CHARACTERISTICS OF A CW AND PSEUDO PULSED YAG LASER OF 1,2 KW

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I ABSTRACT : The main characteristics of the beam are derived from its quality factor (or the Lagrange-Smith invariant). This parameter has been found to vary from 77 to 266 μm , as a function of the beam power, the source functioning mode (CW or pseudo-pulsed), and its transport modalities (throw an optical fiber or throw lenses and mirrors). The maximum power density delivered varies from 0,2 to 2 Mw/cm^2 . The size of the beam waist after the focalisation system, the depth of the field and the spatio-temporal distribution of the beam energy have also been determined. The knowledge of all these characteristics allows the user to control and reproduce the materials processing by the high power laser beam.

II INTRODUCTION :

The control of materials processing by a high power laser beam necessitates the knowledge of all the characteristics of the beam. Namely, the divergence, the size and position of the beam waist, its quality factor (or the Lagrange-Smith Invariant) defined as the product of the divergence by the beam waist, the mode factor and the field depth (or the Rayleigh distance), the spatial distribution of its cross section energy, the S.D.E., and its polarization. This study aims to present such characteristics for a 1,2 Kw cw and pseudo-pulsed laser beam delivered by a NEC YL 117 4C source type.

III EXPERIMENTAL TECHNIQUES :

The methodology followed in this study is the same that we have published elsewhere [1]. Its is based on the measurement of the beam diameter D as a function of the propagation distance Z . The measurement is done using the diaphragm method and a definition of the beam diameter as the one which let pass 86% of the total beam power (fig.1). The propagation law given by the following equation (see [2] for example) allows one to determin such characteristics :

$$D^2 = D_0^2 + \text{tg}^2\theta Z^2 \quad (1)$$

where D_0 is the beam waist size and θ is the divergence of the beam. The plot of D^2 as a function of Z^2 gives D_0 and $\text{tg}\theta$. The other characteristics are then given by :

- the Lagrange-Smith Invariant $I = D_0 \times \text{tg}\theta$
- the Rayleigh distance $Z_r = D_0 / \text{tg}\theta$
- the mode factor $K^2 = I(\pi/4\lambda)$
- the power density $D_p = 4P/(\pi D^2)$

where P is the beam power.

On the other hand, the SDE has been measured by a system comprising a CCD camera, a photo-electrical cell and a micro computer data acquisition and treatment system. It has been described in details else where [3], (fig. 2).

IV RESULTS

Table 1 and figure 3 give the characteristics of the beam at the output of the cavity for the CW and the pseudo-pulsed (PP) modes. Table 2 and figure 4 give the same characteristics after an index gradient fiber of 600 μm of diameter. Table 3 and figure 5 give them after a 75mm focal system.

Table 1 : Characteristics at the output of the cavity for the cw and 60Hz PP modes

Source power W	$\text{tg}\theta$	$D_{0\text{m.m}}$	$l_{\mu\text{m}}$	$Z_{\text{r.m.m}}$	κ^2
685 CW	0,0143	5,4	77	379	57
1020 CW	0,0188	5,4	102	286	75
1250 CW	0,0217	5,4	117	249	87
685 P.P.	0,0121	6,5	78	536	59
1020 P.P.	0,0157	6,4	100	408	75
1250 P.P.	0,0186	6,5	121	350	89

Table 2 : Characteristics at the output of the fiber

Source Power W	$\text{tg}\theta$	$l_{\mu\text{m}}$
685 CW	0,317	190
1020 CW	0,367	220
1250 CW	0,443	266
685 P.P.	0,345	207
1020 P.P.	0,341	205
1250 P.P.	0,368	221

Table 3 : Characteristics after a 75mm focal system (expander X3)

Source power W	$\text{tg}\theta$	$D_{0\mu\text{m}}$	$Z_{\text{r.m.m}}$	D_p (MW/cm ²) Power Density
685 CW	0,303	254	0,84	0,884
1020 CW	0,302	338	1,12	0,693
1250 CW	0,297	394	1,33	0,616
685 PP	0,345	226	0,66	2,02
1020 PP	0,325	308	0,95	1,577
1250 PP	0,326	371	1,14	1,632

They show that the Lagrange-Smith invariant ranges from 77 to 266 μm . This leads to a considerable variation of the beam waist after the focal system (from 254 μm to 603 μm). The Maximum power density varies from 0,2 Mw/cm² to 2,02 Mw/cm². The S.D.E. varies from a top hat distribution to a central maximum distribution when the power varies from 300 to 1200w and when the beam goes through the fiber (fig. 7).

V CONCLUSION

This study has presented the characteristics of a 1,2 Kw YAG laser beam delivered by a YL 117 4C NEC SOURCE. It showed that they vary considerably with the functioning mode of the source (cw or P.P.) and the transport mode of the beam (fiber or lenses). It is therefore absolutely necessary to determine them if one wants to fully control the materials processing by a high power laser beam.

VI REFERENCES

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Fig 1: propagation characteristics

Fig 2: S.D.E. measurement

Fig 3: Lagrange invariant versus power

Fig 4: Lagrange invariant versus power

Fig 5: beam waist versus power

Fig 6: power density versus mean power

After optical head

300 W

1200 W

After optical fiber

Fig. 7 : Spatial distribution of the Energy