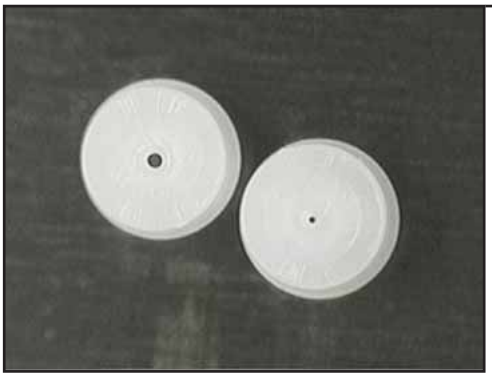
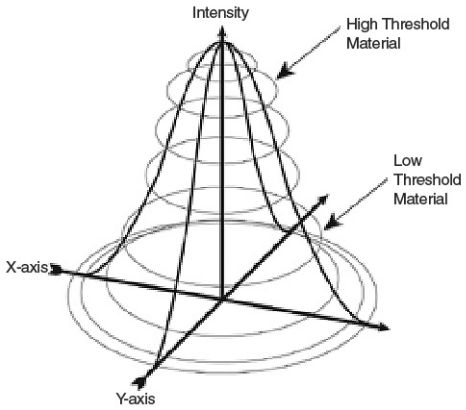
SYNRAD

"Tip Processing" Applied to Drilling



In the case of the polyacetal plastic shown here, nozzle diameters ranged from 75 microns to over 300 microns. This variety of hole diameters is due to two features of the laser: (1) the gaussian mode of the beam, and (2) the fine energy input control.



As shown in this figure, the method of drilling a hole smaller than the spot size is to precisely control the laser's energy input in combination with a high threshold material.

CO_2 lasers excel at drilling small holes (small defined as less than 0.01" in diameter). Small holes are drilled directly without trepanning, resulting in reduced cycle times. Direct drilling also highlights one of the unique characteristics of lasers - the focused spot from a single laser can produce a range of hole sizes in a range of different materials.

The term "tip processing" means that only the central part of the gaussian beam is used for drilling. As the circular diameter of the gaussian beam decreases, the power density at the outer edge increases. This power density level corresponds to an effective beam diameter. Every material has a threshold of power density required for processing; below this level the material is unaffected, hence the term "tip processing".

Ultimately, the wavelength of the laser will limit how small a focused spot can be. For a Synrad laser, the 10.6 micron CO_2 wavelength allows spot sizes as small as 100 microns without the addition of specialized optics. With a properly sized expander/collimator and an aspheric lens however, spot sizes down to 25-30 microns (roughly 2.5 times the CO_2 wavelength) are possible. With a smaller diameter beam, power density is concentrated in a smaller area resulting in a smaller heated area.

In the case of the polyacetal nozzles, a burst or train of pulses from the laser delivered a precise amount of energy into the material. The final hole diameter depends on where that energy level matches the threshold of the material on the beam's gaussian profile. Additionally, the number of pulses, pulse duration, and pulse frequency enter into the equation. Alter the number of pulses to make small increases in hole diameter; change pulse duration and/or frequency to create larger holes. In many cases, you can hold laser power to a constant value while changing only the laser's pulsing characteristics. To produce holes larger than the spot diameter, use excessive pulse power to enlarge the hole via heat conduction. In the case of larger holes, assist gas is not required since it can disrupt the drilling process causing ragged outer edges.

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