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Design And Fabrication of Table Lamp by Using Co_2 Laser Cutting Machine

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ABSTRACT :

This project explores the design and fabrication of a modern lamp utilizing laser cutting technology to enhance both functionality and aesthetic appeal. The aim is to create a unique lighting solution that seamlessly integrates contemporary design principles with efficient manufacturing processes. The lamp features a geometric structure crafted from sustainable materials, enabling precise cuts and intricate designs that traditional methods cannot achieve. The design process involves digital modelling, where CAD software is employed to conceptualize the lamp's form and light diffusion characteristics. Laser cutting is then utilized to fabricate the components, ensuring high precision and minimal material waste. The assembly process focuses on ease of construction while allowing for customization options in size, cooler, and design motifs. The finished lamp serves not only as a source of illumination but also as an art piece, enhancing interior spaces with its modern aesthetic.

Keywords: Modern lamp, Laser Cutting, Precision Fabrication, CAD Modelling, Finite Element Analysis (FEA), AutoCAD, RD Works.

1. Introduction:

Designing and fabricating a modern lamp with a CO2 laser cutting machine involves creating a digital design, selecting suitable materials, and precisely cutting parts with the laser. The process starts with a computer-aided design (CAD) file that defines the lamp's shape, style, and dimensions. Materials like wood, acrylic, or metal are chosen based on the desired look and compatibility with laser cutting.

The CO2 laser cutter uses this digital file to produce clean, precise cuts or engravings on the material, allowing for complex and detailed designs that would be challenging to achieve manually. Once the parts are cut, they are assembled into the final lamp structure, often with minimal adhesive or hardware. The electrical components, like LED lights or bulbs, are added last to complete the lamp. This method is efficient, highly customizable, and allows for the creation of intricate, modern lighting designs that add style and function to any space.

Lighting has always been an essential aspect of interior design, providing both functional illumination and enhancing the aesthetic appeal of space. Modern lighting design goes beyond functionality, incorporating artistry, innovation, and the latest technological advancements to create unique, environmentally friendly, and efficient lighting solutions. One such innovation is the use of laser cutting technology in the design and fabrication of modern lamps.

This project explores the design and fabrication of a modern lamp using laser cutting, a precise and versatile manufacturing method. Laser cutting technology has revolutionized the production of intricate designs, enabling designers to craft complex patterns and structures with unparalleled accuracy. The integration of laser cutting in lamp design allows for the creation of intricate, lightweight, and durable components, giving rise to new possibilities in both form and function.

1.1 Laser Cutting Process

Laser cutting is a subtractive manufacturing process where a high-powered laser beam is directed at the material to cut or engrave designs with precision. The process is controlled by computer-aided design (CAD) software, allowing for highly detailed and intricate patterns to be created.

1.2 Design Considerations and Objectives

The primary goal of this project is to design and fabricate a modern lamp using laser cutting technology, emphasizing aesthetics, functionality, and sustainability. The design phase will focus on creating a lamp that combines modern trends like geometric shapes, organic forms, and intricate patterns; while also ensuring it remains energy-efficient and easy to produce.

2. Literature Review:

Smith (2017) [1] Examined the potential of laser cutting for creating intricate designs in lighting fixtures. His study revealed that laser-cut lamps offer precision and complexity in design, enabling the development of geometric and organic patterns that are impossible with traditional methods. He noted that this technology reduces waste and enhances customization, making it a preferred option for modern designers.

Johnson and Miller (2016) [2] Focused on the material compatibility of laser cutting in lamp fabrication. Their research highlighted how materials like acrylic, plywood, and aluminum perform differently under laser cutting, with acrylic offering the best results for light diffusion, while plywood provides a warm, natural finish ideal for residential lighting fixtures.

Chen et al. (2019) [3] Explored the use of laser cutting in creating functional and decorative lighting products. They emphasized that laser cutting enables the precise manipulation of light through perforations and cut patterns, offering both aesthetic and functional benefits. Their study also pointed out how different patterns affect light distribution in interior spaces.

Kumar and Gupta (2020) [4] Discussed how laser cutting technology can be integrated into sustainable lighting design. They argued that laser cutting minimizes material waste and allows for the use of recyclable and biodegradable materials, aligning with current trends in green design. Their work showcased several modern lamps made from eco-friendly plywood and bamboo.

3. Methodology:

Download the program and file

File

↓

Origin

↓

Frame

↓

Adjust

↓

Start program

3.1 CO_2 Laser

A CO_2 laser operates by exciting a mixture of carbon dioxide, nitrogen, and helium gases in a sealed tube. The energy source—often electrical—creates a flow of electrons that excite the gas molecules, resulting in the emission of photons. CO_2 lasers are among the most widely used types of lasers in the engraving and cutting industries. The technology relies on a gas mixture that includes carbon dioxide, which allows for efficient energy conversion and high-quality laser emissions.

1. Conceptualization and Design

Determine Lamp Style: Decide on the lamp's purpose and aesthetics (e.g., geometric, minimalist, pendant, or table lamp).

Sketch Initial Ideas: Create rough sketches to visualize the design, dimensions, and potential light diffusion effects.

Select Materials: Choose materials compatible with CO_2 laser cutting, such as wood (plywood, MDF), acrylic, or coated metals.

CAD Modeling (Using CAD Software):

2D Vector Design: Use software like AutoCAD or Inkscape to create a detailed 2D vector design of each component. CAD software will help accurately plan dimensions, angles, and joint placement.

Export the File: Save the file in a format compatible with RD Works (usually DXF, SVG, or AI format).

Fig. 1 - Display Panel of The Co2 Laser Cutting Machine

2. Material Testing and Calibration

Laser Parameter Testing: Use RD Works software to set the laser parameters (power, speed, frequency) based on material thickness and properties. Test these settings on scrap pieces to avoid burning or melting edges.

Optimize Cutting Paths: Within RD Works, arrange shapes for minimal material waste and set optimal paths. Test engraving settings if any text or design details are to be etched onto the lamp.

3. Prototype and Adjustments

Prototype Cutting and Assembly:

Import the file into RD Works to set up the laser paths and cutting layers. Use the software to adjust such as resizing, mirroring, or adjusting cut order.

Run a prototype at a smaller scale, if necessary, to check dimensions, joints, and overall aesthetics.

Evaluate Fit and Adjustments: Assemble the prototype and make any required changes in the CAD file based on fit, stability, or other design adjustments.

4. Fabrication

Prepare Final Design File: Finalize the CAD file and re-export to RD Works. Ensure all components are properly organized in the software and preview the paths.

Laser Cutting (Using RD Works):

Import the final design into RD Works, confirm settings for power, speed, and frequency, and preview the cutting paths.

Place the material on the laser bed, focus on the laser, and ensure ventilation is active for fume extraction.

Begin the cutting process, monitoring consistent cuts and adjusting any real-time settings in RD Works if needed.

Edge Finishing: Perform any post-processing needed on cut edges, such as sanding wood or cleaning acrylic, to achieve a polished look.

5. Assembly

Fit Components Together: Assemble the laser-cut components using appropriate joinery techniques. RD Works can help ensure precise, interlocking cuts if designed with tabs or slots.

Electrical Integration: Add the lamp components, such as sockets, bulbs, and wiring, ensuring safe assembly and standard compliance.

Lighting Test: Test the assembled lamp to ensure proper functionality and even light diffusion.

6. Finishing and Quality Check

Surface Finishing: Apply varnish, paint, or other finishes as needed to enhance appearance and durability.

Final Inspection: Inspect for stability, safety, and any aesthetic final touches. Ensure all components meet the design's standards and expectations.

4. AutoCAD:

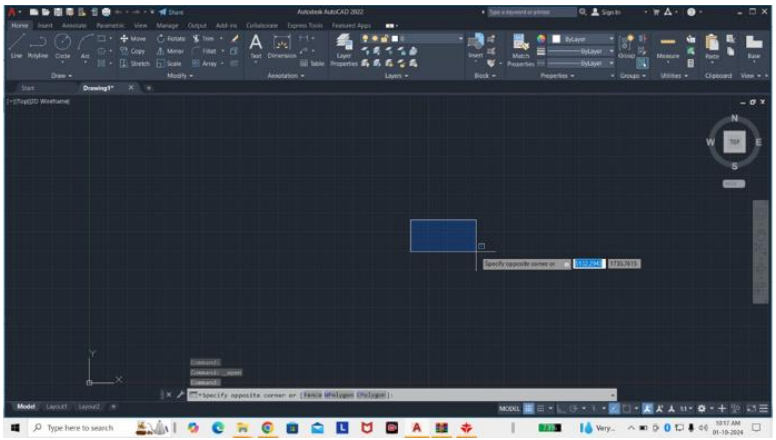

Fig. 2 - Interface of the AutoCAD

4.1 Process in AutoCAD:

1. Choose Lamp Shape and Style

Decide on a basic shape for your lamp, such as a cylinder, cube, or geometric shape (like a hexagon).

Determine how the light will diffuse. For instance, you might want simple cutout patterns (e.g., circles or triangles) on the lamp body to allow light through.

2. Set Up AutoCAD Software

Open AutoCAD or a similar CAD program and set your units (millimeters or inches).

Create two layers:

Cut Layer (for outlines to be cut).

Engrave Layer (for patterns or text you want engraved, not cut).

3. Draw the Base and Top Shapes

Draw the base shape in a simple top view. For example, if using a hexagonal or circular shape:

Use the POLYGON or CIRCLE command to create the base outline.

For the top piece (where the light bulb socket will go), draw a matching shape with a center hole to allow the light socket or wiring to pass through.

4. Design Side Panels with Cutout Patterns

Draw the side panels separately in 2D as simple rectangles (height and width should match your lamp's dimensions).

Add cutout patterns to these panels for light diffusion. For example, you can:

Use circles, triangles, or rectangles as patterns.

Arrange patterns symmetrically or randomly, depending on the style.

5. Add Slots or Tabs for Assembly

Interlocking Tabs: If your lamp has multiple side panels, add tabs on the edges where panels will connect to each other or to the base and top pieces.

Make sure the tab width matches the material thickness.

Check Fit: Ensure all dimensions match up so that the parts will slot together securely when assembled.

6. Save and Export Design

Double-check that all dimensions are correct.

Save or export the design as a DXF file, which is commonly used for laser cutting.

7. Prepare for Laser Cutting

Import the design into laser-cutting software (e.g., RD Works).

Set the laser parameters (speed, power) based on your material.

Arrange the pieces in the software for efficient cutting and minimal waste.

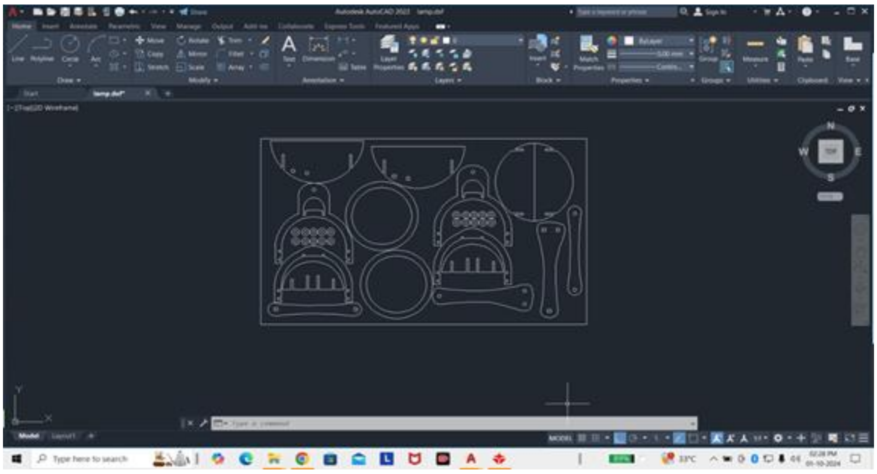

Fig. 3 - Total Components Designed in AutoCAD

5. RD Works:

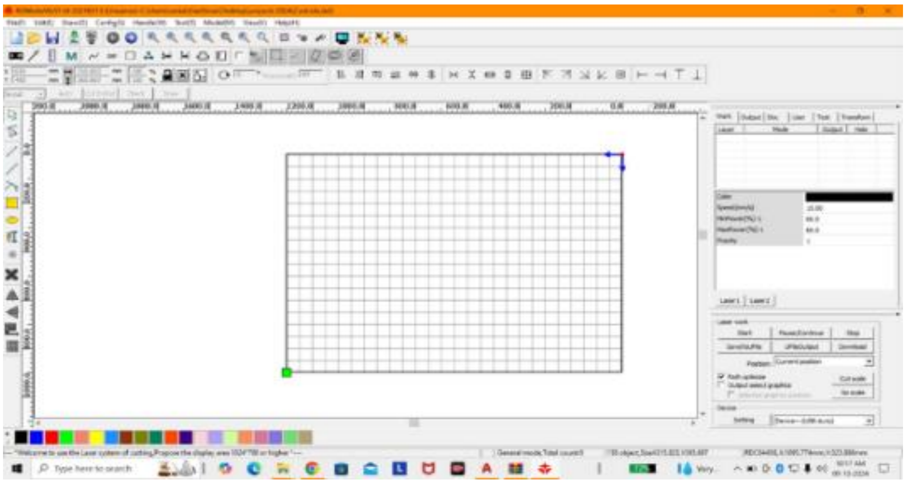

Fig. 4 - Interface of the RD Works software

1. Import the Design File

Open RD Works and import your DXF or AI file from your CAD software (e.g., AutoCAD) by clicking on File > Import.

Ensure all parts of the lamp (base, side panels, top piece, and any cutout patterns) appear on the workspace.

2. Organize Layers for Cutting and Engraving

Assign each part of the design to either Cut or Engrave layers in RD Works.

Select all lines that should be cut (like outer edges and tabs) and assign them to a "Cut" layer.

Select patterns or details that you want engraved and assign them to an "Engrave" layer.

Use different colors for each layer to clearly distinguish them.

3. Set Laser Parameters

For each layer (Cut and Engrave), adjust the power, speed, and frequency settings:

Cut Layer: Set higher power and slower speed to cut through the material. For example, for 3mm wood, try around 60% power and 10mm/s speed (adjust as needed).

Engrave Layer: Set lower power and faster speed for engraving patterns. For instance, try 20-30% power with a speed of 200mm/s.

Test settings on a scrap piece of material first to make sure they're correct.

4. Arrange and Optimize the Layout

Arrange the parts in the workspace to fit within the material dimensions and minimize waste.

Use the Array or Copy functions to duplicate parts if you're cutting multiple copies.

Use Optimize to adjust cutting order, which helps reduce laser travel time and increase efficiency.

5. Preview and Simulate the Job

Use the Preview feature to check the cutting and engraving order, as well as the path. This helps you see how the laser will proceed with the job and make sure there are no missed lines.

Ensure that the design fits within the material dimensions and all parts are correctly placed.

6. Send the Job to the Laser Cutter

Connect to your laser cutter, then click Download to send the job from RD Works to the machine.

Confirm the machine settings, place your material on the laser bed, and ensure proper alignment.

Focus the laser head on the material, start the ventilation system, and begin the cutting process by pressing Start on the machine.

7. Monitor the Cutting Process

Watch the machine as it cuts and engraves to make sure everything goes smoothly.

Once complete, carefully remove the parts and inspect them to ensure that the cuts are clean and fit as designed.

The total dimensions of modern lamp

The overall dimensions: 740*444mm

Material thickness: 4mm

Machine speed for MDF material:

Engraving: 300mm/sec

Cutting: 15mm/sec

Power:

Engraving :25%

Cutting: 60%

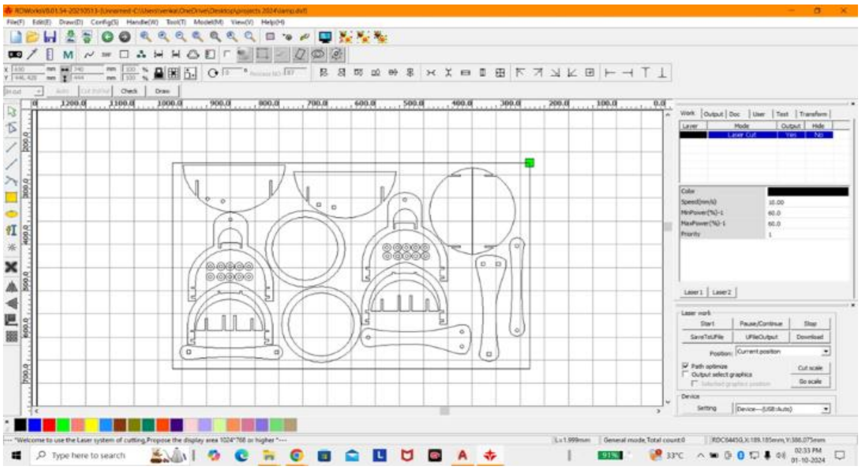

Fig. 5 - Total components Designed in RD Works

6. Result:

Results for the Design and Fabrication of a Modern Lamp Using a CO_2 Laser Cutting Machine

Following the methodology, the results should be reflected:

Precision-Cut Components: Using CAD software and RD Works allowed precise cutting paths and optimized material usage. The parts fit accurately together, achieving the intended geometry and aesthetic.

Efficient Material Usage: RD Works helped in arranging components to minimize material waste, maximizing efficiency. Testing laser parameters lead to clean cuts without burns or melting, preserving material quality.

Stable and Functional Assembly: The lamp components assembled smoothly with secure joints. Proper fitting was ensured through prototype testing, resulting in a stable final product.

Safe Electrical Integration: The lamp's electrical components were safely integrated with standardized wiring and fittings, ensuring functionality and safety.

Consistent Aesthetic Quality: Post-processing steps such as sanding edges and applying finishes provided a polished look. The lamp met the design's aesthetic expectations with clean lines and well-finished surfaces.

Successful Light Diffusion: The lamp provides balanced light distribution, achieving the desired ambiance. The material choice and design structure optimized light diffusion, enhancing the lamp's modern appeal.

7. Discussions:

1.Precision and Efficiency

Using a CO_2 laser cutting machine allows for highly precise cuts, making it possible to achieve detailed and complex designs that would be difficult by hand. The laser cutting process is efficient, minimizing material waste and reducing production time compared to traditional methods.

2.Material Considerations

Choosing the right material is crucial. Wood and acrylic are popular choices for laser cutting due to their clean edges and ease of handling. However, Each material reacts differently to the laser; for instance, wood can burn easily, and acrylic can melt if not carefully handled. Testing laser power and speed settings on each material ensure clean cuts and prevent damage.

3.Prototyping and Assembly

Creating a prototype helps identify issues in the design before final production. Laser-cut parts typically fit well when designed accurately, but minor adjustments to slot or tab sizes are often needed for a precise fit. Properly labeled and organized parts also simplify the assembly process.

4.Customization and Aesthetics

Laser cutting enables customization, allowing unique designs and patterns to be incorporated into the lamp. Cutouts in the lamp's panels not only create an interesting design but also enhance light diffusion, adding to the lamp's modern aesthetic.

5.Software Control

Software like RD Works is essential for setting up cutting paths, managing layers, and adjusting laser parameters. This software helps optimize designs, improve material usage, and ensure the final product matches the original 2D design.

7.1 Assembly Process:

- **Collect the cut components:** Collect the components of the lamp from the co_2 laser cutting machine and clean the components and arrange the components accordingly.

Fig. 6 - Total components cut by using co_2 laser cutting

- **Base Assembly:** Attach the two curved wooden pieces to the flat base piece using screws or bolts. Ensure they are securely fastened to provide a stable foundation.

Fig. 7 - Base Assembly

- **Arm Assembly:** Connect the lower arm piece to the base using a bolt and nut. Ensure the joint is tight but allows for movement. Attach the upper arm piece to the lower arm piece using another bolt and nut. Again, ensure the joint is tight but allows for movement.

Fig. 8 - Arm Assembly

- **Lamp Head Assembly:** Attach the circular wooden frame to the end of the upper arm piece using screws or bolts. Insert the bulb holder into the circular frame and secure it in place. Attach the metal bars around the bulb holder to form a protective cage.

Fig. 9 - Lamp Head Assembly

- **Installing the Bulb and Wiring:** Connect the red and black twisted wire to the bulb holder and install the bulb in the bulb holder. Ensure the wire runs along the arm pieces and is secured in place using clips or ties. Plug the wire into a power outlet to test the lamp.

Fig. 10 - Installing the Bulb and Wiring

- **Final Adjustments:** Adjust the arm pieces to the desired angle and tighten the bolts to hold the position. Ensure all connections are secure and the lamp is stable.

- **Final Product** The finished lamp is a minimalist and functional piece with a wooden aesthetic. Its adjustable features make it ideal for use as a desk lamp, allowing you to direct light where needed. The wooden frame adds a rustic, handmade feel, making it a stylish addition to any workspace.

Fig. 11 - Final component after assembly

8.Conclusion:

This project highlighted the potential and limitations of using a CO_2 laser cutting machine for modern lamp fabrication. CAD and RD Works were instrumental in achieving high precision, but the process required careful calibration, material testing, and iterative design adjustments. The resulting product met design expectations for functionality and aesthetics, proving that laser cutting is an effective tool for modern lighting design—provided there is careful planning and testing at each stage. Future work could focus on optimizing material use and expanding design possibilities, especially for more complex shapes or sustainable materials.

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