GMA GARNET GROUP

WATERJET VS LASER CUTTING:

A Comparative Analysis

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Waterjet vs Laser Cutting: A Comparative Analysis

Are you looking for new ways to keep metal-cutting costs down? Trying to decide which cutting method is worth your investment?

Waterjet and laser cutting are two similar but distinctly separate methods for cutting metal. Each has its own unique benefits, costs, and drawbacks. This guide analyzes the core differences between the two cutting methods, comparing, and contrasting the processes to give thorough clarifications of each one.

By the end of our guide, you'll be fully equipped to make an informed judgment over which cutting method is for your specific project or operation.

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Introduction

Keeping operational costs down is a top priority for many companies, particularly in the uncertain and unpredictable world of modern business. Enterprises are constantly looking for ways to cut costs, which is where technology flourishes.

Historically, metal cutting was done by manual labor. Metalworking is an age-old profession dating back to the Bronze Age, where specialist blacksmiths would fashion weapons from smelted ore. The Industrial Revolution of the late 1700s made the process of cutting metal easier, but it was still an arduous process done by hand.

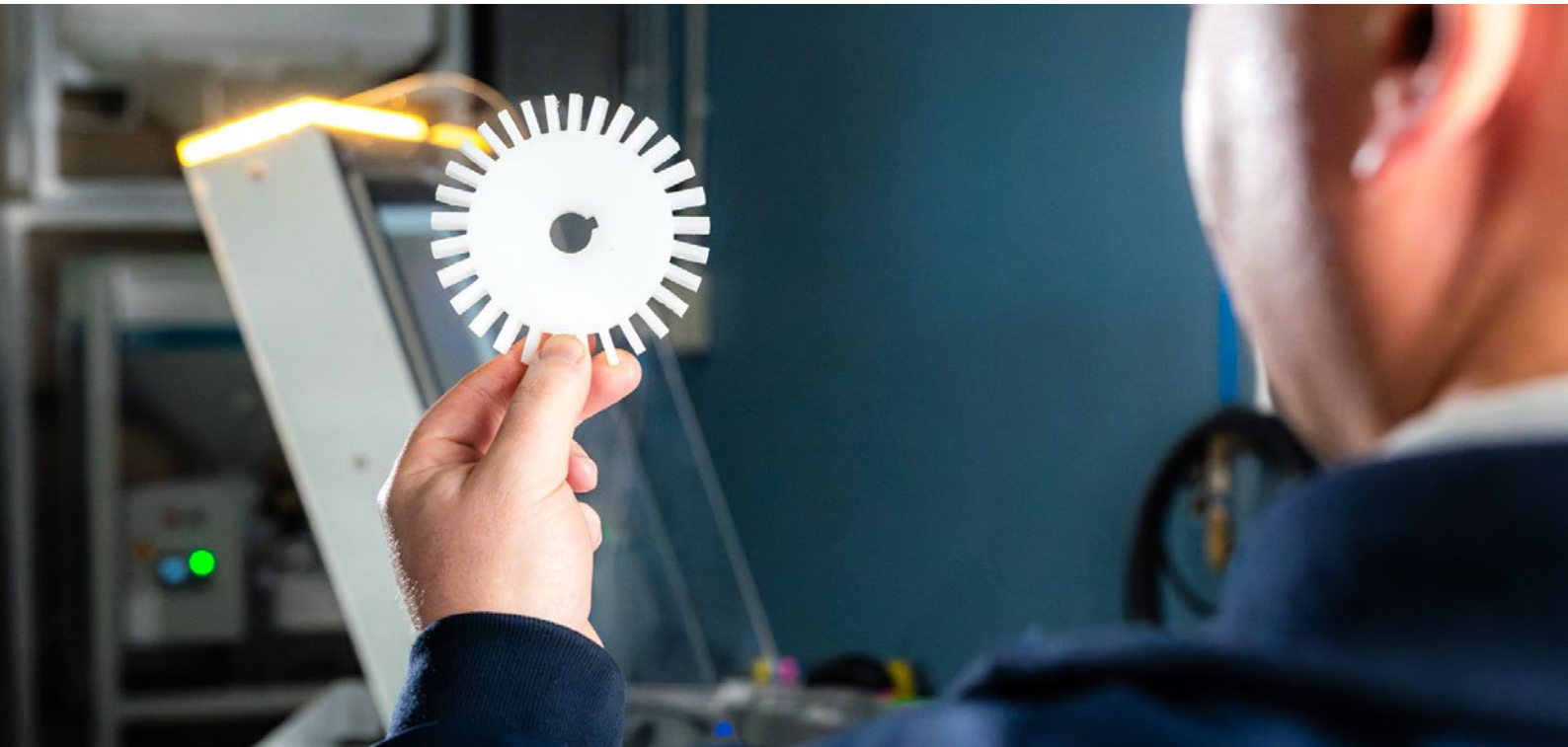
Metal became an essential material for many industries, including construction, mining, textiles, and transport. These industries required large amounts of heavy machinery, which meant metal cutting established itself as a vital part of manufacturing. Over the years, in an attempt to procure more efficient methods, inventors constantly sought alternative ways of cutting metal using non-manual methods. Steam-powered waterjet cutting emerged in the late 1800s, followed by laser cutting in the mid-twentieth century.

In recent decades, these two technologies have emerged as the frontrunners of the metal-cutting industry. Each method offers varying benefits, costs, and solutions, requiring different inputs to produce similar but ultimately distinct results. Due to stark differences in processes and purposes, you must carefully consider your options when choosing a metal-cutting technology.

Your choice of cutting method should relate to your budget, scale, and specific requirements. You must select a technology that your enterprise can afford, but that can also cut through your desired materials.

> Waterjet and laser cutting share many similarities but are best utilized for distinct applications.

This guide offers an in-depth exploration of both processes, delving into the benefits, downsides, costs, applications, and quality of waterjet and laser cutting. By the end, you'll have all the information you need to make an informed decision on which technique to pursue for your company.



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Overview of Cutting Technologies

2.1 Waterjet Cutting

Waterjet cutting started in 1968 by Dr Norman Charles Franz, a professor at the University of British Columbia, Canada, where he patented the concept of waterjet cutting, using pressure up to 700 bar.

In 1983, The first abrasive waterjet machine was used to cut glass, and by the end of that year, aviation and space industries started purchasing abrasive waterjet machines when they discovered the material to be ideal for cutting stainless steel, titanium and composites.

Dr Norman Charles Franz

Dr Mohammed Hashish

Dr Eng.Yih-Ho Michael Pao

WATERJET CUTTING TIMELINE

1968

- Waterjet cutting started in 1968 by Dr Norman Charles Franz, a professor at the University of British Columbia, Canada.
- He patented the concept of waterjet cutting that uses pressure up to 700 bar.

1970

- A small group of Boeing scientists created “Flow Research” and discovered the pure waterjet cutting technique.
- Cut only soft materials, such as wood, plastics and paper.

1974

- Flow International based in Kent, WA, was founded, under the leadership of Dr. Eng. Yih-Ho Michael Pao.
- Improved and developed high-pressure waterjet systems to become tools for industrial cutting, drilling and milling.

1979

- Dr Mohammed Hashish joined Flow Research Inc., now Flow International Corporation in Kent, Washington, U.S., as a research scientist, in early 1979 with the main task to invent a system where garnet particles can be added to the waterjet cutting head to improve cutting speed and the quality of cut on hard materials, such as stone, glass and metal.

1983

- The first abrasive waterjet machine was used to cut glass.
- By the end of 1983, aviation and space industries started purchasing abrasive waterjet machines when they discovered that they are perfect for cutting stainless steel, titanium and composites.

1995

- Abrasive waterjet cutting gained popularity.
- Many small businesses purchased waterjet machines to serve the demand of various industries.

2006

- KMT Waterjet Systems Inc., manufacturer of high pressure, precision pumps and components for waterjet cutting systems launched the next generation of waterjet pumps with ultra-high pressure (UHP) 90,000 PSI/6.200 bar at the international fair “ EuroBlech” in Germany.

Today

- Waterjet machines can be used to cut all types of materials, from aluminium to stone and ceramics.
- Due to constant technology improvements, waterjet cutting capabilities are still evolving till today.

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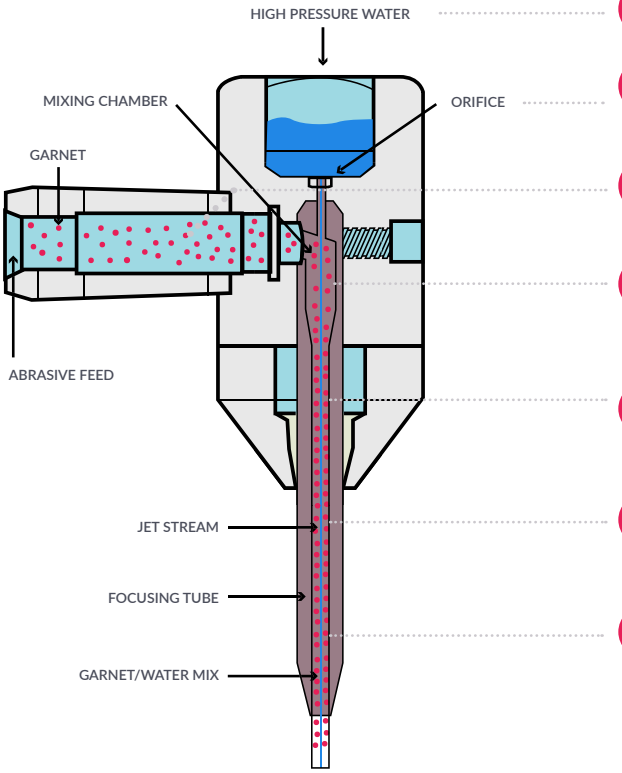
2.1 Waterjet Cutting

i) How it works: The physics behind waterjet streams

Waterjet machines send water through a special pump, which ramps up the pressure and fires the water through a tiny opening at a velocity greater than the speed of sound. Most machines operate using pressures of around 60,000 PSI, but it's common for waterjet streams to reach upwards of 87,000 PSI.



1. A high-pressure pump (Positive Displacement Direct Drive or Intensifier) generates high-pressure water at up to 90,000 psi / 6,200 bar.
2. Transitioned into high-velocity water as it flows through an orifice (made from ruby, sapphire, diamond or TetraCORE™) into the cutting head/mixing chamber.
3. Garnet particles are introduced into the water stream to create an abrasive sheath over the water stream. This form greatly increases cutting performance with any material.
4. In the mixing chamber, the high-velocity water stream – which travels at more than three times the speed of sound – creates a Venturi effect that pulls the garnet particles into the water stream from a separate abrasive feed line.
5. Rubbing action between the outer wall of the water stream and inner wall of the mixing tube accelerates garnet particles from zero to one-fifth of the water stream velocity.
6. Garnet particles are not able to penetrate the water stream due to shear force but are entrained along the outer wall of the water stream.
7. The high-velocity garnet particles are essential in the cutting process, while the primary function of the high-pressure water is to accelerate the garnet particles to the maximum possible velocity. This generates the energy to cut a variety of hard materials.

> Garnet remains the most popular abrasive choice since it's both cost-effective and tough.

Before the water is released, an abrasive substance is added to increase the cutting power of the jet to be able to cut hard materials such as stone, metal and glass.

Other materials have been rigorously tested, but garnet remains the best option in regard of cutting speed, edge quality and component lifetime. Garnet has been considered as the most versatile cutting solution for waterjet. The addition of an abrasive allows waterjet streams to cut through hard materials like metal, stone and glass.

At GMA, our abrasives utilize only the hardest almandine garnet. This mineral's high density, toughness, and hardness make it the perfect addition to waterjet cutting methods. With our uniquely strong garnet, you can cut through metal easily and effectively.

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ii) Benefits of waterjet vs other non-traditional cutting techniques

Waterjet isn't the only non-traditional method of cutting metal, yet it's the one that most benefits engineers and manufacturers. In contrast to other metal-cutting processes like plasma and laser cutting, which rely on heat to burn through materials, waterjet is a cold-cutting process.

This prevents the formation of heat-affected zones (HAZs), areas around the cut which become damaged or discolored due to heat exposure. Certain industries, such as the aviation sector, don't allow HAZs in their manufacturing processes, as they pose risks for their machines.

Here's a summary of the key benefits of waterjet cutting:

No HAZ (heat affected zones): For certain cutting processes HAZ are not allowed, especially in the aviation industry. Waterjet is considered as a cold cutting process, meaning that no heat is used in the cutting process.

High-quality finish: Waterjet is known for its near-pristine cutting quality, creating smooth and unblemished edge finishes on a wide variety of materials. Enterprises worldwide favor waterjet for its quality of cut.

Versatility: Waterjet is a far more versatile process and can be used to slice through a wide variety of materials. From tough surfaces like stone and metal to more fragile materials like paper and glass, a waterjet's pressure can be adjusted to precisely cut through whatever materials you require.

Cost-effective: Waterjet machines, despite their higher initial purchase and operational costs compared to some other metal-cutting methods, may offer a more favorable long-term cost efficiency. When considering the total operational costs, including potential re-work, waterjet machines can sometimes be more economical than laser cutting methods. Additionally, the return on investment (ROI) for waterjet machines could be faster compared to laser cutters of similar quality, making them an attractive option for companies looking at long-term financial efficiency.

No secondary finishing required: Waterjet machines create a desirable end result on the first cut. This means that no additional reworking, sanding, or cutting is required to achieve your desired results.

iii) Drawbacks of waterjet cutting

While waterjet is the preferred cutting method of many enterprises thanks to its versatility, cost-effectiveness, and cutting quality, the process isn't without its drawbacks. Here are some of the main downsides to waterjet in relation to other non-traditional cutting techniques:

- **Slower cutting speed:** Waterjet cutting isn't slow, but it sacrifices some of its speed for a more improved finish and cut quality. Other techniques like laser cutting are faster for thin sheet metal, producing a poorer finish on high thicknesses as a result.

- **More frequent maintenance:** Waterjet machines may require more frequent maintenance compared to laser cutters. This includes regular checks of the cutting head and pump components, as well as occasional replacement of parts. These maintenance needs should be considered when evaluating the operational costs of using waterjet technology.

iv) GMA: Abrasive specialists

GMA is one of the world's leading manufacturers of high-quality garnet for waterjet machines. We control our entire supply from mine to machine, with world-class processing facilities to guarantee every batch contains consistent-sized grains of the purest garnet.

Through repeated X-ray diffraction testing and composition analyses, we ensure the quality of our garnet remains exceptional. Our garnet consistently outperforms others on the market, reducing waterjet cutting time significantly and saving operational costs as a result.

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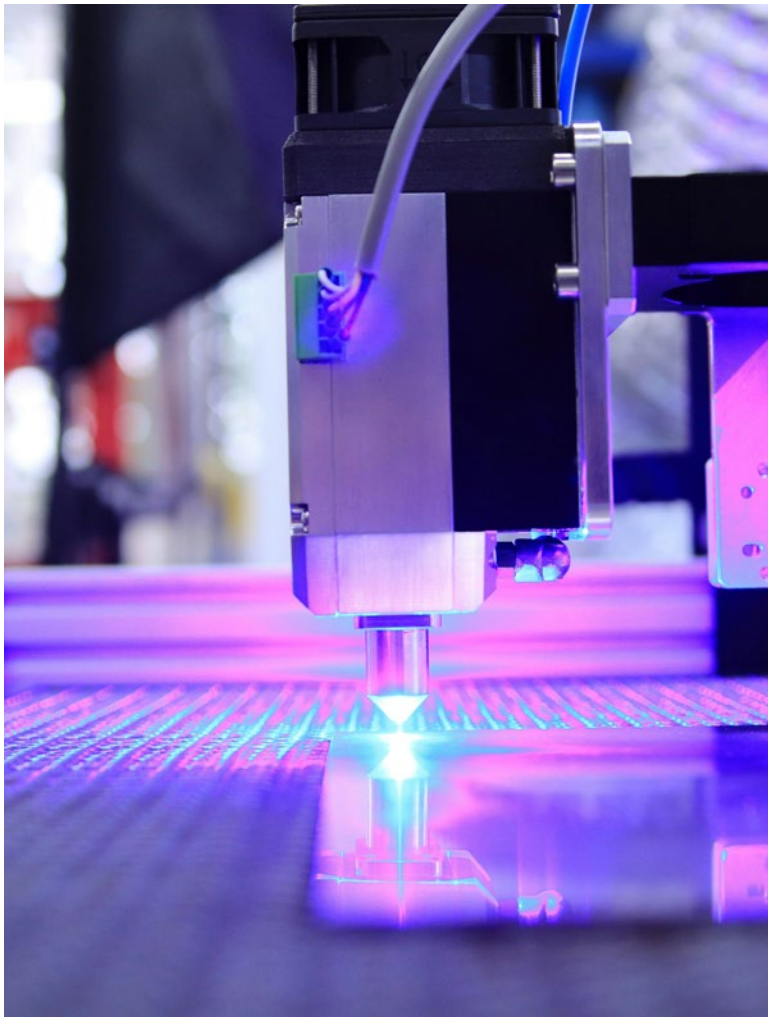
2.2 Laser Cutting

The term “laser” was first coined in the 1960s and is an acronym for “light amplification by stimulated emission of radiation”. The first laser-cutting technology emerged that same decade with the development of machines that could slice through diamonds, metals, and textiles.

> In the years since its invention, laser cutting has become a popular process in many industries, and it is now widely available.

It’s constantly evolving and adapting to cut new materials, and there are now many opportunities to use this technology. Modern machines use a high-quality lens to focus the laser with immense precision onto the desired cutting spot. The heat from the laser vaporizes the material underneath, melting it away and creating a smooth finish.

By adjusting the strength of the laser, engineers can determine how far to cut through a material. Laser-cutting machines can etch and engrave a variety of soft surfaces, such as acrylic and wood, while completely vaporizing hard materials like metal.



i) Different lasers for different applications

Laser cutting is never a “one size fits all” approach. There are several different types of laser used in manufacturing and construction, each with its own distinct properties and applications. Three of the most common types of lasers utilized in laser-cutting processes include:

- **CO_2 lasers:** CO_2 lasers are the most common type used in laser cutting, largely due to their relative versatility, efficiency, and simplicity. These types of lasers are formed by passing an electric current through carbon dioxide gas and can cut through a wide variety of materials, including titanium, steel, aluminum, plastic, and wood.
- **Nd/Nd:YAG lasers:** Nd and Nd:YAG lasers are identical in style but different in application. The latter is used where higher power is required, but both types can be used for boring and engraving. The core industrial uses of Nd and Nd:YAG lasers are to engrave metals and ceramics.
- **Fiber lasers:** Unlike CO_2 lasers, fiber lasers are created using solid materials and optical fibers. They are becoming increasingly popular in the metal-cutting industry thanks to their improved efficiency, cutting speed, reliability, and upkeep simplicity.

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ii) The benefits of laser cutting

Laser cutting is a popular process in the manufacturing and construction industries. It has remained widely utilized thanks to a variety of benefits, including:

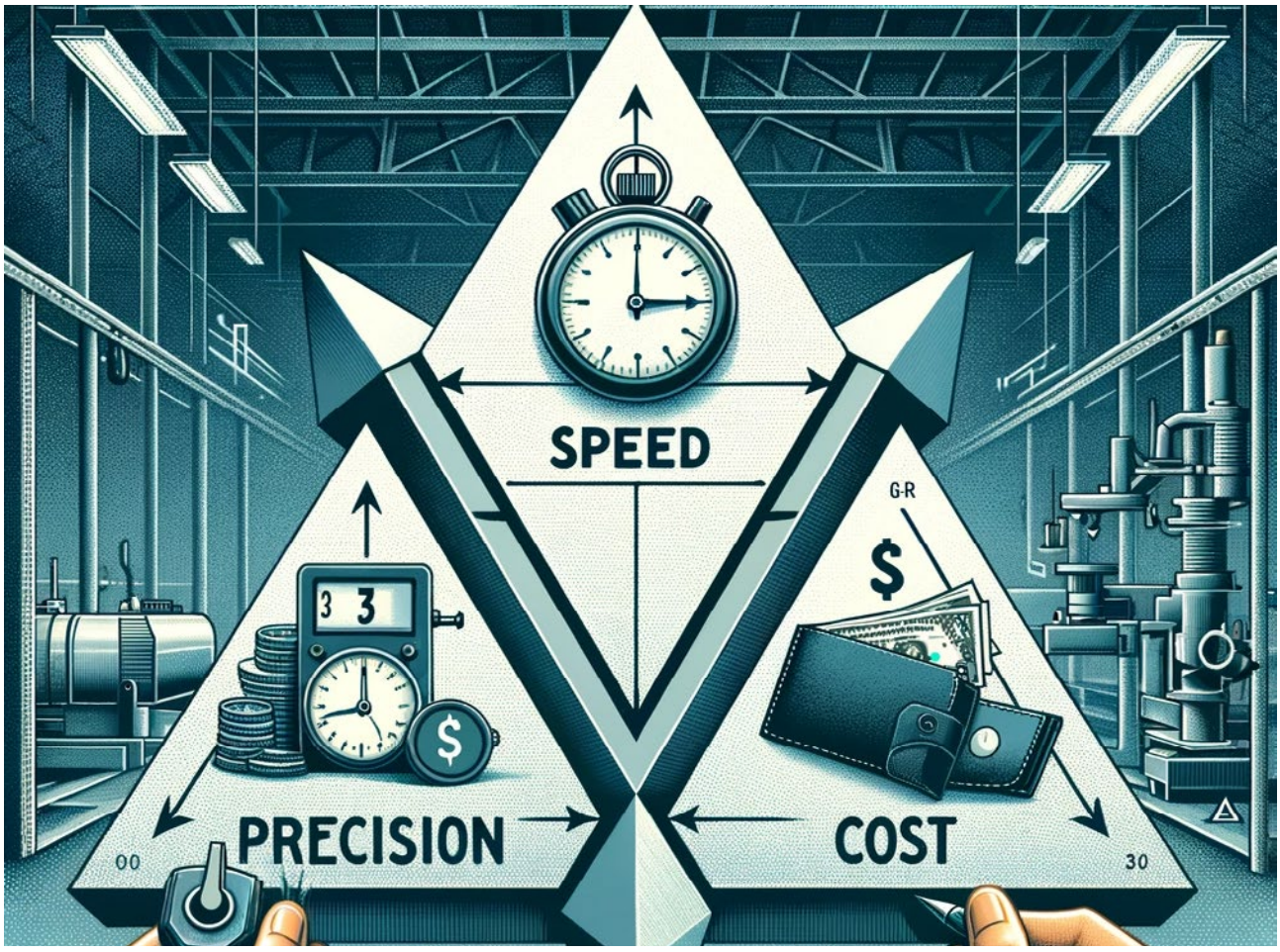
- **Precision:** Laser cutting allows you to achieve exceptionally precise cuts and intricate engravings. This is particularly valuable in the medical and aviation industries, where instruments are created to highly refined specifications.
- **Speed:** Some lasers require minimal setup and can vaporize materials relatively quickly. This accelerates the entire cutting process and gives you faster results.
- **Material wastage:** With minimal material wastage during laser cutting, the process is efficient and cost-effective. It's ideal for situations where resource utilization is vital.

iii) Balancing speed, precision, and cost

Laser cutting can be a quick, precise, and cost-effective process, but proponents of this method must ensure they strike an appropriate balance between these three qualities. Speed, precision, and cost seem to counteract each other, and it's difficult to attain one without losing another.

For instance, increasing the cutting speed of the laser may compromise the quality and precision of the result. Conversely, prioritizing extreme precision will lengthen the process and increase operating costs. If you want to keep costs down, however, you'll likely end up with slower and less accurate laser technology.

As a result, your enterprise needs to carefully consider its priorities when committing to laser-cutting technology.



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iv) Drawbacks and limitations of laser cutting

Despite its benefits, laser cutting can be a challenging and problematic process. It has a significant number of downsides, which, for many companies, outweigh the upsides. This has led to a reduction in laser cutting in certain industries as enterprises instead begin to favor waterjet cutting for its improved environmental impact, efficiency, and cut quality.

> There has been a reduction in laser cutting in certain industries in favor of waterjet cutting.

While laser cutting still offers fast and precise results, there are several drawbacks and limitations that are inherent in the process:

- **Heat-affected zones:** Unlike waterjet, laser cutting can leave marks around the affected area. These are caused by heat from the laser and vastly impact the end quality of the cut material. HAZs need rectifying after the cut, which impacts the speed of the process.
- **Micro Cracks and Oxide inclusions:**
  - Laser cutting causes micro cracks and/or oxide inclusions.
  - In the aviation industry micro cracks and oxide inclusions are considered as flight critical and therefore laser cutting is not allowed for certain applications.
- **Secondary cutting:** Because of heat-affected zones and material deformation, laser cutting may require additional processes to achieve an acceptable edge quality, especially on high thicknesses.
- **Reduced versatility:** While lasers can be used to cut a wide variety of materials, their range isn't as extensive as other non-traditional cutting methods like waterjet. Additionally, laser cutting is best undertaken on flat surfaces, so complex 3D shapes may require extra time and effort to cut.
- **Lower material suitability:** A laser-cutting approach is unsuitable for many materials, such as reflective metals, leather, carbon fiber, and other ABS. Additionally, where heavy metals are involved, there is a higher risk of harmful gasses like carbon dioxide being released into the environment.
- **Risk of hazardous gasses:** Laser cutting typically produces waste gasses that can pollute the atmosphere. Laser-generated air contaminants (LGACs) such as airborne benzene, toluene, and isocyanates are hazardous byproducts of the laser-cutting process.
- **Poor finish:** Laser cutting often produces a poor finish on the surfaces of metals. The quality typically remains robust for the first 6-8mm but quickly vanishes as the material becomes thicker. It can also leave oxide layers and rust on cut parts, which are unsuitable for many industries like medicine, catering, and construction.

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Waterjet vs Laser Cutting: Key Comparisons

We've discussed the core features, benefits, and drawbacks of both waterjet and laser cutting, but now it's worth comparing them side by side. To truly understand which process is worth your investment, it's crucial to develop a clear picture of how waterjet differs from laser cutting and vice versa.

In this section, we aim to highlight the similarities and differences between waterjet and laser cutting. By evaluating both processes against several criteria, we can determine where they stand out and where they come up short. You'll also be able to ascertain which process best suits your unique requirements and budget.

3.1 Speed and Efficiency

As the old business saying goes, "Time is money". There's a reason this phrase is repeated time and again; it's because there's a great deal of truth about it.

Waterjet and laser cutting offer rapid solutions to a task that would otherwise be undertaken by time-consuming manual labor. However, today's hyper-modernized world has moved beyond those standards, and

> companies are constantly striving for quicker, more efficient processes.

As a result, your firm needs a fast and optimized metal-cutting system.

To gauge the efficiency of waterjet and laser-cutting machines, analysts examine standardized metrics like inches-per-minute (IPM) and meters-per-minute (MPM). These measurements quantify a system's performance by recording how fast it can cut a predetermined length of material. There are, however, several factors that influence these metrics.

So, what can impact the speed and efficiency of waterjet and laser cutting systems? Several factors can affect performance in this regard: material type and thickness, power settings and nozzle sizes, and setup time and repeatability.

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i) Material type and thickness

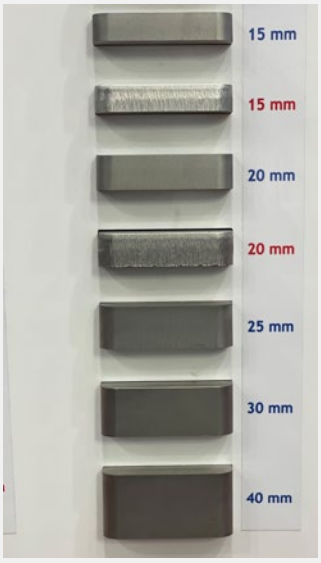
Generally, laser-cutting machines cut faster than waterjet systems.

However, the thickness and type of material greatly affect this. Waterjet typically cuts through a wider range of materials than laser cutting since reflective surfaces like brass prevent lasers from melting through the material.

Tougher materials slow down both waterjet and laser cutting, as do thick materials. Laser cutting speed is additionally impacted by heat-resistant materials, as they require a slower, more focused cutting process for the laser to burn through effectively on high thicknesses. In general, the thicker the material, the slower the cutting rate for both methods.

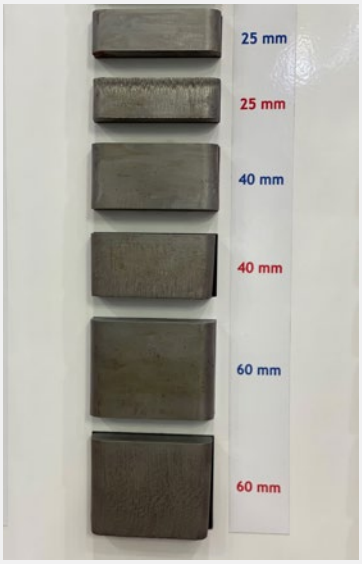
CUTTING COMPARISONS

Waterjet machine cut with GMA Garnet™ (measument inscription in blue) in comparison to cutting with a Laser (red marked)

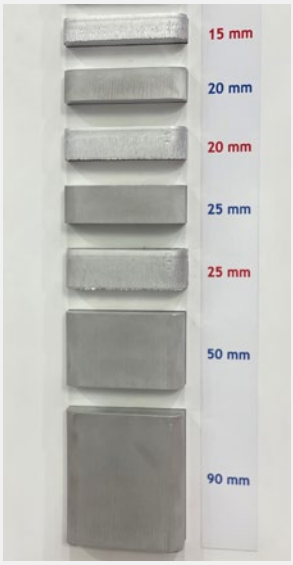


Aluminum: Comparison between 15, 20, 25mm

(Note: 50 and 90mm was not cut by Laser due to a lack of performance



Carbon Steel: Comparison between 25, 40, 60mm



Stainless Steel: Comparison between 15 and 20mm

(Note: 25, 30 and 40mm was not cut by Laser due to a lack of performance

To better illustrate this point, we've compiled a graph that clearly demonstrates the linear relationship between a material's thickness and how long it takes to cut. Both waterjet and laser cutting processes become slower as a material gets thicker, but laser cutting suffers the most from thicker materials.

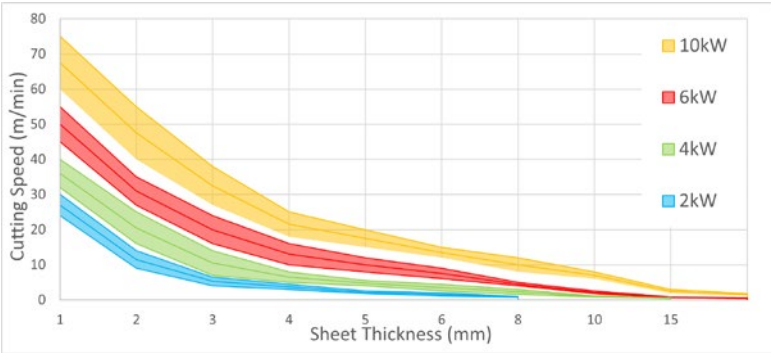


Figure 1 Cutting Speed Ranges

Source: https://espritautomation.com/stainless-steel-laser-cutting/

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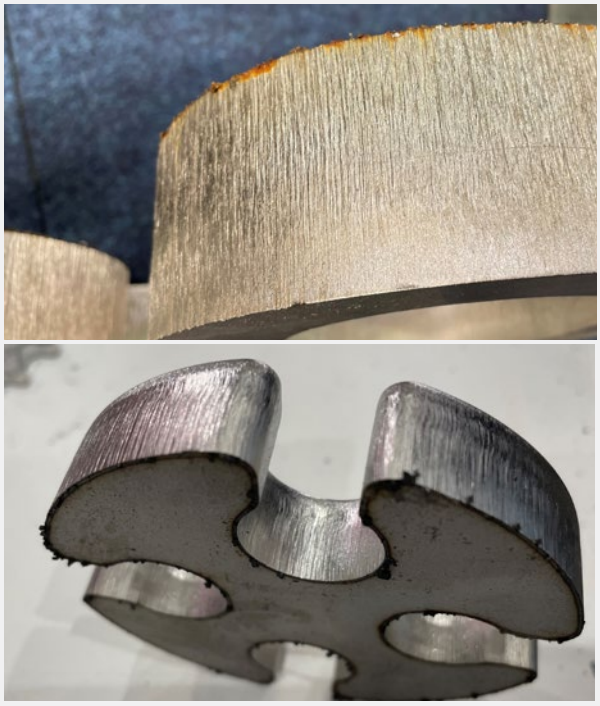
ii) Power settings and nozzle sizes

The speed and efficiency of laser cutters and waterjets are affected by each system's respective power control. For laser cutters, that's the power setting, while the strength of a waterjet is controlled by its nozzle size, pump pressure and the right water supply.

The higher the power setting of a laser cutter, the quicker it can cut through materials. However, a higher power also typically leaves a lower-quality finish since the increased heat leaves HAZs and scorch marks across the material's surface.



Heat affected zones and scum formation when cutting thick materials with laser cutting.

The majority of waterjet systems operate with two fluid circuits exist in a typical intensifier pump, the water circuit and the hydraulic oil circuit.

The water circuit consists of the inlet water filters, booster pump, intensifier, and attenuator. Ordinary tap water is filtered by the inlet water filtration system – usually comprising cartridge filter. The filtered water is then sent to the intensifier pump and pressurized to up to 60,000 psi or 87.000 for ultra high pressure pumps.

The hydraulic circuit consists of an electric motor and a hydraulic pump.

The electric motor powers the hydraulic pump. The hydraulic pump creates oil pressure. Pressurized oil goes to the low pressure part of the intensifier. From there oil pressures versus water with a ratio of 1 to 20 and creates water pressure from 60k to 87k.

Pressurized water flows from the Intensifier to the attenuator.

The attenuator is needed for certain pressure pumps to compensate for water pressure fluctuations, thus ensuring that water arrives at the cutting head steady and consistent. Without the attenuator, the water stream would visibly and audibly pulse, leaving marks on the material being cut.

During the cutting process, water flows from the high-pressure pump into the cutting head, into the orifice, in a venturi motion. Garnet, fed into the stream from a separate tube, is sucked into this VENTURI, which then propels the garnet at 1/5 of the water speed into the mixing tube and finally touches the surface of the cutting material.

The right ID size of the orifice depends on the hp pump power and water supply.

> The higher the power setting the quicker the cutting, but typically leaves a lower quality of finish.

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iii) Setup time and repeatability

Speed isn't solely based on cutting time. To determine whether a method is fast, you must consider the entire process, from setup to repeatability.

If you purchase a waterjet device with an advanced control system, setup time is minimal. That said, you must regularly check your garnet supply is topped up and your pump is delivering the correct water pressure. Once your system is installed, though, you can repeat cutting processes with relative ease between jobs.

Because of their complex designs, laser cutters typically require more upkeep and installation time.

3.2 Cutting Quality and Finish

Cutting quality is a key priority for many enterprises that value the robustness and functionality of their components. To minimize health and safety risks and the possibility of lawsuits, you must ensure your metal-cutting machines can produce high-quality cuts.

Some metrics by which we can determine the cutting quality of a system:

- **Surface finish:** How smooth, clean, and aesthetically pleasing a material looks after it has been cut. Waterjet finishes are typically smoother, while laser cuts may produce HAZs or oxide layers.
- **Kerf Width:** Typically, waterjet cutting produces a wider kerf (width of the cut made by the cutting tool) compared to laser cutting. This is because the waterjet uses a high-pressure stream of water, often mixed with abrasive materials, which results in a slightly broader cut line. On the other hand, laser cutting, utilizing a highly focused laser beam, achieves a narrower kerf, allowing for more precise cuts and finer details in the workpiece. This difference in kerf width is an important consideration in applications where precision and material conservation are critical.
- **Tolerance:** The extent to which a laser or waterjet stream may deviate from its course.

We'll now assess waterjet and laser cutting on these three metrics and examine the technical challenges each system faces. We'll also discuss the implications cutting quality has on post-production and the importance of this in various industries.

i) Technical challenges: heat-affected zones and oxide layers

Heat-affected zones and oxide layers are the main technical challenges of laser cutting systems. HAZs are produced as a result of the heat from the laser, which burns areas around the cut and produces unsightly scorch marks along its edges.

The carbon dioxide gas used in many types of laser cutters also produces oxide layers on certain metals. These can cause rust and damage to the part, reducing the functionality and structural integrity of the cut component.

Waterjet, meanwhile, offers relatively few technical challenges. Because it's a cold-cutting process, it does not produce HAZs or oxide layers, instead leaving a smooth and sleek finish.

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ii) Implications on post-processing and assembly

Cutting quality directly affects the extent of post-processing requirements and ease of assembly. Machines that produce a higher-quality finish will contribute to a quicker, more simplified post-production process.

Waterjet's minimal HAZs and oxide inclusions, combined with its smooth and refined edge finish, can reduce the need for extensive post-production processes. Parts cut using waterjet require fewer touch-ups and refinements, and they can often be directly integrated into the assembly process.

> Quality cuts in metal fabrication are essential for safety and reliability.

Laser cutting, on the other hand, will likely require additional finishing steps to ensure the parts are functional and safe to use. Sanding, grinding, and surface treatment may be needed to meet quality assurance standards. You may also need to carry out another pass of the laser to complete the cut. This slows down post-production and assembly and reduces overall efficiency and cutting quality.

iii) Importance of cutting quality in industry

Cut quality is crucial for many industries because they adhere to strict standards and regulations that govern their operations. Many enterprises, from aviation firms to catering companies, require high-quality components that minimize safety risks and ensure the robustness of their equipment.

In the aviation industry, for instance, aircraft are built according to ultra-strict regulations. In the medical and catering industries, components need to be of the highest quality to minimize health risks. Metal parts and instruments need to be cut and assembled properly.

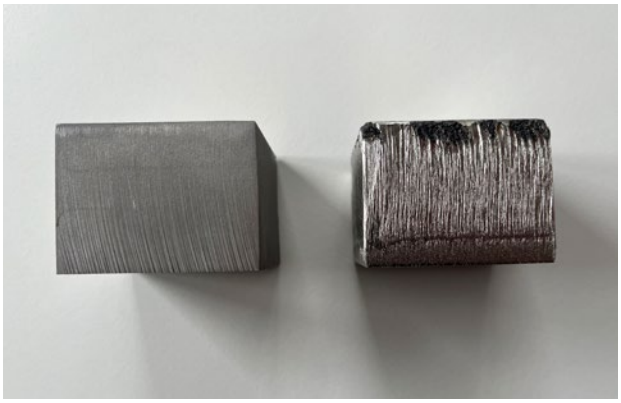
The oxide layers and HAZs that hot processes like laser cutting can produce may warp and damage the integrity of the metal. As a result, many aviation firms and part suppliers prefer cold-cutting methods like waterjet, which produces the best results in terms of cut quality.

iv) Waterjet vs laser cutting finishes: Image comparison

Waterjet and laser cutting produce distinct cutting finishes. This is mostly due to the way each process works, as waterjet systems cut using cold water and garnet, while laser cutters use heat to melt the material.

> While laser cutting may be faster and more precise, it doesn't offer the same high-quality cutting finish as waterjet does on high thicknesses.

The two pictures below show the same part cut from a metal alloy, one using waterjet and the other with laser cutting. The laser-cut component clearly shows unsightly grooves and HAZs caused by the laser's heat. By contrast, the waterjet-cut part exhibits a clean finish without any unwanted marks or damage.



Side-by-side comparison showing the finish of the same metal part cut from a waterjet and laser cutter.

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3.3 Service and Maintenance

A metal-cutting machine's value doesn't just come from its speed and quality. Reliability and durability are two additional influential factors that you should consider when evaluating waterjet and laser cutting systems.

After all, a machine's fast cutting speed may be hampered by a constant need for routine maintenance and upkeep. Similarly, the overall quality of a machine may drop if you don't have the capacity to perform regular service checks.

In this section, we'll explore how waterjet and laser cutting systems compare in terms of service and maintenance. We'll examine their routine upkeep and service intervals, durability and longevity, and any vendor support or service packages offered by typical suppliers.

i) Routine upkeep and service intervals

Waterjet systems and laser cutters require regular maintenance to uphold their quality and functionality. For example, you must ensure no dust enters the nozzle or opening of either system since this could cause the stream or laser to deviate off-course.

If your team has the capacity to manage regular service intervals, you can keep operational costs down. Unscheduled maintenance, however, can be expensive, particularly when you must unexpectedly replace worn parts.

Laser cutters have longer service intervals than waterjets and require fewer unexpected repairs, making laser cutting a more favorable system for companies wary of constant maintenance costs. With greater control over maintenance, enterprises with laser cutters can schedule upkeep during off-peak times to minimize disruptions.

That said, high-quality garnet abrasive can dramatically extend the lifetime of your waterjet machine's components. GMA Garnet™, for instance, is much finer and higher quality than many others on the market, leading to fewer impurities and less wear and tear on the machine.

ii) Durability and longevity of equipment

In general, waterjet machines require more frequent maintenance than laser cutters. Routine service checks are needed every 500 hours or so, compared to around 2,000 hours for laser-cutting machines. Plus, nozzle and pump parts may need replacing somewhat frequently.

By contrast, laser-cutting machines are typically more durable in the long run. However, they require more thorough and specialized training to operate, which leads to time-consuming onboarding with new hires. As a result, laser-cutting may not be ideal for your company if you struggle with high staff turnover rates.

iii) Vendor support, warranties, and service packages

The level of vendor support and the quality-of-service packages offered can significantly influence maintenance experiences. Many waterjet suppliers, for instance, provide comprehensive support that includes warranties and service packages, giving you security and peace of mind when you purchase a waterjet machine.

> The extensive support from waterjet suppliers helps mitigate maintenance challenges and keeps costs down.

Users often praise this thorough level of support, which reduces production delays and improves the quality and speed of routine upkeep. Laser-cutting vendors also offer decent support and will often provide tailored service packages for their customers.

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3.4 Operational Costs

Operational costs are a critical factor in any purchase decision and must be carefully considered when comparing waterjet and laser cutters. It's vital to strike a balance between initial investment costs and long-term running costs, as saving money with a cheaper upfront purchase may prove disastrous in the long run if your machine begins to show why it deserved a smaller price tag.

In this section, we'll examine the direct and indirect costs of purchasing and operating waterjets and laser cutters. We'll also assess the value of a potential return on investment over time for each technology and calculate the value of both.

> Assessing operational and long-term costs is key in choosing between waterjet and laser cutters, balancing upfront savings against future expenses.

i) Direct costs: Equipment, consumables, and energy

Waterjet machines aren't cheap and can cost anywhere between $50,000 and $500,000. Laser cutters can be equally expensive but the 4kW and 6kW lasers work out cheaper at around $25,000 to $200,000, noting the speed and thickness of the cut will be compromised dramatically at this price point.

High-powered fiber lasers can cost upwards of $500,000, with the highest-quality lasers reaching into the millions of dollars. If you want a cost-effective and high-quality machine, it often proves more economical to buy a waterjet cutter.

Case in point, Dubai-based engineering company Franz & Olsen favors waterjet over lasers when cutting thin materials like aluminum sheeting. This is because the operational costs work out cheaper, as the nitrogen gas required for laser cutting is expensive. They also prefer waterjet for cutting thick stainless steel because the quality of the finish outweighs the higher costs involved.

Lower-powered 4kW lasers are very energy-inefficient but are mostly cheaper to run than waterjets. Waterjet machines consume large amounts of water, energy, and abrasives, all of which add to the overall operational costs of the machine. That said, many companies still prefer the precision and strength of waterjet cutters over the cheaper running costs of lasers.

ii) Indirect costs: Downtime, maintenance, and training

Indirect costs represent expenses that are not immediately associated with the purchase and daily operations of the machine but may still have an impact on its overall cost. These include downtime, maintenance, and training expenses.

Waterjet machines need servicing more often than laser cutters, which contributes to higher maintenance costs and more frequent downtime. Replacement parts like nozzles and pumps also add to the overall cost of running a waterjet machine.

Onboarding costs are similar for both technologies since each process is highly specialized and requires an appropriately comprehensive level of training. However, laser-cutting machines may need more training to operate, which could increase indirect operational costs.

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iii) ROI over time for waterjet and laser cutting

Calculating an accurate return on investment (ROI) can be difficult because no two companies have the same requirements and operating costs. However, using the payback period formula and informed estimates, we can work out the long-term value of waterjets and laser cutters.

By adding together the initial purchase payment and the yearly running costs and dividing this total by the periodic benefit acquired from the new technology, we can determine how many years it would take to get an ROI.

Let's say a top-of-the-range fiber laser costs $1,000,000 upfront and $20 an hour to run for five days a week, twelve hours every day. If we also say the periodic benefit you acquire is $250,000, you will see an ROI in four years.

With the same calculations for a high-quality waterjet costing $300,000 upfront and $30 an hour to run, with a benefit of $150,000, you would see a ROI in just two and a half years.

As we can see, even though waterjets have higher day-to-day operational costs, they represent a better ROI when compared to high-tech fiber laser cutters.

This table helps visualize the financial considerations, including the initial investment and ongoing operational expenses, for each cutting technology, providing insights into their return on investment timelines.

Item	**Fiber Laser Cutter** *(Based on $20/hour, 5 days/week, 12 hrs/day)*	**Waterjet Cutter** *(Based on $30/hour, 5 days/week, 12 hrs/day)*
Equipment Cost	$1,000,000	$300,000
Yearly Running Costs	$62,400	$93,600
Total Periodic Benefit	$250,000	$150,000
Payback Period (Years)	4.16 years	2.62 years

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3.5 Material Suitability

Both waterjet and laser cutting systems can handle a wide variety of materials. However, waterjet is more versatile thanks to its cold-cutting process that removes the potentially harmful effects of heat on some materials. In this section, we'll discuss the material suitability of waterjet and laser cutters in more depth.

> Waterjet cutting's cold-cutting process offers greater versatility across a range of materials, avoiding heat-related damage possible with laser cutting.

i) Waterjet: Suitable materials

Waterjet can cut through a vast range of different materials, including aluminum, steel, plastic, wood, ceramic, composites, and stone. Thanks to its cold-cutting nature, it can be used effectively on heat-sensitive surfaces.

Waterjet is also an ideal option for more reflective metals such as copper and glass as there will be no reflectivity issue like there is for laser cutting.

Material thickness and density also factor into the speed and quality of a waterjet cut but offer relatively few issues compared to laser cutters.

Many industries favor waterjet thanks to its exceptional versatility and strength. For instance, construction and architecture companies use waterjet for its ability to cut through an extensive range of materials. Meanwhile, aerospace enterprises may use either waterjet or laser cutters for slicing through lightweight yet durable materials.

ii) Laser cutting: Suitable materials

Compared to waterjet, laser cutting is a less versatile method and has more limitations when it comes to what materials it can cut through. While it excels in engraving soft materials, it is unsuitable for thick and reflective surfaces and those sensitive to heat.

Wood, plastic, paper, and certain metals (like steel, mild steel, and non-ferrous metals) are ideal for laser cutters because they are often thin and non-reflective. However, not all materials are suitable for laser cutting. If a surface is too sensitive to heat or light, it can reduce the laser's effectiveness and worsen the quality of the final cut. Additionally, materials with varying thickness levels may cause inconsistencies in cutting quality and speed for laser cutters.

This chart provides a clear overview of which materials are suitable for each cutting method, helping in decision-making for specific applications.

Materials	Waterjet Cutting Suitability	Laser Cutting Suitability
Aluminum	✔	✔
Steel	✔	✔
Plastic	✔	✔
Wood	✔	✔
Ceramic	✔	✘
Composites	✔	✘
Stone	✔	✘
Copper	✔	✘
Glass	✔	✘
Paper	✔	✔
Mild Steel	✔	✔
Non-ferrous Metals	✔	✔

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3.6 Environmental Considerations

As industries begin to accommodate shifting global attitudes toward environmental responsibility, sustainable practices are becoming a priority. In this section, we'll examine the environmental impacts of waterjet and laser cutters, exploring their energy consumption, water usage, waste management, and general sustainability.

i) Energy consumption and water usage

Given their industrial purposes, waterjet and laser cutters generally require a significant amount of energy consumption to operate. Laser cutting typically uses more electrical energy, but waterjets have a much higher water usage.

According to **scientific analysis by Kellens *et al.*,** conventional CO2 lasers are inefficient and waste a significant amount of energy. Typical laser-cutting machines used in numerous industries have an energy efficiency of around 10%, which means they require a lot more energy than they should to run, causing significant harm to the environment. Average estimates of energy consumption are around 50kW of power per hour.

Waterjets are a lot more efficient. They can run using most premises' water lines and require only about 4 liters (1 gallon) per minute to operate. And with the addition of an abrasive like garnet, high-pressure waterjet streams can operate at a much higher cutting efficiency.

ii) Environmental impact and waste management

Both waterjet and laser cutting produce waste. Gas emissions, byproducts, and part replacements all have a potential environmental impact. The more environmentally friendly option, however, is waterjet, as it is more sustainable and produces less harmful waste.

The byproducts and assist gasses like carbon dioxide in laser-cutting technology contribute significantly to the environmental impact of the process. Nitrogen and oxygen used to stabilize the laser are released into the surrounding atmosphere, as are harmful pollutants like hydrochloric acid and airborne benzene from vaporized materials, which can cause damage to the environment.

Waterjet cutting, meanwhile, does not release any harmful gasses into the atmosphere. However, it does produce a liquid byproduct that contains a mixture of water, abrasive, and eroded material. In most of the metal waterjet applications the sludge is not considered as hazardous waste and can be disposed of easily. Many waterjet companies also recycle their water, further reducing their environmental impact.

At GMA, we also operate a garnet return program in many countries that allows you to send us spent garnet at the sole cost of transport. This reduces disposal costs and improves your sustainable practices, further solidifying waterjet as the more eco-friendly cutting process.

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Customer Testimonials: A Win for Waterjet

Despite the significant benefits of laser cutting technology, waterjet machines consistently prove to be the more popular choice in a variety of industries. There are many reasons for this, but the overarching factor is the quality of the finish.

In this section, we explore why two successful enterprises - Al Qimma Equipment Company and Jacquet Nova Srl - favor waterjet over laser cutting technology. We examine the challenges they faced and how they utilized waterjet technology to overcome these issues.

4.1 Al Qimma Equipment Company

Al Qimma Equipment Company is based in Jeddah, Saudi Arabia. The firm specializes in manufacturing heavy machinery and building block materials for a variety of industries. As a result, they require powerful metal tools.

The company invested in several laser cutters, including 5kW, 6kW, and 20kW machines, alongside a FLOW Hyperjet Intensifier 50HP waterjet cutter. Although they found that their laser cutters performed well, they noticed quality issues with certain materials. These were promptly solved with the waterjet machine, which produced a higher-quality cut.

> Al Qimma Equipment Company's shift to waterjet cutting resolved issues of material distortion and tapering experienced with laser cutters, enhancing cut quality and reducing secondary processing needs.

Source image: alqimma.com/

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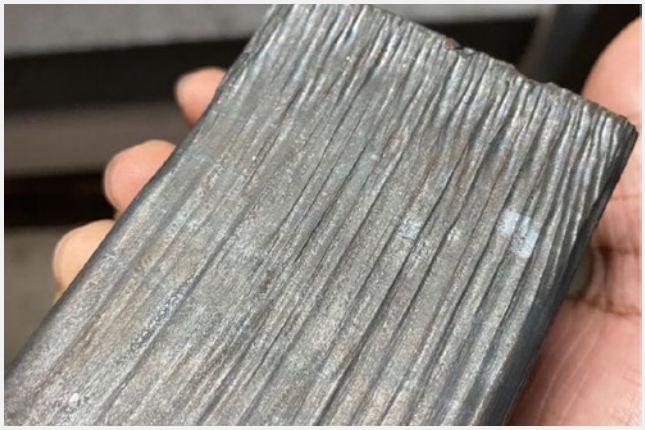
i) Challenges and issues faced

Al Qimma Equipment Company recently acquired high-powered laser cutting technology. Initially, they were satisfied with the machines, as they had cheaper operating costs and could cut through materials with speed and precision. However, they soon encountered issues.

Despite the numerous advantages of laser technology, a spokesman for Al Qimma Equipment Company remarked that they couldn't rely on laser cutters to do the entire work. For certain metals, using a hot-cutting process with lasers negatively impacted the quality of the cut. Laser cutters distorted and warped heat-treated metals, and the oxygen gas required can burn through parts of the material, producing unsightly and ineffective results.

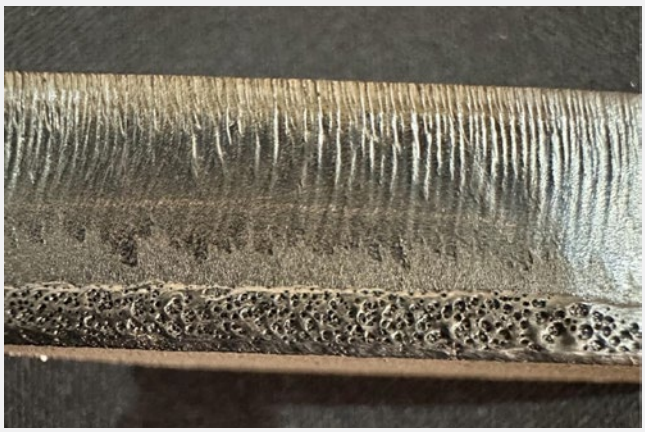
Moreover, they found a higher rate of tapering on their laser-cutting machines than with waterjet. The kerf width at the top and bottom of the cut was often different, leading to poor-quality parts that needed secondary processing. This extra work increased overall costs.

Comparison photos of cutting-edge quality using Laser and Waterjet:



80mm thick A36 metal cut with LASER using Oxygen.

30mm thick A36 metal cut with LASER using Oxygen.



HARDOX 12 mm metal cut with LASER using Oxygen. In this photo we can clearly see the burning of metal piece at the bottom portion of the work piece.

HARDOX 450 – 40mm HARDOZ material cut with waterjet machine. This photo clearly shows that no burns occur during the cutting process.

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ii) Solutions and results

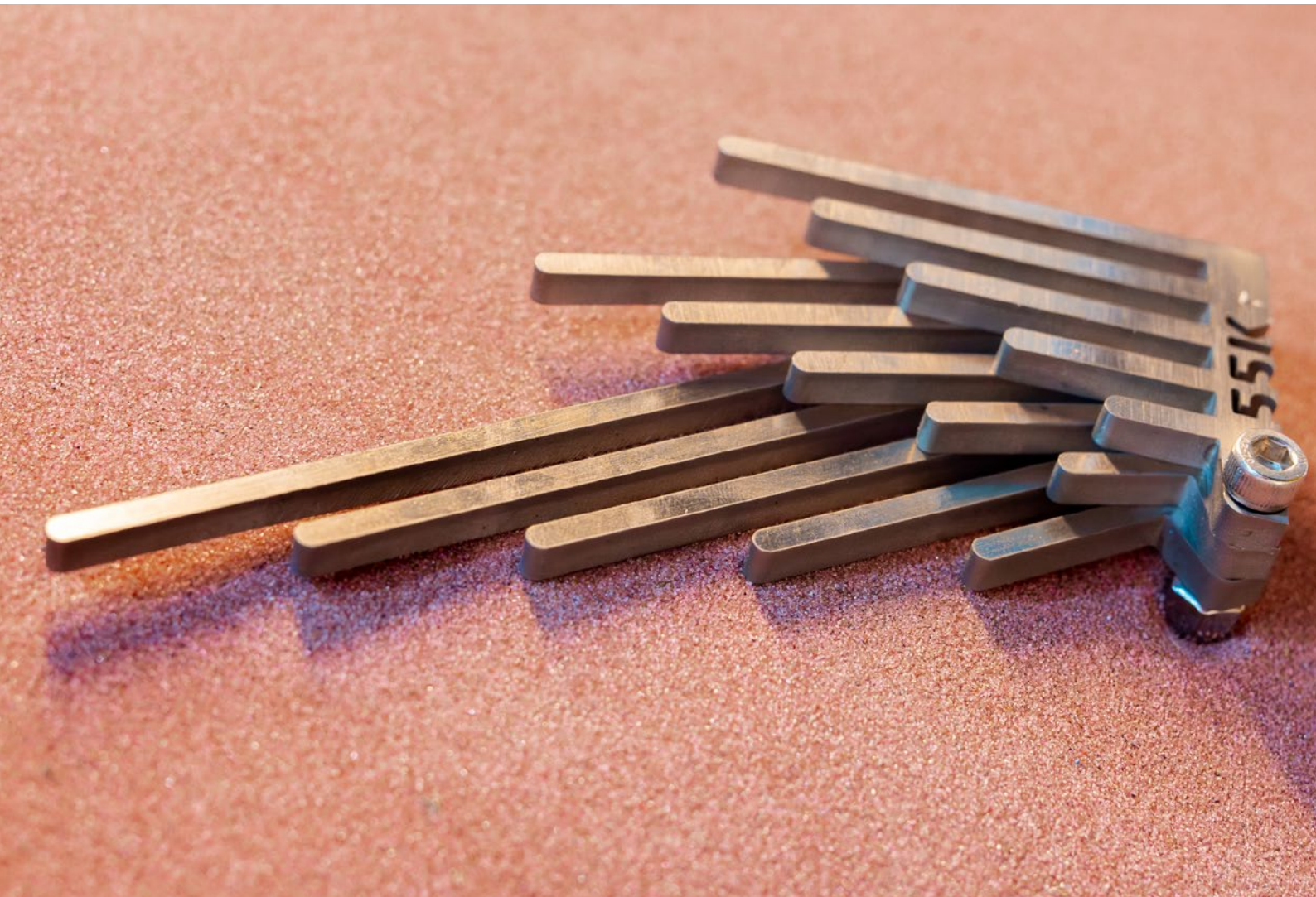
To improve the cutting quality and finish on materials like heat-treated metals, Al Qimma Equipment Company began using waterjet cutters with GMA ClassicCut™ garnet. This greatly improved the cutting speed of their work, and the firm praised the garnet for its efficacy and quality in combination with their waterjet machine.

Although their waterjet cutter costs more to operate on a day-to-day basis, the company found that the higher-quality edge finishes on metal parts outweighed any financial drawbacks of the technology. The cold-cutting process did not warp the metal and instead produced a smoother finish that required no additional reworking. This saved the firm vast amounts of time and money.

iii) Lessons learned and future prospects

After testing out the two metal-cutting processes and comparing the cutting quality of both, Al Qimma Equipment Company established that they cannot completely depend on laser cutters, even despite the speed and financial benefits. Instead, they will prioritize waterjet for certain heat-treated metals and for clients that require exceptional quality in their parts.

The firm has noted that laser cutters are becoming more popular in the Middle East but has urged others to consider waterjet technology for superior cutting quality. Although operational costs are typically higher for waterjets, the additional processing and grinding required in laser cutting essentially levels the playing field in terms of day-to-day costs.



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4.2 Jacquet Nova Srl

Jacquet Nova Srl is a large-scale distributor of AISI 304 stainless steel and nickel alloys. They specialize in providing metal parts, sheets, plates, bars, and tubes cut to size and ready for use in construction. With worldwide operations, the firm requires high-powered metal-cutting machines and frequently works with both laser cutters and waterjets.

i) Comparing AISI 304 stainless steel parts

Since Jacquet Nova Srl works with a variety of metal-cutting technologies, they decided to compare the quality of waterjet cuts against laser-cutting finishes. They selected a 40mm-thick AISI 304 stainless steel part for the test, as this material is widely used for its corrosion resistance and durability.

> Jacquet Nova's test reveals waterjet's edge in quality over laser for AISI 304 steel.

Two identical AISI 304 stainless steel parts were cut: one using a 4000 bar waterjet, the other with a 20kW laser-cutting machine. The company then evaluated the speed of each process and the end quality of both parts.

Jacquet Nova Srl was founded in Italy in 2001. We provide a large stock of stainless steel, nickel alloys, special metals and a wide range of CNC cutting machines including Plasma, Laser, saw and Waterjet Systems to achieve high quality finishes, tight tolerances and fast deliveries for our customers. For stainless steel and nickel alloys thickness exceeding 40 mm we recommend waterjet cutting with GMA Garnet™ provides excellent cutting edge qualities, without heat affected zones, deformation or oxide inclusions. Waterjet cutting is the perfect choice when cutting maximum thickness.

Robert M – *Managing Director – Jacquet Nova Srl*

ii) Results and wider industry implications

Here are the side-by-side results of the two AISI 304 stainless steel parts cut using waterjet and laser-cutting machines.

As you can see from the photos, waterjet cutting produced a smoother finish with fewer scorch marks and less tapering. The laser-cut part, meanwhile, exhibited HAZs, oxide inclusions, and deformation of the material. The findings by Jacquet Nova Srl raised questions about the reliability and suitability of laser-cut parts for certain industries and applications.

The mechanical properties of AISI 304 stainless steel include 18% chromium and 8% nickel, which makes it highly corrosion-resistant. However, laser cutting may change the chemical properties of this material due to the HAZs and oxide layers.

Although the laser cutter produced quicker results, this was severely undermined by the end quality of the cut. On the other hand, the waterjet-cut part displayed a more refined edge finish, which Jacquet Nova Srl valued due to its commitment to high-quality standards.

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iii) Future plans and potential waterjet expansion

As a result of this test, many companies are now questioning the suitability of laser-cutting technology in a variety of applications. Industries that require precision-cut, corrosion-resistant parts (like aviation and architecture) are beginning to favor cold-cutting processes like waterjet because there are no HAZs or oxide inclusions that could impact the mechanical properties of their parts.

While both waterjet and laser cutters have their merits, Jacquet Nova Srl plans to expand its waterjet usage. The company aims to uphold high standards and provide high-quality parts to its customers and clients. Waterjet technology allows them to improve the quality of their work, which is why they plan to expand their use of these machines.

However, laser cutting does offer speed benefits. Jacquet Nova Srl can produce more components more quickly with laser cutters, but the quality is lacking. As such, the company has stressed the need to find a balance between speed, precision, and quality.

Image source: https://www.getfy.it/jacquetnovasrl

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Future Trends and Projections

Metal-cutting is an industry that's constantly evolving, influenced by changing global attitudes and rapid technological advancements. In this section, we'll explore what the future could entail for waterjet and laser-cutting technologies and examine the potential trends and disruptors in this volatile industry.

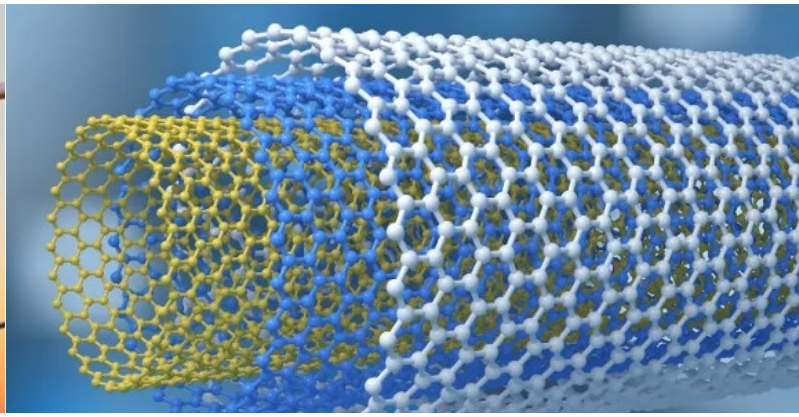
> Emerging trends in metal-cutting spotlight precision, sustainability, and cost-effectiveness, with waterjet technology gaining prominence due to its versatility and eco-friendly nature.

5.1 Analysis of Current Market Trends

To understand where the metal-cutting industry is headed, we must first look at current market trends and analyze their significance for the industry. The present market dynamics reveal three key priorities for companies that utilize waterjet and laser-cutting technology:

- **Demand for precision:** Amid the eternal struggle between precision, speed, and cost, companies are increasingly prioritizing the accuracy of their cuts. Whether they're in the aviation, automotive, electronics, or medical industry, the increased demand for precision is pushing technology suppliers to develop innovative cutting solutions.
- **Sustainability and environmental concerns:** As the world begins to advocate for more sustainable practices, manufacturers are increasingly seeking more eco-friendly machines. Waterjet cutting, due to its more environmentally friendly design, is gaining popularity as a result.
- **Cost-effective solutions:** Keeping costs down has always been a priority for companies, and this trend is likely to continue in the future. This has led to a recent resurgence of waterjet technology, thanks to its cost-effectiveness.
- **Change in material types:** Technological advancements have led to the creation of new, lighter materials that can be used in construction and manufacturing. These materials - such as silicon wafers and microchips - require highly precise cutting methods, increasing the demand for laser and waterjet.
- **Growing military demands:** With countries constantly looking to bolster their armies, military-grade weapons are in high demand. These require the precision cutting techniques of waterjet, which has led to a spike in this process' popularity.

Growing future miliary demands



Future materials science breakthroughs

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5.2 Predictions Based on Emerging Technologies

With the rise of new technology, we can start to predict what the future of the metal-cutting industry may involve. Waterjet and laser cutters will likely become more high-tech and powerful, and we will potentially see new cutting methods invented.

In the future, waterjet and laser technology may be combined into one hybrid machine. Waterjet-guided laser technology has already been developed and pioneered by companies like Synova, so we may see these designs mass-produced for manufacturing companies within a decade. As enterprises start to place more value on precision, this hybrid machine can meet their requirements and bring the best of both worlds into one device.

Materials may also be different in the future. As new compositions and chemicals are created for innovative industries like aerospace and construction, they may require new technology to cut. For example, new variants of microchips that require silicon wafers are becoming more widespread, as are new types of plastics made from recycled materials. As a result, we may see a rise in waterjet machines thanks to their versatility for use on a wide variety of materials.

5.3 Potential Disruptors in the Cutting Technology Space

Industries are rife with competition and disruption, and the metal-cutting space is no exception. Constant technological developments mean new competition is never far away. Waterjet and laser cutters are still at the forefront of modern metal-cutting machines, but new inventions may seek to disrupt their popularity.

Additive manufacturing, for one, may reshape supply chains and production. New technologies like 3D printing, while not direct replacements for waterjet or laser cutters, might cause companies to rethink their manufacturing processes and requirements.

Similarly, nanotechnology is growing from strength to strength and may disrupt the popularity balance between waterjet and laser cutting. Since these parts are so small, incredibly precise technology is required, which may lead to new innovations around laser cutting and reduce the demand for waterjets.

5.4 The Role of Research and Development in Shaping the Future

Research and development will undoubtedly shape the future of waterjet and laser-cutting technologies. As new inventions are developed and our understanding of material compositions improves, waterjet and laser-cutting systems will be altered in line with new research.

Energy-efficient technologies will become more integrated into metal-cutting processes, as will automation and artificial intelligence. This will help companies adapt to increasing sustainability concerns while reducing human error and improving efficiency in the work.

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Conclusion

In this comparative analysis of waterjet versus laser cutting technology, we've covered the intricacies of the two processes and their benefits, flaws, costs, and material suitability. We've explored several case studies illustrating real-world challenges and ingenious solutions, as well as what the future might hold for the metal-cutting industry.

While both waterjet and laser cutting have their merits, it is waterjet that appears the better system. Many companies prefer cold-cutting methods like waterjet because, unlike lasers, they leave no HAZs, no oxide layers, no scorch marks, and no material disfiguration.

Despite the volatile landscape of the metal-cutting industry, current market analysis and company testimonials indicate that waterjet machines may become more popular in the next few years. With the rise of new materials and a greater focus on environmental sustainability, waterjet systems provide the versatility and eco-friendliness that many firms value.

To maximize your profits and cutting quality, you must ensure your company remains informed and updated with emerging technologies and industry trends. It's also worth conducting your own research into how waterjet and laser cutters compare when used with your own materials.

For further information on how waterjet technology works and how it can help your company achieve its high-quality standards, contact GMA today.

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About GMA

At GMA Garnet, we have a rich history of exceptional service. The company was founded in 1983 and has since blossomed into a large-scale operation that provides much-needed garnet abrasives globally. Our partners and clients represent some of the top construction and manufacturing firms on the planet.

Our main business is garnet, which we source directly from our own mines and distribute to high-end firms across the globe. Our expertise also extends to cutting technologies, as we can provide tailored support on using our garnet in your waterjet systems.

Here's what GMA can offer your company:

- **High-quality garnet abrasive:** At GMA, garnet abrasive for waterjet cutters is our specialty. We are globally recognized as a leading producer and distributor of premium-quality garnet sourced from our own mines. Our garnet is proven to deliver superior results for a wide variety of applications and materials.
- **Controlled supply from mine to machine:** We are the only garnet supplier in the world with full control over our product directly from its source all the way to your waterjet system. This way, we can guarantee the immaculate quality of our abrasive.
- **Consultation and support:** We are more than just a supplier; we remain your partners throughout your journey. Our team of certified experts is always on hand to provide impeccable support, guidance, and training should your company need it.

With a wide variety of satisfied customers, including large-scale enterprises like Franz & Olsen, Jacquet Nova Srl, and Al Qimma Equipment Company, our services speak for themselves.

Connect with us at GMA Garnet to explore how your company can benefit from our expertise. We invite you to collaborate with us and embark on a journey of innovation and growth, reshaping your company into a thriving, future-proof entity.

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