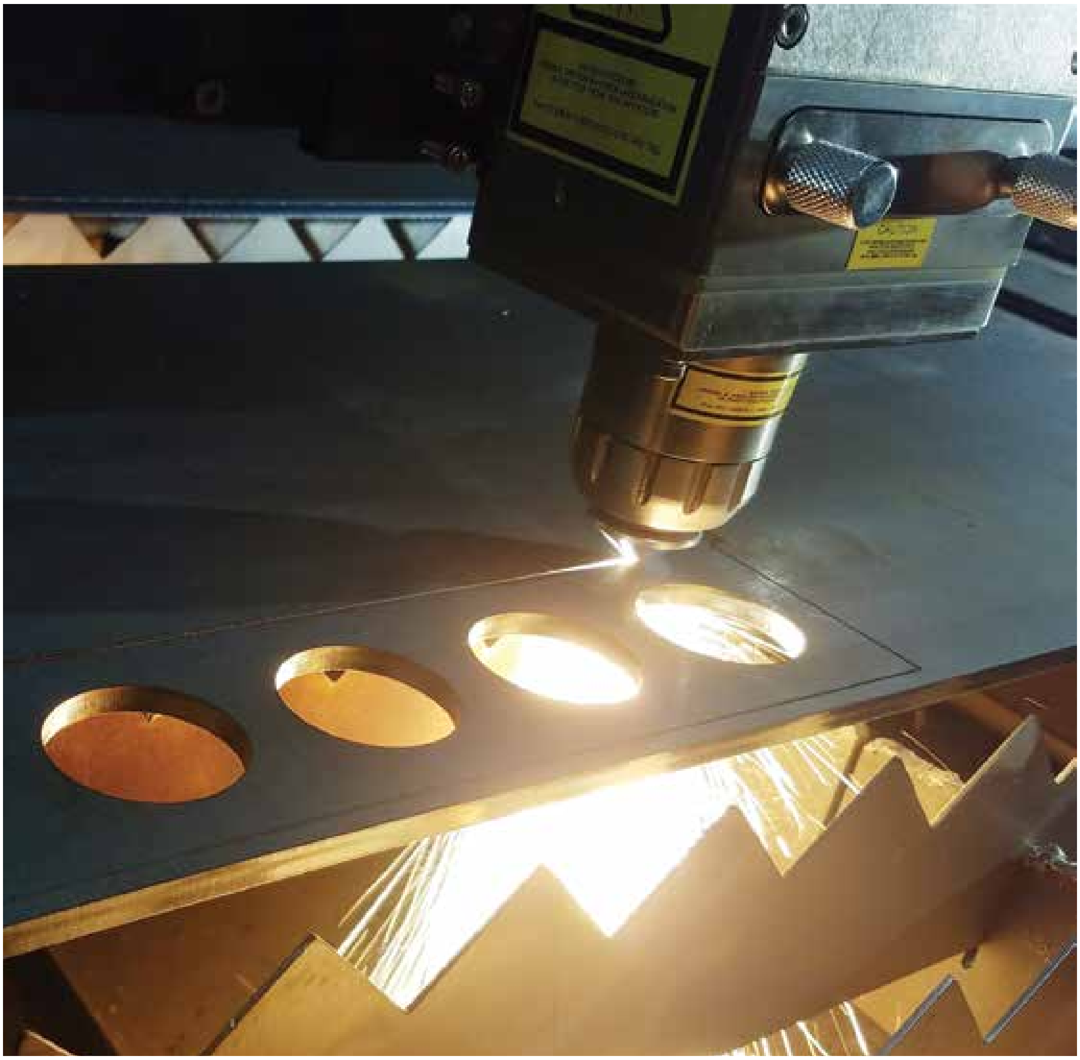
Ultra-High-Power Fiber Lasers Change the Competitive Landscape of Cutting

WITH THE INTRODUCTION of kilowatt-level fiber lasers in the early 2000s and their subsequent integration into cutting tools in the late 2000s, fiber lasers have transformed laser cutting from a niche method to a mainstream fabrication process. Since then, fiber lasers have dominated the laser cutting of sheet metals because of their ease of integration, reliability, low maintenance, and low capital and operating costs versus prior laser technology, high cutting speeds, and the possibility of scaling up their power. The laser cutting market has grown more than 10 percent annually in the past decade, more than double the rate of other profile cutting processes.

In recent years, the fabrication industry has seen rapid adoption of ultra-high-power (UHP) fiber lasers in the range of 10 to 40 kW for cutting. By following state-of-the-art laser cutting systems



Laser cutting of carbon steel. (Photo provided by Ipg Photonics)

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each year on FABTECH's exhibition floor or in its educational seminars, one would have noticed that the maximum power available for cutting has dramatically risen from 6 kW in 2016 to 40 kW in 2022, a nearly sevenfold increase in six years. In the past three years alone, the maximum laser power on cutting systems has jumped from 15 to 40 kW. The fast pace of UHP laser developments has continued this year, led by two notable recent developments: The availability of the 50-kW fiber laser for cutting and its testing in the field; and the release of high-efficiency UHP fiber lasers with electrical efficiencies of more than 50 percent, which offers significant energy savings for high-power cutting applications with high-duty cycles.

The overlapping of three major developments in the past few years has made the UHP cutting trend feasible, namely lowered cost/kW-power of fiber lasers, availability of cutting heads that can handle the ultra-high laser power, and better knowledge of application engineering regarding high-power laser cutting.

Cutting speeds dramatically rise with greater laser power, leading to a substantial reduction of operating costs (including gas usage, cycle time per part, and energy consumption per part) and significantly lower cost-per-part. Cutting speed of most stainless steel thicknesses, for example, more than quadruples by increasing power from 6 kW to 15 kW, while utilizing the same assist gas pressure and nozzle size (i.e., same gas flow) in both low- and high-power cutting, leading to a multiple-fold reduction in gas usage and other operating costs.

UHP lasers also allow for dross-free cutting of thick carbon steel and stainless steel with high-pressure air instead of more expensive nitrogen, or oxygen cutting that is much slower. Cutting with air-assist gas is significantly faster than oxygen cutting at high laser powers, as in air cutting—unlike with oxygen cutting—the speed scales up with laser power. For example, when cutting 16-mm thick carbon steel with a 30-kW laser, the cutting speed is greater than 9 m/min with air-assist gas, but is only about 2 m/min while using oxygen.

When cutting with nitrogen-assist gas for 10-mm thick stainless steel, the cutting speed increases from about 2 m/min at 6 kW to more than 12 m/min at 15 kW, a sixfold increase with a 2.5X jump in power. This increased speed easily drives a two- to threefold drop in cost-per-part for most part designs. However, a twofold more productive laser cutting system is not twice as expensive as the cost of the laser source per kilowatt decreases with increasing laser power and the higher laser cost is absorbed in the overall machine tool cost.

By significantly improving cutting speeds, UHP has made laser cutting more competitive versus mechanical-cutting methods such as punching, while preserving the unique advantages (namely flexibility, lack of tool wear, non-contact cutting, and ability to cut intricate thin walls). The advantage of punching versus any profile-cutting process such as laser, is typically in the mass manufacturing of parts of relatively simple geometries, for which the initial upfront tooling cost can be justified. However, as the fabrication industry increasingly demands more flexibility, the high cutting speeds provided by UHP lasers have shifted the cost consideration of laser vs. punching in favor of lasers.

Before the rise of high-power lasers, the common assumption was that lasers were best suited for thinner cutting while plasmas targeted thicker cutting. Although, plasmas do perform well in cutting thick metals, the dramatic rise in laser power over the past six years has elevated the perceived laser/plasma thickness boundary in favor of lasers every year.

Application tests have shown high-quality laser cutting of metals up to 100-mm thick with 30 kW. Recent tests show that with 40 kW, carbon-steel laser cutting up to 230-mm thickness can be achieved with air-assist gas. Comparative tests between UHP lasers and high-power plasma show that 40-kW fiber laser cuts of stainless-steel sections 12 to 50 mm thick are 3-4X faster, and mild steel sections 12 to 30 mm thick are 3-4.5X faster with laser. Thanks to ultra-high productivity, increased thickness capabilities, and good cut quality (dross-free, near taper-free cuts), lasers with 15 kW power and higher are replacing plasma cutters in an increasing number of applications.

In summary, ultra-high-power lasers in the 10 to 50 kW range are changing the competitive landscape of metal-cutting processes by enabling ultra-high productivity and lowered cost-per-part, as well as improved range and quality of thick cutting. UHP laser cutting reduces manufacturing costs by decreasing assist gas consumption per part, replacing N_2 and O_2 assist gases with compressed air while preserving the quality, reducing electricity consumption per part, and reducing machinery footprints and the number of required machinery operators.

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These powerful benefits are expected to become even more compelling as ultra-high-power lasers continue to increase in power and energy efficiency, which expands their ability to transform cutting applications across different industries. In a few years, lasers' ultra-high power may not seem "ultra" after all.

Laser processing is a fast-changing field. To learn the fundamentals and get up-to-date training on laser cutting, laser welding, and other laser applications, including more details on ultra-high-power laser cutting, look for this year's laser sessions at FABTECH 2022 in Atlanta (Nov 8-10).

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