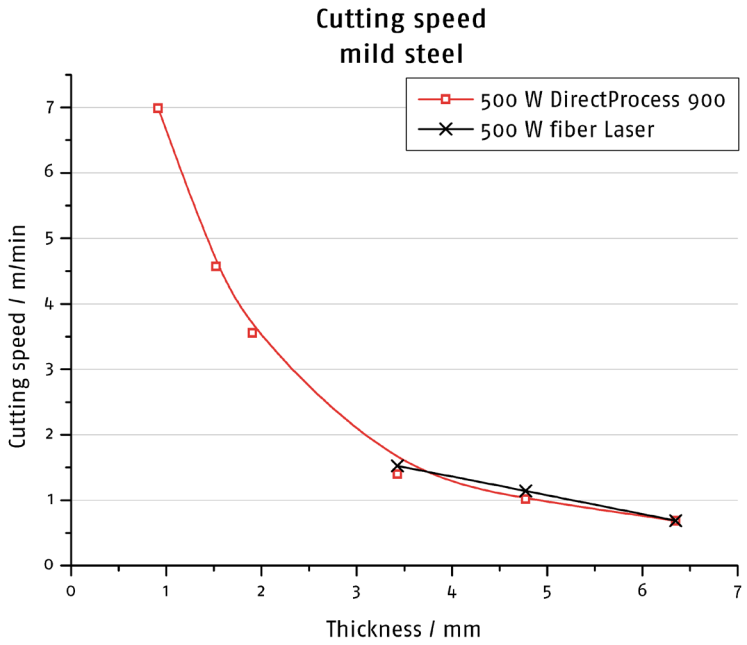
The test fiber laser was operated at 500 W and at 1.5 kW in a series of measurements. A 200 µm delivery fiber, an f = 100 mm collimator and an f = 160 mm focusing lens were used for all tests with the fiber laser.

CUTTING SPEED

Mild steel

The DirectProcess 900 achieved cutting speeds between 7 m/min for mild steel with a thickness of 0.9 mm and 0.7 m/min for mild steel with a thickness of 6.4 mm. These values are very similar to cutting speeds obtained using a 500 W fiber laser (overplotted for samples of high thickness in the chart below).

Fig. 1: Cutting speed for mild steel samples of different thickness.



Stainless steel

For cutting stainless steel, the DirectProcess 900 used an alternative focus lens (see Table 2) to optimize the focal spot size. In this way, again cutting speeds were achieved that are comparable to those obtained using the fiber laser[2]. Using a stronger collimator system (decreasing the focal spot size), the cutting speed can be further increased, if required.

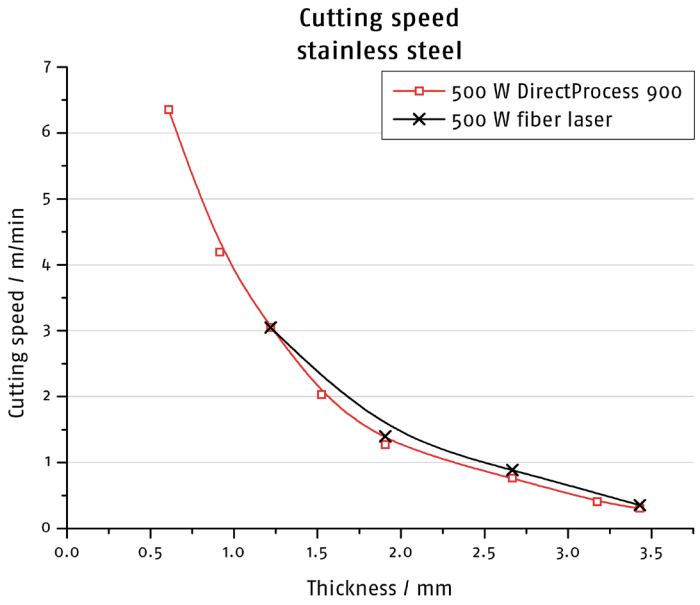


Fig. 2: Cutting speed for stainess steel samples of different thickness.

CUT QUALITY

The cut edges were classified according to the quality tolerances defined by the standard ISO 9013:2002(E). The primary cut quality determinants are:

- Perpendicularity or angularity tolerance, u, which can be related to edge angularity, and
- Mean height of the profile, Rz5, or surface roughness.

Results are shown compared to those of a 1.5 kW fiber laser. Operation at a relatively lower power (500 W) for the DirectProcess 900 was compensated by a reduced cutting speed, enabling the optimum speed cut generated by the two lasers to be compared.

Mild steel

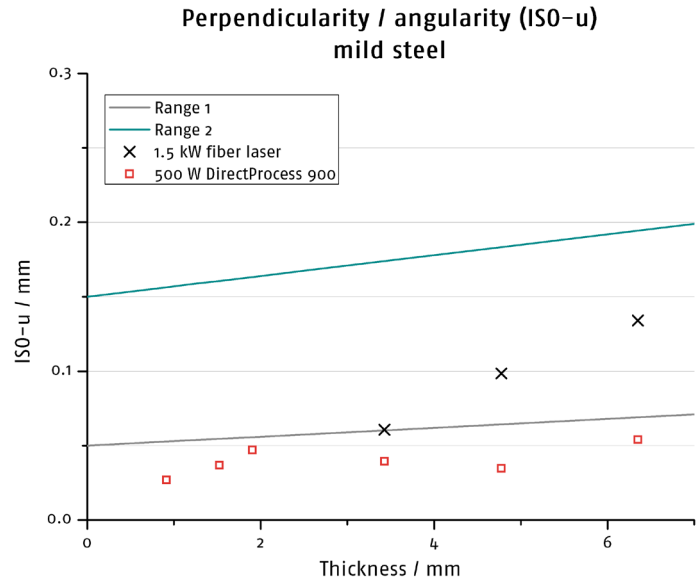
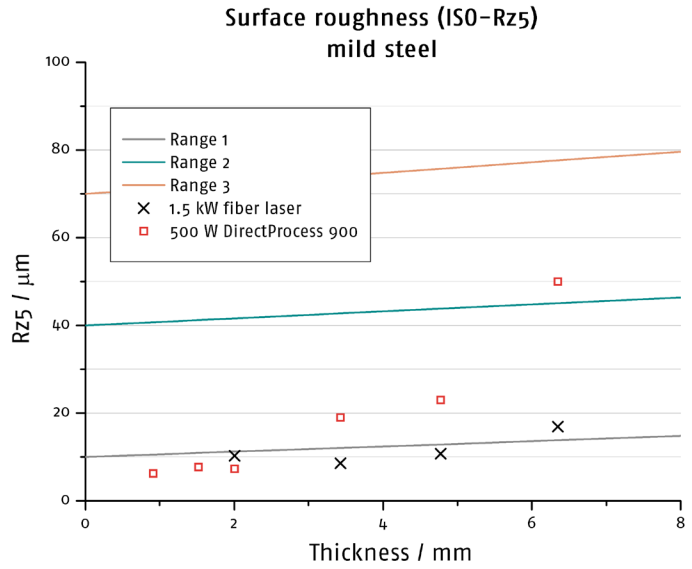


Fig. 3: Edge angularity for mild steel cuts. The solid lines indicate the ISO ranges of angularity tolerances.

[2] *Note that the fiber laser was operated in a fixed setup for mild steel and stainless steel.*

Fig. 4: Surface roughness for mild steel cuts. The solid lines indicate the ISO tolerances.



Stainless steel

Fig. 5: Edge angularity for stainless steel cuts. The solid lines indicate the ISO ranges of angularity tolerances.

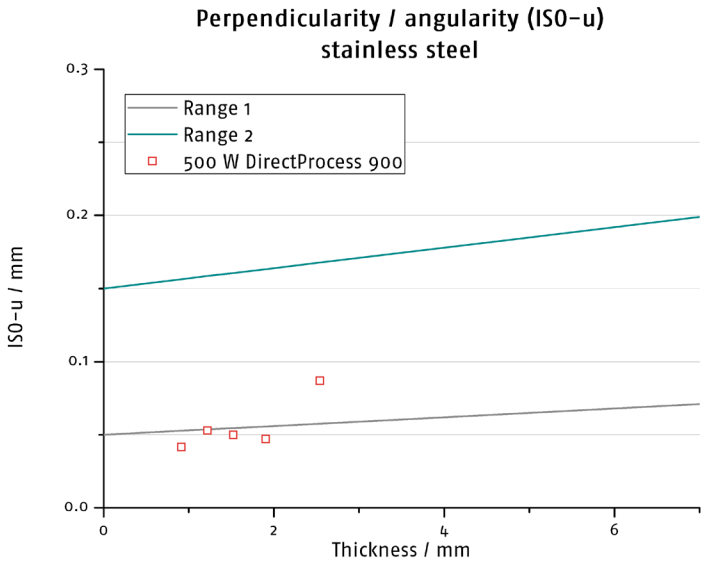
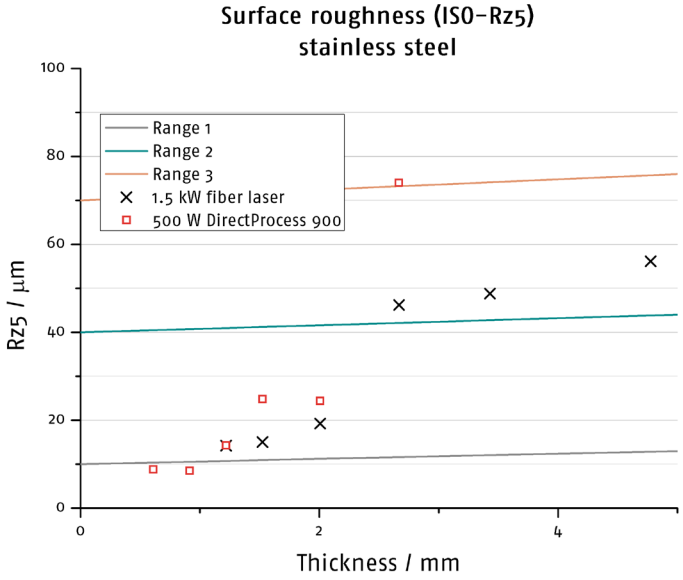
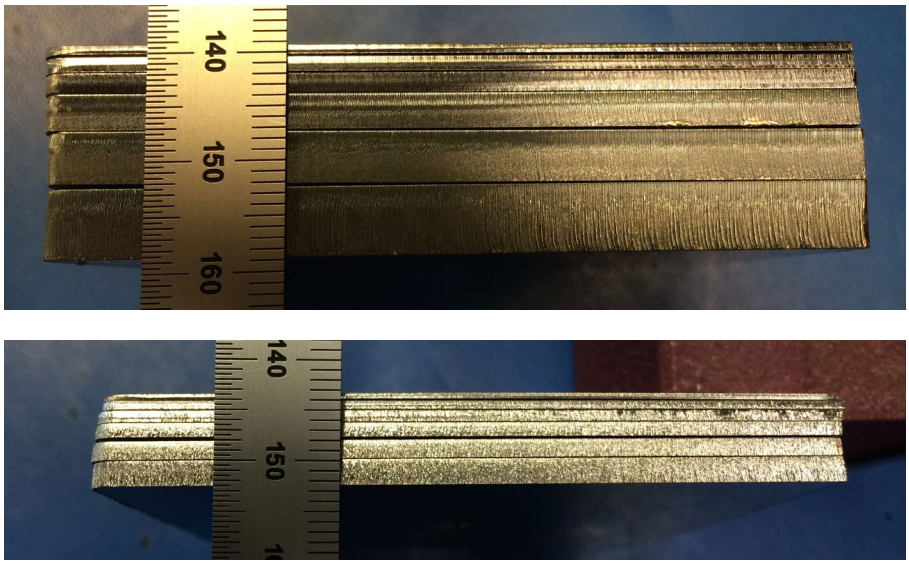


Fig. 6: Surface roughness for stainless steel cuts. The solid lines indicate the ISO tolerances.



For all mild steel samples, the DirectProcess 900 direct diode laser exhibits superior edge angularity compared to the 1.5 kW fiber laser. The angularity tolerance of the DirectProcess 900 lies within ISO Range 1. When cutting mild steel below a thickness of 5 mm, the surface roughness of the cuts lies within ISO Range 1 or Range 2, and compares favorably with good-quality laser cuts. However, the surface roughness of the mild steel and stainless steel samples in general is slightly higher than that yielded by the 1.5 kW fiber laser. This effect could be counteracted by also operating the DirectProcess 900 at a higher output power [1].



Photos showing a stack of cut samples.
Top: Mild steel cut samples with thicknesses:
0.9, 1.5, 2, 3.5, 4.8 and 6.4 mm.
Bottom: Stainless steel cut samples with
thicknesses 0.6, 0.9, 1.2, 1.5, 1.9 and 2.6 mm.

References:

[1] H. Fritsche, B. Kruschke, R. Koch, et al.: Highly modular high-brightness diode laser system design for a wide application range, in High-Power Diode Laser Technology and Applications XIII SPIE Vol. 9348, 93480A (2015)

DirectPhotonics focuses on developing and producing ultra-high brightness direct diode laser solutions for use in micro- and macro-material processing applications/markets. Founded in 2011, the company has its headquarters in Berlin, Germany.

Leveraging patented technologies from Fraunhofer Institutes, DirectPhotonics has significantly increased the brightness of fiber-coupled and direct diode laser systems to become the new workhorse in cutting and welding applications.

DirectPhotonics Industries GmbH
Max-Planck-Straße 3
12489 Berlin, Germany

T +49 30 6392 87240
F +49 30 6392 8742
info@directphotonics.com
www.directphotonics.com