



Image source: Sergey Bogomyako / Adobe Stock. All others: iPG Photonics

Laser cutting (left frame) and plasma cutting (this frame) for sheet metal fabrication

## Advantages of ultrahigh-power laser cutting over plasma cutting

### Background of the technology shift in the metal cutting industry

Fahrettin Ucar

In heavy metal fabrication, a technological shift is blurring the line between laser and plasma cutting. High-power fiber lasers, once limited to thin sheet applications, are now challenging plasma cutters even in thick plate cutting. This article examines the state of the market, compares performance metrics, analyzes economic factors, and explores the strategic impact of adopting high-power laser technology, using objective data from industry examples.

For decades, the rule of thumb was “use plasma for thick, rough work and lasers for thin, precision work”. This distinction was historically justified by process limitations. Plasma cutting, based on an electrical arc and ionized gas jet, offered robustness and cutting capability for heavy plates, while laser cutting

was restricted to thinner materials. However, recent advances in fiber laser technology have significantly altered this balance. Today’s ultrahigh-power (UHP) fiber lasers in the 20–60 kW range can cut steel plates with a thickness of up to 40–50 mm with industrially acceptable quality. In controlled conditions and for selected materials, more than 80 mm are technically feasible, although typically at reduced cutting speeds and with limited industrial adoption. As a result, laser cutting increasingly overlaps with plasma and even oxy-fuel cutting in applications previously considered impractical for lasers.

Industry demand for these thickness ranges is primarily driven by construction, shipbuilding, heavy machinery, and general industrial manufacturing. In the construction sector, laser cutting is applied to structural steel base

plates and profiles, commonly in the 10–40 mm range, with occasional requirements extending up to 80 mm. These parts are frequently welded after cutting, making edge quality and weldability critical. In shipbuilding, the focus lies on two-dimensional cutting of very large plates, typically 12–40 mm thick, processed on large-format machines with extended tables. Heavy machinery and general manufacturing exhibit a broader thickness distribution, sometimes exceeding 100 mm, while still requiring precise features such as small holes or complex contours.

### Market drivers for the technology shift

Several factors are driving the gradual transition from plasma to laser cutting in heavy plate applications.

One of the primary drivers is the reduction in cost per part enabled by higher cutting speeds and increased throughput. Although the capital expenditure for a high-power laser system remains higher than that of a plasma cutting machine, the productivity gain can significantly reduce unit production costs when the machine is sufficiently utilized.

Another important driver is improved weldability. Laser cutting typically produces clean, oxide-free edges with minimal heat-affected zones, which often eliminates the need for secondary edge preparation prior to welding. Plasma cutting, by contrast, frequently requires grinding or other surface treatment to achieve comparable weld quality.

Lower post-production requirements further contribute to the economic advantage of laser cutting. The narrow kerf and superior perpendicularity of laser cuts reduce dimensional deviations and taper, thereby minimizing downstream rework. In addition, manufacturing efficiency plays an increasingly important role in high-cost industrial environments. Higher throughput per square meter of production space allows a single laser system to replace multiple plasma machines, reducing the cost associated with factory floor area. Environmental considerations also support the shift, as laser cutting generally produces fewer fumes and waste, and lower overall emissions, which is becoming increasingly relevant under tightening workplace regulations.

### Interdependence of market drivers

While each of these drivers provides incremental justification for laser adoption, their combined effect creates a structural shift in fabrication economics. Cost-per-part reductions alone are rarely sufficient to justify higher capital investment. However,

when coupled with improved weldability and reduced postprocessing, the cumulative impact extends beyond cutting speed into overall production flow. Reduced edge preparation shortens lead times, lowers labor intensity, and improves consistency in downstream operations such as welding and assembly.

Space efficiency further amplifies this effect in high-cost industrial areas. As workshop layouts become constrained by floor space, throughput per square meter emerges as a decisive metric. In such environments, replacing multiple plasma systems with a single high-power laser does not merely consolidate equipment but fundamentally alters capacity planning and material flow. This shift is particularly relevant in mixed-production settings, where flexibility, rapid changeover, and consistent part quality outweigh the advantages of lower initial capital expenditure.

Consequently, the market transition from plasma to laser cutting is not driven by a single dominant factor, but by the convergence of economic, operational, and spatial constraints that collectively favor high-power laser technology once defined utilization and application thresholds are exceeded.

### Technical advancements enabling the technology shift

The expansion of laser cutting into heavy plate applications has been enabled by several key technological advancements. Foremost among these is the availability of ultrahigh-power laser sources reaching up to 60 kW while maintaining industrial-grade reliability and uptime. High reliability is essential, as the economic rationale for laser adoption depends strongly on sustained throughput.

Improvements in beam delivery technology have also played a critical role. The ability to transmit

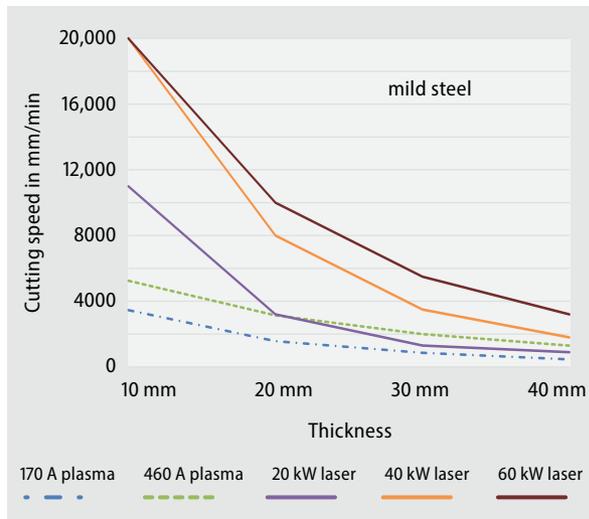
multikilowatt laser power over long fiber lengths enables flexible machine layouts and supports large-format cutting systems required in construction and shipbuilding. In parallel, the development of ultrahigh-power cutting heads with advanced thermal management, low focal shift, and integrated monitoring has made stable high-power operation feasible in industrial environments.

Assist gas technology represents another important enabler. For mild steel cutting, mixed gas processes combining nitrogen and oxygen can significantly increase cutting speed within defined thickness limits. As an illustrative example, mixed-gas cutting is typically applied up to approximately 20 mm thickness for a 20 kW laser system, while 40 kW systems can extend this range to around 40 mm under optimized conditions. Beyond these limits, pure oxygen is generally required, which reduces the speed advantage of laser cutting while preserving its geometric and metallurgical benefits.

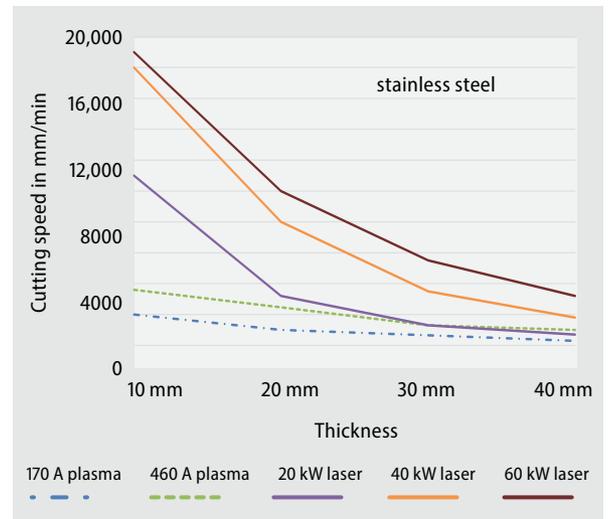
### Performance comparison

From a performance perspective, laser and plasma cutting rely on fundamentally different physical mechanisms. Plasma cutting removes material by melting it with a high-temperature plasma arc, which results in a relatively wide kerf and a larger heat-affected zone. Laser cutting, by contrast, concentrates energy into a focused light beam that rapidly melts material, producing narrow kerfs and limited thermal diffusion. These differences directly influence cutting speed, edge quality, and dimensional accuracy.

As illustrated in the speed comparison (Figs. 1 and 2), lasers exhibit a clear advantage in the 10–20 mm thickness range for both mild and stainless steel. At higher thick-



**Fig. 1** Speed comparison on mild steel with different thicknesses



**Fig. 2** Speed comparison on stainless steel with different thicknesses

nesses, such as 40 mm, high-power lasers in the 40–60 kW range continue to maintain a speed advantage over high-definition plasma systems, although the margin decreases with increasing thickness. The advantage is particularly pronounced for stainless steel where the performance gap is even bigger.

### Interpretation of performance differences

Beyond absolute cutting speed, the performance differences between laser and plasma cutting have important implications for industrial productivity. Higher cutting speeds at moderate thicknesses directly translate into increased machine throughput, enabling a greater number of parts to be produced within a fixed shift duration. In laser cutting, this advantage is amplified by shorter pierce times, smaller piercing diameters, higher positioning accuracy, and reduced need for lead-in and lead-out allowances, which collectively improve effective cutting time per part.

The narrowing speed gap observed at higher thicknesses does not eliminate the performance advantage of laser cutting. Even when linear cutting speeds approach

those of high-definition plasma systems, laser cutting still offers superior edge quality, more consistent kerfs, and higher dimensional accuracy. These characteristics reduce secondary operations and allow tighter nesting of parts, thereby improving material utilization and overall production efficiency.

### Cost comparison

Cutting performance alone does not determine technology selection; economic considerations are equally important. Laser and plasma cutting systems differ substantially in their cost structures. Laser cutting machines require higher initial investment and depreciation costs, whereas plasma systems tend to incur higher variable costs related to consumables, labor, and postprocessing. Based on the assumed utilization level and the fixed and variable cost parameters, high-power laser systems achieve a lower cost per part across a broad range of material thicknesses.

### Assumptions for cost-per-part analysis

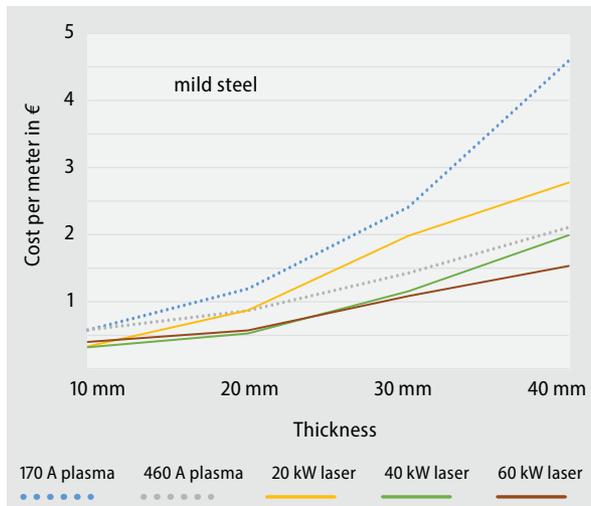
To ensure a consistent and transparent comparison of cost per part

between laser and plasma cutting technologies, a standardized set of economic and operational assumptions was applied.

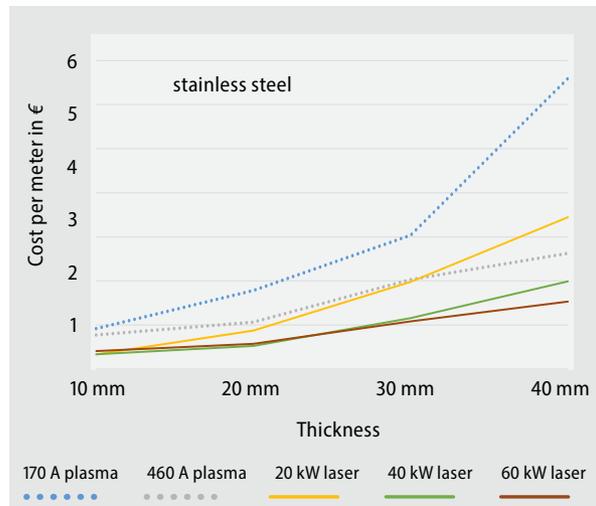
For the cost structure, expenses were categorized into fixed and variable components. Fixed costs were defined as those independent of production volume within the assumed operating regime and include depreciation associated with capital investment, scheduled machine maintenance, direct labor, and overhead costs. These costs were treated as fixed under the assumption that the machines operate at stable staffing and overhead levels within the defined utilization scenario.

Variable costs were defined as costs directly proportional to machine operating time and include electrical energy consumption, cutting consumables, and assist gas usage. These elements scale with production output and differ significantly between laser and plasma cutting processes.

All machines were assumed to operate under full utilization of the available production shift, defined as one shift per day under typical German industrial conditions. This assumption reflects a common baseline for European fabrication



**Fig. 3** Cost per part comparison on mild steel with different thicknesses



**Fig. 4** Cost per part comparison on stainless steel with different thicknesses

workshops and allows a consistent comparison of cost efficiency between technologies without introducing multishift complexity.

### Assumptions for cutting performance

For the cutting process itself, an average of four piercings per meter of cutting length was assumed, reflecting typical geometries found in structural and heavy-plate fabrication. In addition, a seventy percent duty cycle for laser emission or plasma arc on-time was assumed, accounting for non-cutting movements, pierce delays, and process stabilization periods. This value represents a realistic average for industrial cutting operations and avoids overstating achievable productivity.

For example, at 40 mm mild steel thickness, a 60 kW laser system can achieve a cost-per-part advantage of approximately thirty percent compared to a 460 A plasma system, with even larger advantages observed for stainless steel. At lower thicknesses, the cost gap further increases in favor of laser cutting due to higher relative productivity (Fig. 3). The same holds for stainless steel (Fig. 4).

### Decision framework

The choice between laser and plasma cutting ultimately depends on utilization, application requirements, and economic constraints. Because laser systems combine higher capital cost with lower unit production cost, their economic advantage increases with higher utilization. In single-shift operations with moderate utilization, payback periods for the additional investment typically range between one and two years.

In high-utilization environments, such as facilities operating multiple shifts, the payback period can be significantly shorter. For example, replacing three 300 A plasma cutting machines with a single 40 kW laser system can consolidate throughput while reducing labor, postprocessing, and floor space requirements. In such configurations, payback periods in the range of 18 to 24 months are achievable, depending on local cost structures.

Laser cutting is particularly advantageous when parts require fine features, small holes, or high-quality edges suitable for direct welding. Plasma cutting remains a viable option for low-utilization scenarios or applications where capital expenditure constraints dominate

and the benefits of laser cutting cannot be fully realized.

### Conclusion

The ongoing laser versus plasma cutting debate has shifted decisively in favor of lasers for a growing range of heavy plate applications. Advances in ultrahigh-power fiber laser technology have extended laser cutting into thickness ranges once reserved for plasma and oxy-fuel processes. When combined with superior cutting quality and favorable cost-per-part economics at sufficient utilization levels, laser cutting represents a compelling alternative for modern fabrication environments.

### Author

#### Fahrettin Ucar

Commercial Product Specialist  
IPG Photonics GmbH & Co. KG  
Carl-Benz-Str. 28  
57299 Burbach  
Germany  
phone: +49 (0) 151 64026108  
e-mail: fucar@ipgphotonics.com  
Website: www.ipgphotonics.com