An Overview Study on Laser Technology and Conventional Technology's Effect on Wood and Sheet Metal Manufacturing for The Furniture Industry

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Abstract:

The laser was one of the most important inventions of the twentieth century, improving many aspects of daily life. Because of its clean cutting-edge capabilities, delicate welding lines, potent etching strokes, high power operation, and precise distance measurement capabilities, laser technology has gradually taken over and dominated the mechanical market, particularly in the field of material handling and metal parts for the furniture industry. By creating intricate and continuous features, lines, shapes, and patterns in metal using lasers, the wood, and sheet metal furniture industries are given new opportunities. However, it is still confusing for designers and manufacturers which is the best method to produce their designs. Hence, there is a need to compare the conventional technology of traded furniture production with laser technology. In order to support the industry in a way that serves to save time and effort and enhances sustainability. We demonstrate that using laser cutting and engraving devices in intricate and sophisticated processing is an amazing technology on flat sheet materials. In conclusion, the laser is more flexible in conjugation with a high degree of accuracy, and the quality of the cutting kerf all add up to make the use of this tool particularly interesting for machining. The focused beam of a modern CO2 laser cuts wood and metal sheets quickly, and accurately and requires no contact or clamping. There is no tool wear and the laser is more or less maintenance-free. Otherwise, using a CNC router is preferred when cutting, or engraving in case of thick wood or metals sheet.

Keywords:

Wood and sheet metal industries, laser cutting, laser welding, CO_2 laser beam, furniture design, CNC machining.

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Introduction:

The development of laser technology started in the middle of the 20th century. After more than 50 years of ongoing growth and development, practicality is rising. Shoes, tools, printing, medical equipment, and other goods are frequently made using a variety of lasers. The employment of laser technology in the furniture manufacturing industry in recent years has produced successful outcomes and improved product quality and productivity. Two ways that laser technology is used in the manufacture of furniture are engraving and cutting. Similar to cutting, engraving is a non-destructive processing method frequently used for patterns and word engraving. Metals and non-metals can be sliced with great power using a laser. Due to the difficulty in producing metal, metal furniture used to be fairly expensive. The advantages of metal laser processing, such as arbitrary drawings, random size and depth adjustments, high precision, high speed, burr-free cutting, automatic configuration of type and material consumption, etc., address a variety of issues with metal processing.

Additionally, the homogeneity of furniture sector products is also a major problem. The various demands of modern society in this age of individuality are still far from being met by the mass manufacturing process. The furniture items can be more diversified and multipurpose while still being processed precisely thanks to the laser cutting machine's ability to generate more variations of furniture pieces at the same cost and volume as the traditional processing method. However, another conventional technology can be used because a laser's capacity to operate with specific material thicknesses and cutting patterns is limited. Both technologies must accurately identify the product's material type in order to make maximum use of their capabilities.

In this paper, we give a general overview of the use of laser technology and conventional methods in the production of furniture, whether it be made of wood or metal. The contrast between thermal laser cutting and mechanical vector cutting of thin material plates is something we are particularly interested in. For a variety of reasons, the production of sheet metal furniture will increase over the next few years relative to that of solid wood furniture. Additionally, as laser technology for material processing develops, it will eventually supplant other conventional techniques.

Research Problem:

The research problem is limited to the following questions:

1- What are the differences in operating methods capabilities that are used in cutting wood and metal sheets in the furniture industry?
2- How do the type of cutting technique and material thickness affect the quality of wood and metal sheets edge cutting?

Research Objective:

This study aims to:

1- Study the conventional cutting techniques used in wood and metal sheets such as CNC mechanical cutting, and CNC thermal cutting.
2- Study laser cutting technology used in thin wood and metal plates and its applications in furniture manufacturing.
3- Determined the advantages and disadvantages of the cutting techniques and their effect on the material operating.

Hypothesis:

From the previous questions, the researcher assumes the following:

The kind of cutting methods, and material thickness affect the cutting quality of wood and metal sheets edges and surfaces in the furniture industry.

Significance:

The importance lies in the following points:

1- Assure the importance of choosing the perfect cutting method for wood and metals that improve the quality of furniture manufacturing.
2- Consecrate on the effect of the technical side in the development of the contemporary furniture industry.

Methodology:

Descriptive and analytical approach through studying and describing the conventional cutting techniques and laser cutting technology and analyzing the effect of applying it on wood and metal sheets for furniture manufacturing.

Theoretical Framework:

1. Conventional methods applied to the wood and sheet metal industries.

Application of CNC Cutting Techniques in the Furniture Industry

Many different materials must be handled during the making of furniture; some of these materials are too tough to be cut using tools and physical manual force; instead, machine cutting must be used. Materials can be cut using a variety of machinery, and each process has unique capabilities, constraints, and costs. The traditional methods of cutting materials are not ideal for intricate cuts since they are slow, expensive to operate and require highly trained operators. As well, Due to the interaction between the tool and workpiece, breaking can happen while cutting composite materials using traditional machining (Kumar, U.A, Alam, S.M and Laxminarayana, P. (2020)).

Otherwise, computer numeric control (CNC) machines are outstanding in their capacity to produce complicated designs that are impossible to make with manual tools or require a trained craftsperson. A design is programmed into CNC machines so that hundreds or even thousands of copies can be made of it. Every product that is made will be the same. Since no longer using humans, the process has above-average accuracy and precision. There are two main (CNC) machining methods for cutting materials: mechanical cutting and thermal cutting. The CNC mechanical cutting where the material is removed by physical contact and material wear includes router cutting that uses power-driven equipment to shape and form material and water jet cutting. CNC thermal cutting refers to using an energy source (light beams or gas or flam) to heat parts of the material, causing it to turn into liquid, it includes flame cutting, plasma cutting, wire cutting, and laser cutting. The friction process that occurs between the cutter and the material during mechanical cutting operations, whether they are performed by traditional machines or CNC router machines that use cutting tools, causes changes in the materials' surface or edge roughness. Due to the fatigue strength, this friction leads to heat generation, material removal rate, rate of residual stress and strain, cutting forces, and cutting tool wear (Mohsen Soori and Mohammed Asmael. (2020)). The cutter is kept out of touch with the material by a supporting bearing, which distinguishes thermal cutting operations from mechanical ones (A. V. Yudin and A. V. Baranov. (2017)). With this type of operation, friction with the material is avoided, protecting it from the damaging effects of attrition, which offers operations for engraving, drilling, and cutting materials with benefits including clean cuts, flat surfaces, smooth edges, and no dust-flying. As a result, without any additional treatments, sanding, or smoothing, the sheets or work pieces might be employed right away in the furniture sector.

Not all CNC cutting processes are appropriate. Additionally, a beam cut can be used to create a variety of profiles and shapes. H beams, I beams, T beams, pipes (of various diameters), HSS squares, HSS rectangles, angles, C channels, bulb flats, and flats are only a few of the possibilities that are accessible, and also capable of using a sheet and a bar.

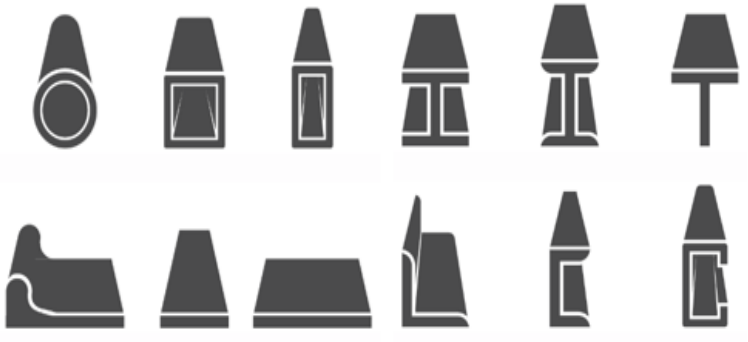

Fig. (1) Structural profiles. Presented by beam cut operations

According to Fig. 1, it is graded as meeting design needs. Particularly with hard materials like metals, this capacity to make profiles can be utilized to manufacture strong-structured furniture elements as separate pieces without welding, for any job or material form. For effective use of CNC machining, material selection is a crucial stage. Choosing a CNC machine that is insufficient for the materials is a common error. We'll discuss several CNC machining considerations in reverse and the best materials to use for it in the part after that. The choice of machine quality, whether structural production or flat manufacturing, depends on the quality of the production processes as well.

CNC Mechanical Cutting:

CNC routers are one of the most popular methods used in material cutting. They have many applications for various industries. They use bits to remove material from a workpiece at high speeds. Its rotational speed is used as the driving force in the making of cuts.

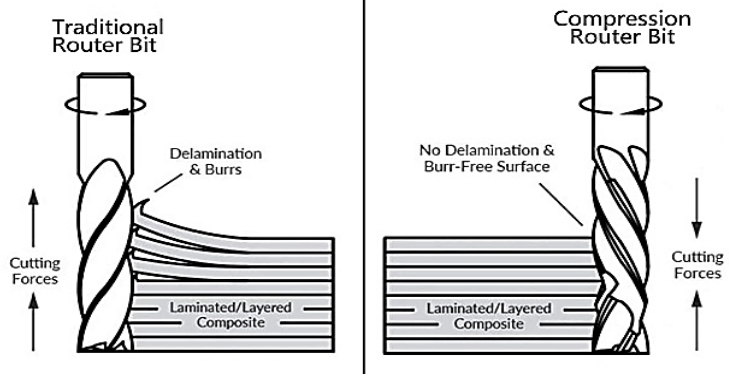

Fig. (2) Shows the impact of router bits on the quality of cutting layered composite material

Routers usually have three axes, but they may have more according to the job required. Routers operate in compatibility with a wide range of materials, including wood, plastics, metals, glass, foam, and composites. It is more suitable for various types of wood cutting and engraving in a precise and homogeneous way for woodcraft (K Bangse, A Wibolo and I K E H Wiryanta. (2020)). It could be applied in solid wood or fiber material panels. Routers have many tasks to do in wood cutting applications including edge trimming, mortising and strip-shaped holes, clean straight cut, sizing, and grooving. That depends on the shape and size of the used router bits, every single bit has a specific use to perform well. Fig. (2) Shows the impact of two different bits on the surface and edge of the material cutting. Only the soft (non-ferrous) metals including aluminum and brass could be cut with a router, as the hard metals should not be used in mills; it causes high-stress loads and brake parts (Autodesk. (2014)). However, router cutting is an accurate method to create complex parts while achieving tight tolerances. There is more material wastage as it cuts away portions of the material to form the finished part. Furthermore, it causes a difference in the required quality of surface finish (Kücük Hüseyin Koc , Emine Seda Erdinler, Ender Hazir and Emel Öztürk. (2017).) Routers have a feature of rotating carousels that can hold and change numerous bits. However, those bits (cutting tools) do wear out. This leads to a lack of performance quickly and efficiently. In addition to being widely employed in the machining of steel and plastic, CNC routers are also widely used in the woodworking industry. CNC routers have significantly outperformed conventional instruments in the furniture industry. As seen in Fig., they provide priceless capabilities for cutting, milling, and engraving 2D and 3D. (3) Patterns on the work. It is a sustainable technology that uses little energy and produces little waste while providing great accuracy and cutting-edge planning. The CNC is managed to generate tool path directions, select the cut speed, and construct a vector-based file. The material attached to its table is then started to be machined by the CNC machine.

(Tomás Queiroz Ferreira Barata, Osmar Vicente Rodrigues, Beatriz Martino Matos and Renato Santos Pinto. (2016)) With the use of a CNC wood router, engraving, woodwork, such as arches, joins, and 3D relief carvings may be produced more rapidly and effectively. On both wood and metal, it is possible to create distinctive designs. CNC Routers can execute numerous tasks like routing, boring, grooving, planning, and sanding in succession by using multiple heads and automated tool changes.

Fig. (3) Reveals the use of a CNC router for 2D milling MDF 18mm covered with melamine, for furniture piece (desk) (Tomás Queiroz Ferreira Barata, Osmar Vicente Rodrigues, Beatriz Martino Matos and Renato Santos Pinto. (2016))

Another CNC mechanical cutting is water jet machines. It releases a water jet with very high pressure, or a water jet combined with an abrasive substance such as garnet, silica sand, aluminum oxide, silicon carbide, which strikes at the target material in Fig. (4). a water jet has a strong linear cutting ability to cut almost all kinds of materials from thin sheets to very thick plates, even the Steels (Sarvesh Talele ,Aishwarya Dalvi ,Gauresh Rane and Janhavi Nawar. (2020)). Water jets can cut metals, alloys (Copper, Titanium, Inconel), natural substances (Wood, Glass, Marble, stone), composites (Kevlar, Fiberglass, Carbon Fiber), rubber, textile and leather, mineral wool, paper, cardboard, and polymer composite materials. Water jets are available for cutting wood panels such as chipboard, MDF, and cement-bonded panels, and also for cutting solid wood no more than 30 mm in thickness. Wood moisture uptake average is relatively insignificant in water jet cutting, presenting no serious hindrance practically (Kinga Gerencsér and László Bejó. (2007)). It can be used for cutting heat sensitivity because this process is technically a cold cutting process and any heat that may be produced is cooled by the water stream. It also cut hard and reflective materials without warping, distortion, and material hardening. Water jet cutting is an eco-friendly technique as it produces no dust or fumes. The loss material to be cut is too small and the reuse of the abrasive up to 80% is possible. Unfortunately, water jet cutting has some limitations, at high speed cutting it deviates from circles and arches, may produce notches of inner angles and striations may occur along the depth of cutting thick materials (Mert, T. (2012)). Also, water jet cutting gets a kerf taper angle along the cut line because of spreading out the water jet stream away from the nozzle instead of traveling in a straight line. By reducing standoff distance and speed, and boosting water pressure, this issue can be resolved (Tawfik El Midany, Tarek M. Ahmed, Ahmed S. El Mesalamy and Amro M. Youssef. (2019)). Water jet machines have a wide capability to cut and engrave many types of materials that could be used to serve the furniture industry.

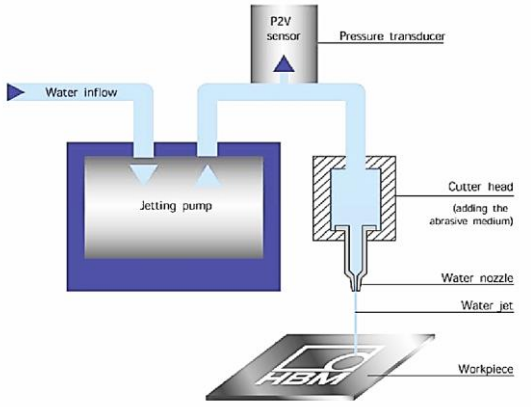

Fig. (4) Shows the water jet system (Schäfer, A. (2018).)

CNC Thermal Cutting:

The CNC thermal machines concept depends on using focused beams from a nozzle to heat the materials. This process causes cut or bend or weld material parts. The different operations of CNC thermal methods are mostly specialized for metal fabrication. Flame cutting goes by many names, including oxy-fuel cutting, oxyacetylene cutting, and oxy-cutting. It is carried out using an oxygen jet and a heated flame as shown in Fig. (5), the

flame is not for melting the metal, but rather for bringing the material to its ignition temperature. Then, a stream of oxygen is aimed at the metal and cuts through it. Flame cutting is carried out in very cold conditions (below 10 °C) or in heavy plate thicknesses. As flame cutting requires pre-heat to 100–200 °C (Development, D. o. (2007)). It's most commonly used to cut thick metal plates. However, it can cut a variety of metals with thicknesses ranging from 1 mm to 1000 mm. The great majority of commercial metals can only be melted at temperatures high enough for gas flame at a relatively low cost. Although flame cutting is an efficient method to cut ferrous metals such as iron and steel, it is not a suitable choice for cutting aluminum, bronze, and stainless steel which resist oxidation. Moreover, the cut edge of the steel plate is subject to residual strains as well as high tensile stresses due to flame cutting (T. Jokiaho , S. Santa-Aho, P. Peura, and M. Vippola. (2020)). frequently needs extra treatments to get an acceptable end product. For these reasons, manufacturers turn to plasma cutting as an alternative to flame cutting. Especially, while working with aluminum or stainless steel. Plasma cutting technology uses a fast-moving jet of ionized gas – as shown in fig. (6)- used to generate high temperatures that melt and cut only electrically conductive materials like metals, unlike laser cutting, which is capable to cut any material, even not electrically conducting (Valerian Nemchinsky. (2017)).

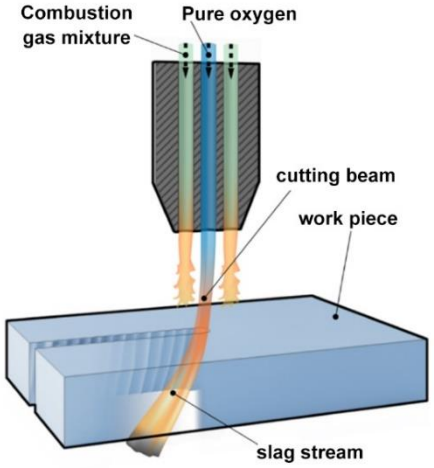

Fig. (5) Show flame-cutting system (https://www.manufacturingguide.com/en/flame-cutting-2d)

Plasma cutting is performed for different types and thicknesses of metals in various industrial applications with high cutting speeds (up to 10 times higher than with oxyfuel). Is characterized by low noise levels and very low heat exposure at the workplace underwater operating conditions. Even though Plasma cutting is known with its excellent performance in cutting medium to thick plates, it is non-effective for processing thin material. The kind of metal and the degree of the cut determine the plasma parameters that are implemented. Therefore, thin metal sheets require setting optimal values for torch height, pressure, Intensity, and speed to reach an accurate cut result (Adel Gani , William Ion and Erfu Yang. (2021)). This technique could provide high-quality, and unique metal artwork that could be used in the furniture industry. Fred P. Liza et al cut a 2-mm mild stainless steel plate to perform a coffee table as shown in Fig (7), they achieved a high accuracy with the assistance of the screw-type air compressor system and the high-capacity 120-ampere plasma generator (Fred P. Liza, Cameron B. Yao, Joein L. Luces, Vincent Boy E. Manabat, and Renann G.Baldovino. (2015)).

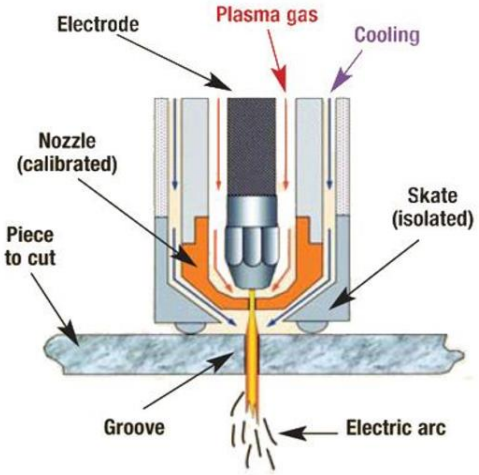

Fig. (6) Plasma Arc Cutting system (Kunal S. Panchal and M. Mungla. (2020).

Fig. (7) Stainless steel Coffee table cut by plasma. (Fred P. Liza, Cameron B. Yao, Joein L. Luces, Vincent Boy E. Manabat, and Renann G. Baldovino. (2015))

There is also a cutting method called Wire-Cut Electrical Discharge Machining (EDM wire). It uses eroding sparks emitting from a continuously circulating wire as an electrode as demonstrated in Fig. (8). When a steady current discharges between

two electrodes, cutting takes place. which are isolated by a dielectric fluid and are exposed to an electric voltage. Material is removed from the workpiece along a programmed path. The wire anode is made of thin copper wire or brass wire or molybdenum wire or Steel-core wire or Tungsten wire. The type and diameter of wire are chosen according to the work conditions like material thickness, required accuracy, cut straightness, and durability of wires. It is used for cutting greater thicknesses of slabs and plates of metal (Muhammad Wasif and Muhammad Tufail. (2022)) with an excellent finish. But, it is hard to control the accuracy of wire-cutting thickness due to the residual stresses and the heating effects in the workpiece, which decrease the accuracy in the rough cut (Takayuki Nakagawa, Mitsuji Sampei and Atsushi Hirata. (2020)). Wire cutting technique is also used for woodworking, marble, ceramic, silicon, stones, rubber, plastic, and material combinations. This is thanks to the diamond wire machines, which are characterized by thin kerf and higher sawing rates (Florian Wallburg, Meinhard Kuna b Michael Budnitzki and Stephan Schoenfelder. (2022)). Also, the flexibility to change cutting directions and workpiece orientation during cutting. The cutting process with diamond wire offers several advantages over conventional cutting processes. Such as lowest roughness, no broken edges, constant cutting pressures, clean cuts in composite materials, and dry and wet separating cuts. Moreover, there is no need for heat input like flame and plasma cutting. So wire diamond machines are a good option to cut very high hardness non-conductive materials.

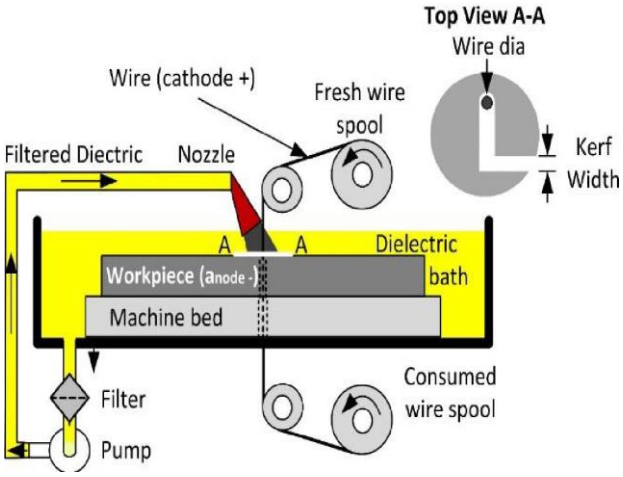

Fig. (8) Components of Wire EDM process (WEDM) (Muhammad Wasif and Muhammad Tufail. (2022))

Benefits of CNC Multi-axis machines in the furniture industry:

CNC thermal and mechanical techniques have a high-quality 2D cut by X, Y, and Z motions. In addition, the 3-D structural workpieces can be operated like a 2-D cutting job. The beams could be placed directly in the correct position for cutting. It could be rotated 180 degrees to accommodate the cut by utilizing a fixture or portal system together with extra shafts to facilitate tilting and rotation as shown in Fig. (9). But it's a complex process that cannot operate with the 360 degrees shapes. The Limitations in machining 3D shapes are improved by the Progress in CNC cutting technology that led to the development of multi -Axis CNC cutting. where a robotic arm attached to the cutting head of the machine or the cutting table (holder) can rotate around the X, Y, and Z axis. This development brings the advantages of CNC cutting to more complex 3D parts which would otherwise be timely and expensive to machine.

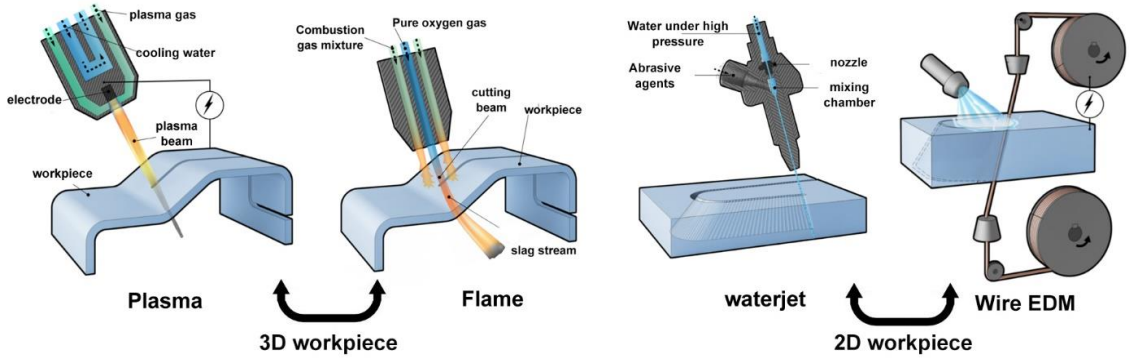

Fig. (9) Shows the limited ability of a 3-axis CNC machine (cutting 3D structural workpiece and cutting 2D flat workpieces in 3d rotation)

When talking about multi-axis simultaneous, it usually means that the workpiece is mounted on a rotating table that can be rotated simultaneously, which gives an additional degree of freedom. CNC's Multi–axis enables it to adapt to deviations in the outer diameter and still perform an accurate 3D cut.

The growing need to mass production of various components of furniture. High quality is required in a short time with low costs. Leeds to use digitization technique through CNC machining. Moreover, the CNC multi–axis machines allow the manufacturing of complex shapes for innovative furniture designs as shown in Fig. (10). Due to the ability to move in 4 or more directions and the ability to operate on metal, wood, and other, which provide designers and manufacturers with CAD/CAM operations without limitations.

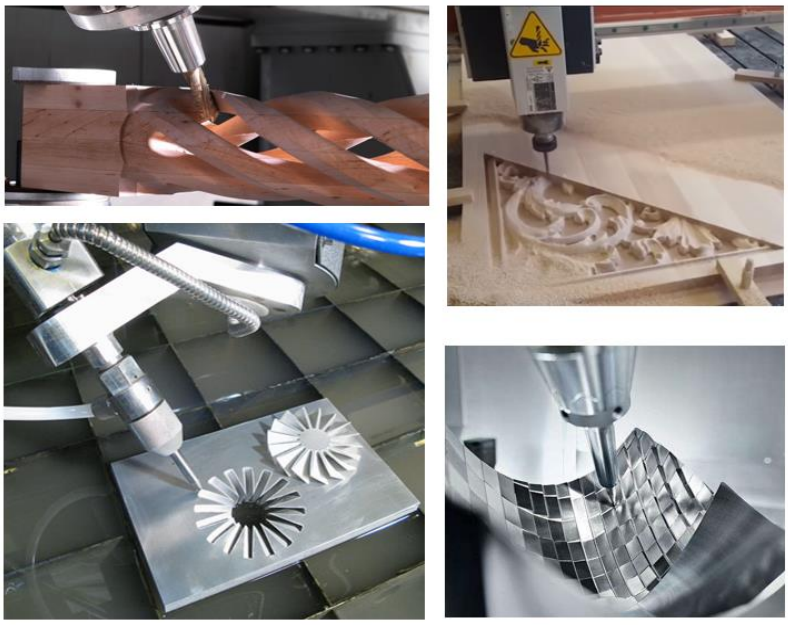

Fig. (10) Reveals the application of 5 axis CNR in wooden and steel parts

2. Application of laser technology in the furniture sector for wood and metal sheet.

The laser is regarded as one of the most important inventions of the 20th century, and laser technology is used in many aspects of daily life. In today's manufacturing industries, laser technology is valuable and offers particular advantages in fields like laser material processing and all manufacturing. The sheet metal industry benefits from laser cutting technology's quick processing times, clean cutting edges, and simple programming (Hong, K.M., Shin, Y.C. (2017)). The material market has gradually been captured and dominated by laser technology, particularly in metal parts and material handling (Schmidt, M. (2017)). The laser light is able to concentrate into a spot approximately the size of its wavelength thanks to the interaction of phases (104 cm). Consequently, a 1 W laser can concentrate energy to an intensity of 108 W/cm2, making it a high-power laser that can drill, cut, and etch images quickly and accurately (Sing, S.L., An, J., Yeong, W.Y., Wiria, F.E. (2016)). The benefits of laser cutting technology for the mechanical industry include fast processing, a smooth cutting surface, and simple programming. On tools, machine parts, and even tiny cutting workpieces, lasers may quickly cut diverse sheet or tube metal surfaces (Malinauskas, M. (2016)).

The employment of laser technology for cutting and engraving in the furniture production business in recent years has produced positive results and enhanced the product's quality and productivity. In order to move energy into the cutting zone quicker than heat is transported, laser metal cutting requires a high energy density laser beam. Additionally, molten metal will be pushed out of the cutting zone by the support gas flow (Gibson, I. (2017)) .Laser cutting is mainly used in the manufacture of furniture for the cutting of veneer. MDF (Medium Density Fibreboard) veneer furniture is the mainstream of current high-end furniture, regardless of neo-classical furniture or modern panel furniture, using MDF veneer production is a development trend.

Living standards are rising steadily, which has a positive impact on the home environment and raises expectations for furniture in terms of taste, quality, and style. The use of laser technology will boost the technological sophistication of furniture and encourage the industry's continued growth and success.

Because of the laser industry's continual growth and development, the usability of laser cutting technology has lately increased. In addition to its extensive usage in sheet metal processing, hardware cabinets, elevator processing, hotel metal products, and other industries, metal laser cutting machines are now used in the furniture business. This entails adding top-notch hollowing and cutting techniques into the initially immobile and chilly metal elements. Establish a new basis for modern metal furniture design.

Metal furniture used to be quite expensive because

of the complexity of processing metal. The advantages of metal laser processing include arbitrary graphics, random size and depth adjustments, high precision, quick processing, burr-free cuts, automatic typesetting, minimal material usage, and no mold consumption, among others, which address a number of issues with metal processing.

Additionally, there is now a severe homogenization problem in the furniture sector. The mass production approach falls far short of fulfilling the many needs of contemporary society in this age of individuality. However, the laser cutting machine can produce more types of furniture goods at the same cost and output as the conventional processing method, enabling the furniture items to be more diverse and multifunctional while maintaining processing accuracy.

Recently, laser cutting technology has been used more and more widely in the processing of handicrafts, whether in the field of metal cutting or non-metal cutting. Faced with many laser cutting equipment on the market, how to choose the laser cutting machine that suits the needs of the company can be considered from the following aspects:

Firstly, consider the materials processed by the company. The processing material is generally divided into two types, metal cutting, and non-metal cutting. There is also a kind of mixed cutting. Considering the relationship of wavelength to material absorption, the metal cutting is mainly realized by the fiber laser cutting machine with a wavelength between 1060 and 1070, and the non-metal cutting is realized by the CO2 laser cutting machine with a wavelength of about 10,600

Secondly, for non-metal cutting, the machine is divided into high power and low power according to different application functions. Some low-power cutting machines are only suitable for color plates, architectural models, small signage, and three-dimensional handicraft materials processing. This small power laser cutting machine has been popular for some time, but with low power which will greatly affect its application range. Another type of laser cutting machine is mainly fiber laser cutting machines, which have high cutting precision and good cutting quality. Besides that, there are many different sizes of work formats to choose from. Like Oree Laser, which has four different sizes to meet the needs of different industries. For small DIY workshops, you can choose a small power laser cutting machine like a CO2 laser cutting machine. For metal cutting, if the company usually processes the metal plate within 3mm, and the processing product is small in size and variety, you can choose the 5000w laser cutting machine. If the company itself is mainly processing handicrafts, then the 40w-150W laser cutting engraving machine is the best choice for the equipment procurement cost is low and the processing materials are diverse and cost-effective. Therefore, the power cannot be used as the only indicator to evaluate the quality of a laser cutting machine. A device that can properly meet the processing level of the enterprise is a more rational choice.

Thirdly, reliable and high-quality laser equipment is another crucial statistic. It is a difficult task for the company to complete customer orders with quality and quantity, uphold the company's reputation, and increase corporate competitiveness because the product development cycle is short, the update is happening faster and faster, the product variety, prototype trial production, and mass production are increasing. That is to say, there are additional factors to consider when buying laser equipment, including stable processing equipment as the foundation, selecting a brand with a large market share, a reliable after-sales service system, a strong after-sales service network, and thorough market research over an extended period of time. Due to its low cost and poor quality, it cannot be purchased, which will have a significant negative effect on the business's production.

Today, as laser technology advances, the laser can do an increasing number of tasks, including precision drilling, fine cutting, selective material removal, etc. This has led to the development of new applications, new theoretical frameworks, and increased industrial production. For the micro-precision machining of diverse materials, a laser is a perfect tool. The workpiece is not directly impacted and cannot easily be damaged. As a result, it has benefits including superior cutting quality, little waste or emissions, and environmental protection.

The workpiece is illuminated by a focused, high-power laser beam on the laser cutting equipment, which causes the material to rapidly melt, evaporate, ablate, or reach a flash point. A high-speed airflow coaxial with the beam blows the molten material off at the same time, cutting the workpiece. One technique for hot cutting is laser cutting. When using a laser to cut something, there is no touch between the torch and the object being cut, hence there is no tool wear. In addition, the laser cutting method has the advantages of minimal vibration, minimal noise, and zero pollution.

Fig. (11) Gives instances of how laser cutting technology has been used in the (a) furniture industry for wood, and (b) furniture industry for sheet metal.

Fig. (11) Laser Technology application in (a) Wood Furniture Industry (b) metal furniture industry

Co_2 laser- functionality and the area for application.

The CO_2 laser, also known as carbon dioxide laser, is a member of the gas laser family. The brightest emission line from the CO_2 laser is typically 10.6 m, with a wavelength range of 9 to 11 m. It can deliver pulse energies of up to 100 KJ and very high average output power of up to 80 KW. Fig. (12). CO_2 lasers are employed in industrial metalworking, fur cutting, and marking organic workpieces due to their high efficiency (up to 15%) compared to gas lasers and low cost of purchase.

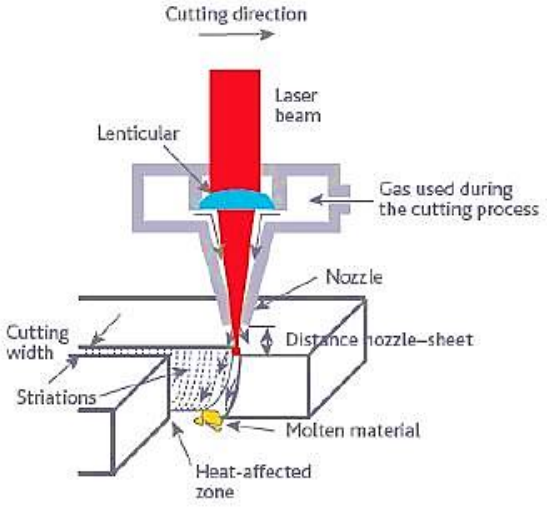

Fig (12) CO_2 Laser Cutting System

Thin, organic materials like wood, fabrics, or plastics are sliced, perforated, or engraved using CO2 lasers with a power range of 10 to 400 W. Industrial lasers for welding, hardening, or re-melting metals often have CO2 lasers with increased powers between 1 and 6 Kilowatts. CO2 lasers are increasingly used for oxide-free laser cutting in contemporary industry. Laser cutting equipment is utilized in sheet metal manufacturing, especially for small batches. For bigger amounts. Punching remains the more affordable choice.

The larger wavelength of the laser light is transformed into heat as it passes through the substrate, allowing for the laser cutting of wood or sheet material. The heat produced by this procedure causes localized melting (a process known as melt shearing) and/or vaporization of the material (sublimation process). The molten material and/or the vaporized material are forced away from the cutting region by a gas or air jet that operates in coaxial alignment with the laser beam. The sheet thickness must be taken into consideration while adjusting the laser power and cutting speed. In general, with thicker sheets, the power is raised but the cutting speed is decreased. Given that the pulsing effect would result in surface striations, it is advised to keep the frequency as high as possible (> 1 kHz) (rough surface). When the cutting speed is not optimized, using a high laser power (> 1000 W) can lead to material degradation and sheet yellowing. By reducing the laser's output wattage at a specific sheet thickness and increasing cutting speed, the greatest cutting quality can be obtained.

The fundamental workings of a laser cutter are very straightforward and may be summed up as follows:

1- A laser produces an intense beam of infrared light.
2- Using a lens, this beam is directed onto the workpiece's surface
3- The material is heated by the concentrated beam, which creates a confined melt (often with a diameter of less than 0.5 mm) that spreads across the sheet's depth.
4- A pressured gas jet working coaxially with the laser beam expels the molten material from the region (see Fig.1). (Note that with some materials, this gas jet can speed up the cutting process by performing both chemical and physical work.) Steels, for instance, are typically cut in a stream of pure oxygen. Initiated by laser heating, the oxidation process produces heat on its own, considerably increasing the efficiency of the procedure.)
5- A cut is created by advancing this small area of material removal across the sheet's surface. The sheet is moved physically on a CNC X-Y table or by manipulating the focused laser point (using CNC mirrors).

Many different industries employ CO_2 lasers. High quality and versatility are the laser cutting process' standout characteristics. Perfect-cut edges are produced by the quick, precise, and contactless laser-cutting process. The creation of furniture involves the use of a wide variety of materials. Numerous non-metallic materials can be cut and engraved with the help of CO_2 laser systems.

The benefits of laser technology in the manufacture of furniture.

Textiles are cut lint-free and cleanly;
Laser cutting and engraving are performed in a single operation;
No material fixation is required, resulting in less waste;
There are no chippings, so cleaning the area around the machine is not required;
There is no need to clean the knives;
There are numerous contour options available without the need for tool construction or changeover;
Simple production using the design software.

Application of laser welding technology in the furniture industry for wood and metal sheet.

The welding process entails joining non-removable metal pieces together by applying pressure, local heating, or both- individually or in combination- - and joining them with or without the use of additional metal. A welding process is the culmination of all technological actions utilized in a particular type of welding. Welding is the collective outcome of using the welding process. There are two sizable divisions into which welding methods can be classified (Cristian CORBA, Peti FERENCZ, Ioan MIHĂILĂ(2009)).

• Melting procedures used in welding
• Pressure-based welding procedures. The edges of welded components are turned into liquid by local heating in welding techniques that include melting, with or without additional metal. By applying pressure during the welding process, the combination is created under the influence of the forces transferred by pressing the welded pieces, whether or not they have been locally heated. Metals are one type of material that can be melted during laser welding. All welding situations, including welding, overlap welding, and corner welding, can use laser welding. When two materials are heated until they are molten and then fused, welding occurs. Light energy produced by lasers can be absorbed by materials and transformed into heat energy. We can convey this by using a light beam in the visible or infrared range of the electromagnetic spectrum, Using delivery optics, which can concentrate and direct the energy to a very small, precise location, we can convey this energy from its source to the substance. The energy beam has little divergence and can travel over long distances with little or no loss of beam quality or energy since the laser emits coherent radiation. Fig. depicts the laser welding technology method (13).

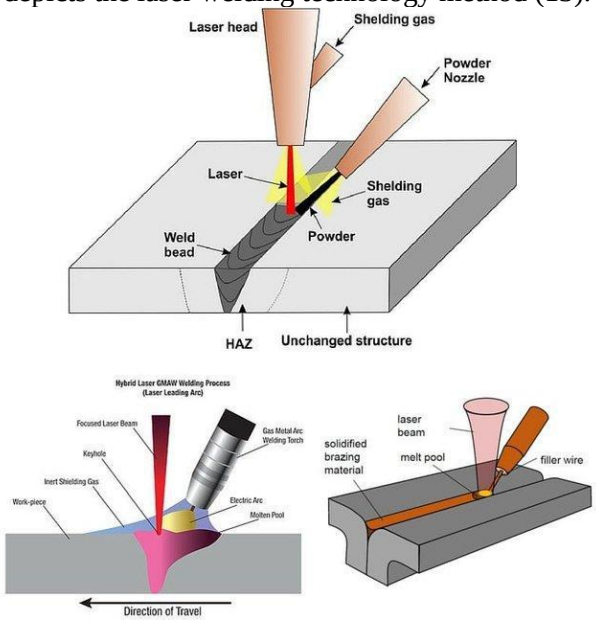

Fig. (13) Laser welding techniques

The benefits of laser welding over traditional welding methods (TIG/MIG, spot welding) include Low deflection; No additional material required; with little to no cost-cutting post-processing, corrosion resistance is maintained. Additionally, the potential for weight loss high welding speed, the

potential for effective automation; profitable construction opportunities, and welding in places that are hard to reach higher solidity at small seam volume due to thin seam geometry. Higher rigidity at small seam volumes and one-sided weld accessibility are sufficient. Additionally, without the usage of compounds like Ki, strong magnetic materials can be welded, strong construction with good fatigue resistance, and connections that are gas- and liquid-tight can be created.

Fig. (14) Reveals the application of laser welding technology for many different materials forms.

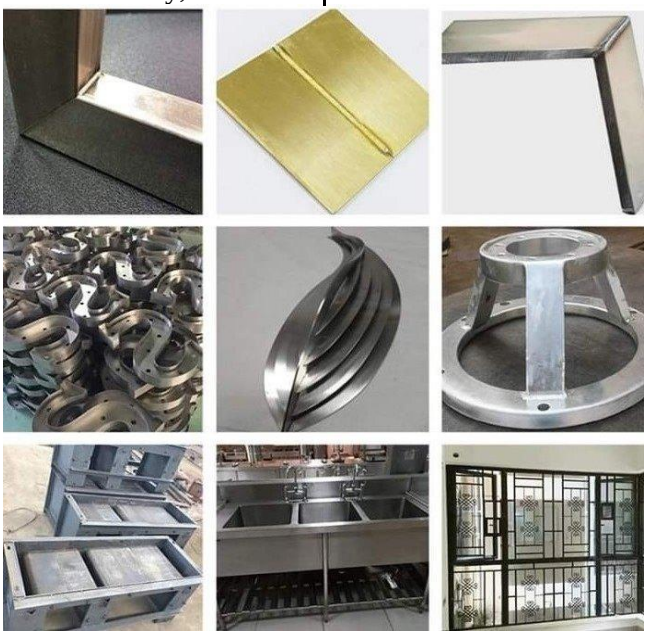

Fig. (14) Application of laser welding technology for the sheet metal furniture Industry

We summarized the comparison between Router mechanical and laser technology in the furniture industry is summarized in table (1)

Table (1) shows a comparison between the advantages and disadvantages of router technology and laser technology in the furniture industry.

Comparison type	Router technology	laser technology
waste material	Produce wastage of material	There is almost none
waste	There is a waste	There is no
Allowed material thickness	The machine can be handled to deal with multiple thicknesses of the material	There are limits to the thickness of the material that varies depending on the machine, but it is limited to the flat furniture parts.
Operations availability	Can be used in structural furniture and flats	Almost preferred for flats
Aloima and classic holographic motifs	It gives strong results for holographic decorations that almost mimic good handcraft	The results are not strong compared to router technology
Accuracy, quality, and softness of letters	Good accuracy, but needs additional finishing	Excellent accuracy but there are some deviations and cracks in the case of arcs and circles with increasing speed
The materials used for the furniture	Usually used with wood	It is used with all furniture materials
the noise	make noise	weak noise

Results:

1- For the wood and sheet metal furniture sectors, there are various traditional cutting and welding techniques available, including 2D and 3D CNC routers, water jets, flame, plasma, and laser technologies.

2- The kind of cutting methods and material thickness affect the cutting quality of wood and metal sheets' edges and surfaces as follows:

- The CNC router Cutting method is not ideal for intricate cuts for thin wood and metal pallets since they are slow, expensive to operate, and require highly trained operators.

As well, due to the interaction between the tool and the workpiece breaking can happen while cutting.

- Water jet has a strong linear cutting ability to cut almost all kinds of materials from thin sheets to very thick plates, even the Steels. Water jets can cut metals, alloys, wood panels, and solid wood no more than 30 mm in thickness.
- Flame cutting is an efficient method to cut ferrous metals such as iron and steel, it is not a suitable choice for cutting wood or aluminum, bronze, and stainless steel which resist oxidation.
- Plasma cutting has an excellent performance in cutting medium to thick plates, it is non-effective for processing thin material.
- laser technology in the manufacturing of metal or wooden furniture has had many advantages in cutting, drilling, and welding without the emergence of any issues on the surface. This enables extremely accurate manufacturing with a reduction in time, lowering the cost of production and production on a large scale. laser technology cannot be utilized on materials with larger thicknesses of wood or sheet metal, it is better to use other traditional technologies instead, such as 2D or 3D CNC, flame cutting, and plasma cutting.

3- The quality of cutting materials is based on the kind of used beams, high cutting speeds, material kind, and material thickness.

Recommendations:

1- The workers in the furniture manufacturing sector should be aware of the abilities of all conventional and developed materials cutting methods to well implement in high-quality products.

2- It is necessary to make use of three-dimensional and two-dimensional laser technology in the treatment of metals of various kinds. To expand the production of metal furniture and mixed furniture, which contributes to a reduction in overall wood consumption and the gradual abolition of wooden furniture as well as the protection and reduction of forests globally, all of which contribute to a better climate.

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