Software Based Designing System for Laser Cutting Machine (CNC): Revolutionizing Material Utilization and Increasing Efficiency

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ABSTRACT: Laser cutting is a highly accurate and adaptable method frequently employed in manufacturing to cut various materials, especially sheet metal. Nonetheless, challenges such as optimizing material use and enhancing cutting efficiency are significant concerns. This paper introduces a new splitting technique aimed at tackling these by reducing the amount of sheet material needed and improving cutting efficiency. The method consists of carefully dividing intricate cutting designs into smaller, more manageable parts, which can be rearranged to decrease waste and lower overall material consumption. This approach utilizes advanced algorithms to optimize the arrangement of these parts on the material sheet, maximizing material utilization. Moreover, the method integrates an efficient path planning strategy that reduces the laser head's travel distance, thus minimizing cutting time and energy use. Experimental findings indicate that this splitting technique substantially cuts down on material waste while boosting cutting speed, presenting a viable solution for industries seeking to improve productivity and sustainability in their laser cutting processes.

KEYWORDS: Laser Cutting; Optimizing material; Cutting Efficiency; Material Consumption; Utilization; productivity; sustainability.

I. INTRODUCTION

Laser cutting plays a vital role in contemporary manufacturing due to its accuracy and adaptability, particularly with sheet metal. Nonetheless, challenges persist in optimizing material utilization and cutting effectiveness. This paper presents a new splitting technique aimed at tackling these problems. By decomposing intricate cutting patterns into smaller components, this approach facilitates a more efficient arrangement of materials, thereby decreasing waste and minimizing the amount of sheet needed. Sophisticated algorithms are employed to enhance the placement of segments, while refined path planning reduces the movement distance of the laser head, leading to shorter cutting times and lower energy consumption. The subsequent sections outline the method's creation, application, and advantages, showcasing significant enhancements in material efficiency and cutting productivity for laser cutting processes.

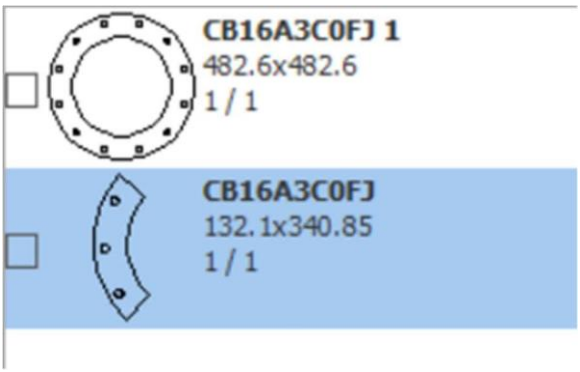
II. RELATED WORK

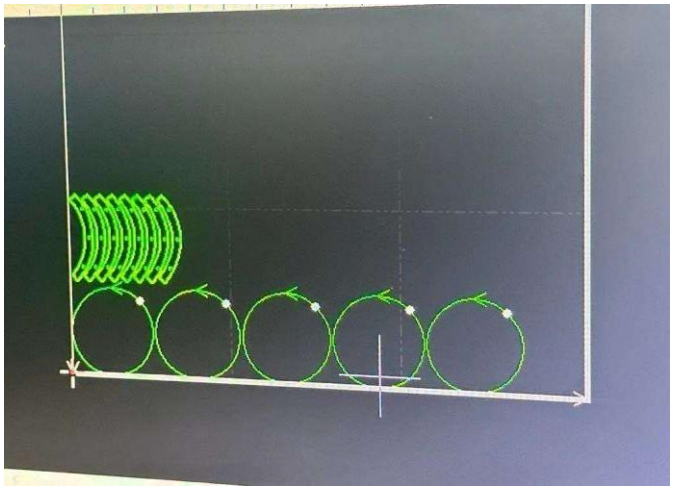
Many research papers show how companies are using laser cutting machines in manufacturing. They often rely on certified power supplies, like battery-powered UPS, for their automatic cutting systems. It's super important to keep up with competitive trade, safety management, ergonomic standards, & ecological rules. There’s a growing use of laser technology with both metals and non-metals. This is big because it helps tackle problems like climate change and the quality of steel produced. The whole process needs a careful watch on drilling & cutting tasks, using sensors to track everything. Data gets sent to special computers that control the CNC machines. These machines use special algorithms, which help cut down on quality issues & save time and money during welding and cutting.

This study also underscores the utilization of laser cutting equipment in manufacturing, with firms relying on certified power sources, such as battery-operated uninterruptible power supplies (UPS), to facilitate the automatic cutting procedures. The focus is placed on maintaining competitive market conditions, managing safety, adhering to ergonomic standards, and complying with environmental regulations. The increasing use of laser technology in various applications relating to both metals and non-metals is acknowledged, particularly in relation to challenges like climate change and product quality within steel production

III. PROPOSED METHODOLOGY AND DISCUSSION

- **Pattern Decomposition**: Intricate cutting patterns are broken down into smaller, easier-to-handle segments. This process is accomplished through sophisticated algorithms that detect the best points for division, allowing the segments to be rearranged without affecting the overall quality of the final product.

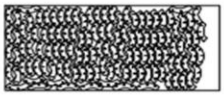




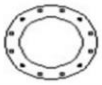
- **Segment Optimization**: The smaller segments are strategically repositioned on the material sheet to enhance material efficiency. This process employs nesting algorithms to ensure that the segments interlock with minimal waste, effectively filling gaps that would otherwise remain unutilized.

- **Simulation and Adjustment**: Before actual cutting, a simulation of the process is conducted to ensure that the optimized segments and paths achieve the desired outcomes. Adjustments are made based on the simulation results to fine-tune the arrangement and path planning.

Plate Info

Order	Thumbnail	Size(mm*mm)	Parts Count	Cut Total Length	Move Total Length	Plan Process Time	Count
1		1500.00 x 3000.00	118	114541.77mm	76862.28mm	31min38.4s	1

Part Info

Order	Part Name	Thumbnail	Size(mm*mm)	Parts Count	Nest Count	Remain Count	Processed
1	CB16A3C0FJ 1		482.60 x 482.60	1	0	1	0
2	CB16A3C0FJ		132.10 x 340.85	118	118	0	0

- **Implementation**: Once the refined cutting plan is prepared, it is uploaded into the control system of the CNC laser-cutting machine. The machine then calibrated to ensure accuracy, adjusting the appropriate laser power, speed, and focus according to the material being used. While the machine carries out the cutting plan, it is continuously monitored, with real-time adjustments made to maintain compliance with the optimized layout. This procedure reduces material waste and improves cutting efficiency, ensuring that every cut is executed precisely and effectively

IV. PROPOSED METHODOLOGY AND DISCUSSION

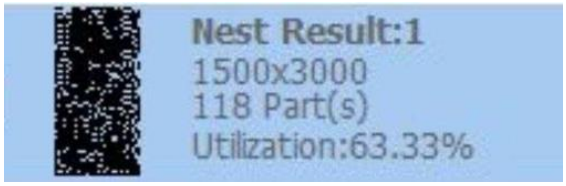
The simulation findings emphasize the notable benefits of the suggested splitting method in laser cutting. This approach increases the number of that can be placed on a single sheet from 16 full circle arcs to 118 segmented parts, thereby optimizing material use, which results in significant cost savings and less scrap waste, ultimately promoting environmental sustainability.

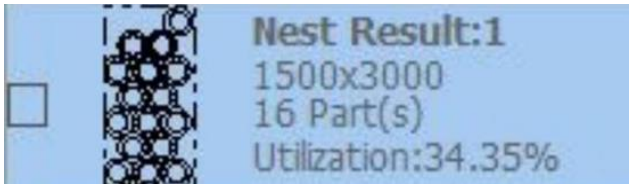
Improved Material Utilization:

In traditional laser cutting techniques, fitting 16 full circle arcs per sheet leads to substantial material wastage due to geometric limitations. The new splitting method divides the arcs into smaller segments and uses advanced nesting algorithms for optimal layout. Simulations revealed that this technique allows for fitting 118 segmented pieces on the same sheet, greatly diminishing costs and waste.

Reduced Cutting Time:

Cutting time plays a vital role in productivity and operational efficiency. Conventional methods took around 120 minutes per sheet with 16 full circle arcs because of ineffective path planning. The splitting technique enhances the cutting route and reduces unnecessary movements, cutting the average processing time down to roughly 85 minutes per sheet, which is a 30% improvement. This advancement increases productivity and decreases energy use, contributing to both cost-effectiveness and environmental advantages.





V. TEST RESULTS

Result: After completing the design and laser cutting process for the enclosure designed for pollution filters, rigorous testing is essential to ensure the enclosure meets its intended purpose effectively. The testing process involves assessing various aspects, including fit and assembly, functionality, durability. Each test aims to validate the enclosure's performance under different conditions and confirm its compliance with relevant standards. By conducting thorough testing, any potential issues can be identified and addressed, ensuring the final product meets the required specifications and performs reliably in real-world environments. Overall, comprehensive testing validates the quality, reliability, and effectiveness of the enclosure, affirming its suitability for use in protecting pollution filters and ensuring optimal performance.

VI. PROPOSED METHODOLOGY AND DISCUSSION

In conclusion, this project sets a new standard for efficiency and accuracy in laser cutting by integrating advanced features and intuitive tools like CYPCUT and CAD. It enhances design flexibility with strong parametric functions, making it easier to create and alter shapes. Automated error detection contributes to greater precision and efficiency by reducing human mistakes, thereby lessening expensive errors. Additionally, the efficient production process, enabled by smooth integration with current laser cutting hardware, significantly speeds up the transformation of digital designs into tangible products. By optimizing designs and incorporating real-time error checking, the project also minimizes material waste, fostering more sustainable manufacturing methods.

REFERENCES

1. Jian Cao, Deyi Ma and Xiaozhi cao "Study on process parameter of high- performance laser cutting machine tool for copper Sheet" International Conference on Information and control Engineering, April 2011.

2. Sorin Tarnovean, Christina Biris , Radu E. Breaz, "Simulation tools for studying the Behavior of CNC laser cutting machines in different working regimes" IEEE International Conference on System Theory, Control and Computing, Oct 2012.

3. Uğur Karanfil, Uğur Yalçin, "Characteristic of laser cutting observation technology and applications." 2016 National Conference on Electrical, Electronics and Biomedical Engineering (ELECO), December 2016.

4. A. F. Tavaeva and A. A. Petunin, "Investigation of cutting speed influence on optimality of the tool path route for CNC laser cutting machines" IEEE 2017 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM), May 2017.

5. Giorgio Santolini, Paolo Rota, Davide Gandolfi, "Cut Quality Estimation in Industrial Laser Cutting Machines: A Machine Learning Approach" IEEE International Conference on Computer vision and pattern recognition workshop, June 2019.

6. Zbigniew Luksik ,Jackek Kozyra , "System of guaranteed power supply for the purposes of automated laser cutter in technologies of industrial cutting material" IEEE International Conference on 2020 Elektro.