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MEASUREMENTS REGARDING MAIN LASER BEAM PARAMETERS DURING LASER CUTTING

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Abstract: *The research is about the measurement of laser beam profile. Bistronic ByVention 3015 was used as the laser system and as diagnostic system, the Laserscope UFF 100. The measurements indicate the quality and the power density of the laser beam. The beam quality of a laser beam can be defined in different ways, but is essentially a measure of how tightly a laser beam can be focused under certain conditions. Measurements were performed on the focused laser beam. 3D caustics are represented and also representation of the mean and maximum power density along the laser beam with different benefits depending on various parameters. The measured parameters are Rayleigh length* Z_R*, beam propagation factor K or* M^2 *factor.*

Key words: *measurement, focus, laser beam, caustics*

1. INTRODUCTION

The aim of the research is to obtain results regarding some parameters that define the quality and the characteristics of the laser beam in order determine if raising the laser power changes the geometry of the laser beam.

The combination of processing depth and productivity requirements are the main factors in determining the laser power required (Ion, 2005). Regarding the laser beam the most common ways to quantify the beam quality are:

-the beam parameter product (BPP), i.e., the product of beam radius at the beam waist with the far-field beam divergence angle

-the M^2 factor, defined as the beam parameter product divided by the corresponding product for a diffraction-limited Gaussian beam with the same wavelength (Paschotta, 2004).

In any optical system, there is a limit, termed diffraction limit, which determines the minimum focal area and hence the maximum irradiance that can be attained (Ready, 2001). ISO 11146-2:2005 specifies methods for measuring beam widths (diameter), divergence angles and beam propagation ratios of laser beams. The calculation of the beam quality according to ISO Standard 11146 is represented:

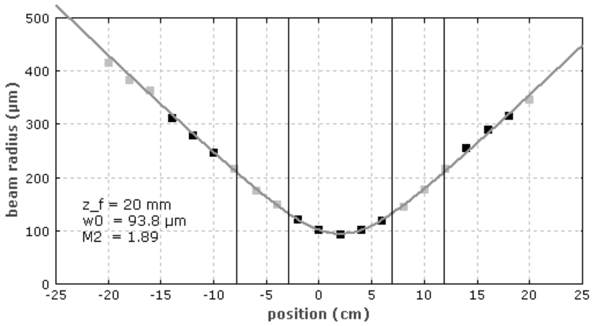

Fig. 1. Calculation of the beam quality from the measured caustic

According to ISO Standard 11146, the beam quality factor M^2 can be calculated with a fitting procedure, applied to the measured evolution of the beam radius along the propagation direction (the so-called caustic).

2. EQUIPMENT

2.1 Laserscope UFF 100

The Laserscope UFF 100 is a diagnostic tool for measuring and monitoring of laser systems with high performance for the material processing. For a better Quality performance an optimal and constant adjustment of the steel laser parameters, radius focus, focus position, power distribution is of big importance. It is possible to measure values to power densities of about 10^7 W/cm^2 and up to 25 kW outputs in focus. That is why you can establish and verify the optimal laser parameters for the task.

2.2 Bistronic ByVention 3015

Bistronic ByVention 3015 is a laser cutting system in 2 and a half axis. It has a CO_2 laser source with a power up to 2200 W and a pulse frequency from 1 Hz to 2500 Hz. The machine is designed to cut metal sheets up to 8 mm for mild steel, 6 mm for stainless steel and 4 mm for aluminum. The Frame of the machine is build of polymeric concrete. This material has been proved to be very efficient for the construction of high precision machines because of its damping capacities and its very low thermal influential. The CO_2 laser is today the most important material processing laser in the industry (Hugel, 1992). For optimal cutting the beam quality must be a suitable combination of a small waist radius and a sufficiently long Rayleigh length (Poprawe, 2005).

3. FOCUSED LASER BEAM MEASUREMENTS

3.1 Measurements at 1800W

The range of the caustic is cca. 12 mm. In function of the X axis is the waist radius w_0 (w_x) = 0.13 mm, the Rayleigh length z_R (w_x) = 1.6 mm. The beam propagation factor K (w_x) = 0.3 and the diffraction factor M^2 (w_x) = 3.4.
In function of the Y axis is the waist radius w_0(w_y) = 0.11 mm, the Rayleigh length Z_R (w_y) = 1.4 mm. The beam propagation factor K (w_y) = 0.4 and the diffraction factor M^2 (w_y) = 2.8

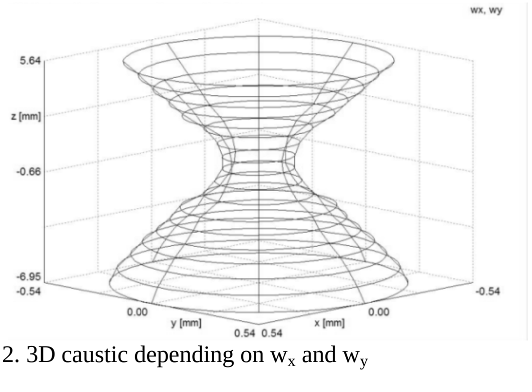

Fig. 2. 3D caustic depending on w_x and w_y

In function of w is the waist radius $w_0(w)$ = 0.12 mm, the Rayleigh length $z_R(w)$ = 1.5. The beam propagation factor K (w) = 0.3 and the diffraction factor M^2 (w) =3.0.

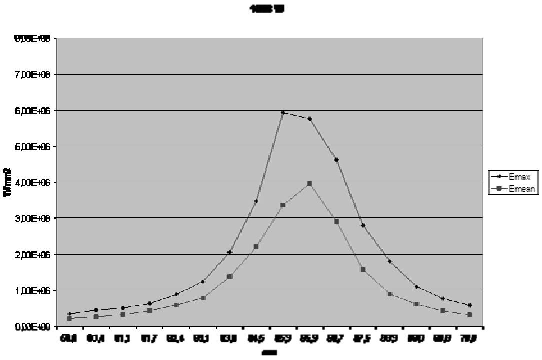

Fig. 3. Mean and maximum power density along the laser beam at 1800 W

3.2 Measurements at 2000 W

The range of the caustic is cca. 14 mm. In function of the X axis is the waist radius w_0 (w_x) = 0.13 mm, the Rayleigh length z_R (w_x) = 1.7 mm. The beam propagation factor K (w_x)=0.3 and the diffraction factor $M^2(w_x)$ = 3.4.

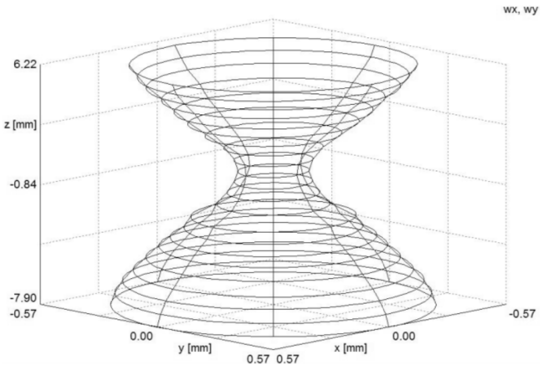

Fig. 4. 3D caustic depending on w_x and w_y

In function of the Y axis is the waist radius $w_0(w_y)$ = 0.11 mm, the Rayleigh length Z_R (w_y) = 1.5 mm. The beam propagation factor K (w_y) = 0.4 and the diffraction factor M^2 (w_y) = 2.7.

In function of w is the waist radius $w_0(w)$ = 0.12 mm, the Rayleigh length $z_R(w)$ = 1.5. The beam propagation factor K (w) = 0.3 and the diffraction factor M^2 (w) =3.0.

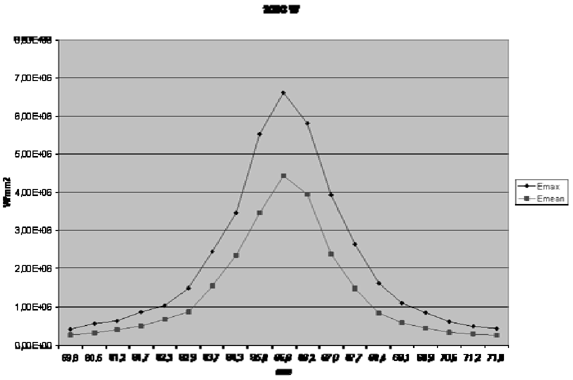

Fig. 5. Mean and maximum power density along the laser beam at 2000 W

3.3 Measurements at 2200 W

The range of the caustic is cca. 10 mm. In function of X axis is the waist radius w0 (w_x) = 0.13 mm, the Rayleigh length z_R (w_x) = 1.7 mm. The beam propagation factor K (w_x) = 0.3 and the diffraction factor $M^2(w_x)$=3.4.

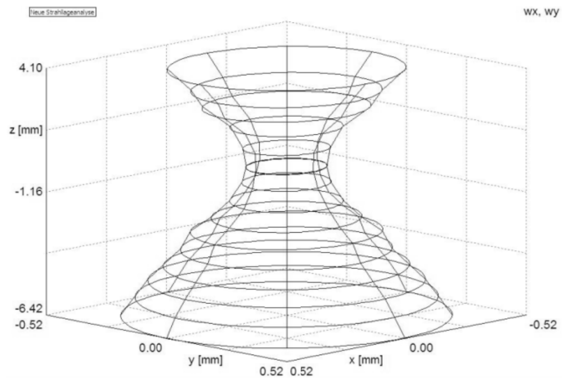

Fig. 6. 3D caustic depending on w_x and w_y

In function of Y is the waist radius $w_0(w_y)$ = 0.11 mm, the Rayleigh length Z_R (w_y) = 1.4 mm. The beam propagation factor K (w_y) = 0.4 and the diffraction factor M^2 (w_y) = 2.7. In function of w is the waist radius $w_0(w)$ = 0.12 mm, the Rayleigh length $z_R(w)$ = 1.5. The beam propagation factor K(w) = 0.3 and the diffraction factor M^2 (w) =3.0.

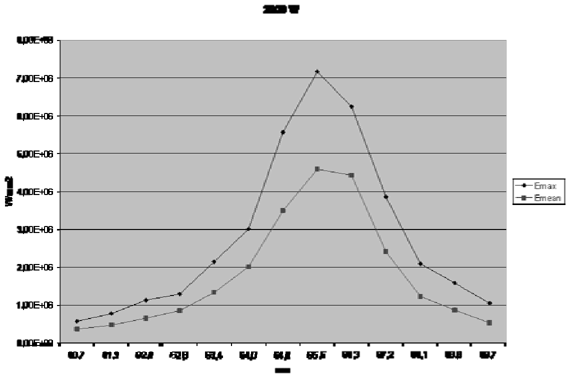

Fig. 7. Mean and maximum power density along the laser beam at 2200 W

4. CONCLUSIONS

For the focused laser beam, based on the diagrams, one can say when the power increases so grows the power density. The maximum power density increases with cca. $6x10^5$ W/mm^2 when the laser power is raised with 200 W. The waist radius $w_0(w)$ is for all powers cca. 0.12 mm and the Rayleigh length Z_r (w) is approx. 1.5 mm. It follows that raising the power has no influence on the waist radius and on the Rayleigh length. The increase in power increases the power density of the laser beam. The increase in power has no influence on the beam propagations factor K and on the diffraction factor M^2. They remain constant. The laser beam geometry for the focused laser beam is independent of the laser power. For increase or decrease of the laser power the focused laser beam has a constant geometry and a constant quality.

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