Optica Applicata, Vol. XXII, No. 2, 1992

Circular diagram of power balance for laser cutting

E. Cojocaru

Institute of Atomic Physics, Laser Department, R-76900, Magurele—Bucharest, P.O. Box MG-6, Romania.

A circular display of three parameters on a bidimensional graph which is easy to access for data manipulation is applied to a simple laser cutting model.

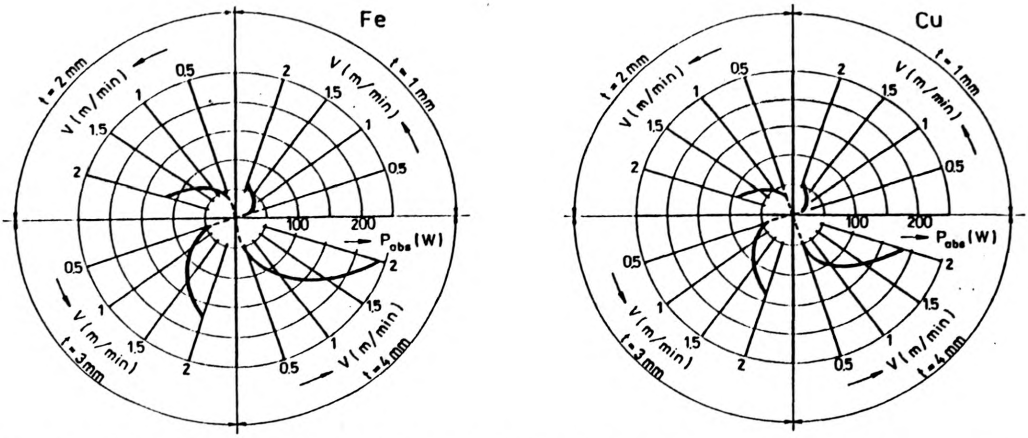
Laser cutting has received much theoretical and experimental attention as a complex laser—material interaction [1]–[5]. Many important parameters of this interaction, such as the absorption coefficient on the cutting front and the temperature and fluid flow velocity distributions, are neither directly nor routinely measurable. The optimum parameters such as, for example, the laser power, the cutting speed, the focal length of the focusing lens are determined experimentally for particular thicknesses of each material. Semi-empiric models based upon insights gained during experimentation giving an estimation of the above parameters could be useful to shorten the time of experimentation. The components of the models and their self-consistent cooperation are demonstrated in nomograms [4] which display the connection between different parameters.

In this work, a circular display of the minimum absorbed laser power necessary for cw CO_2 laser fusion cutting of a given material of various sheet thicknesses at different values of the cutting speed is presented. The simple model of power balance presented in [4], [5] is considered. An appropriate part $P_{abs} = AP_L$ of the incident laser power P_L has been absorbed at the cutting front and has to be transformed into heat

$$P_{abs} = P_t + P_m + P_l. \tag{1}$$

This equation of power balance contains the power-terms of heating P_t, melting P_m and losses by heat conduction P_l. Due to the calculations of this balance by using relations given in [4], [5], it is possible to make statements concerning the amount of laser power which will be necessary to cut a given sheet as a function of the cutting speed if the degree of absorption A on the cutting front is known. Two circular diagrams giving the minimum absorbed laser power estimated to be necessary for cw CO_2 laser cutting of iron and copper sheets are presented in the figure. The four quadrants correspond to four values of the sheet thickness t. The cutting speed v is displayed radially in every quadrant and increases counterclockwise. The laser beam absorbed power P_{abs} is represented by concentric circles increasing from the centre to the border.

The advantage of these circular diagrams consists in the possibility of displaying three parameters on a bidimensional graph which is easier to access for data mani-



Circular diagrams of power balance for cw CO_2 laser cutting of iron and copper sheets of various thicknesses t at different values of the cutting speed v, for a constant width of the cutting kerf $b = 0.2$ mm

pulation, compared to tridimensional graphs. This circular display could be accommodated for other parameters or components of an empiric or theoretical model for laser material processing.

References

[1] SCHUÖCKER D., ABEL W., SPIE **455** (1983), 88.
[2] DECKER I., RUGE J., ATZERT U., ibidem, p. 81.
[3] POWELL J., FRASS K., MENZIES I. A., FUHR H., SPIE **1020** (1988), 156.
[4] PETRING D., ABELS P., BEYER E., ibidem, p. 123.
[5] STEEN W. M., *Laser Material Processing*, Springer-Verlag, London 1991.

Received August 14, 1992