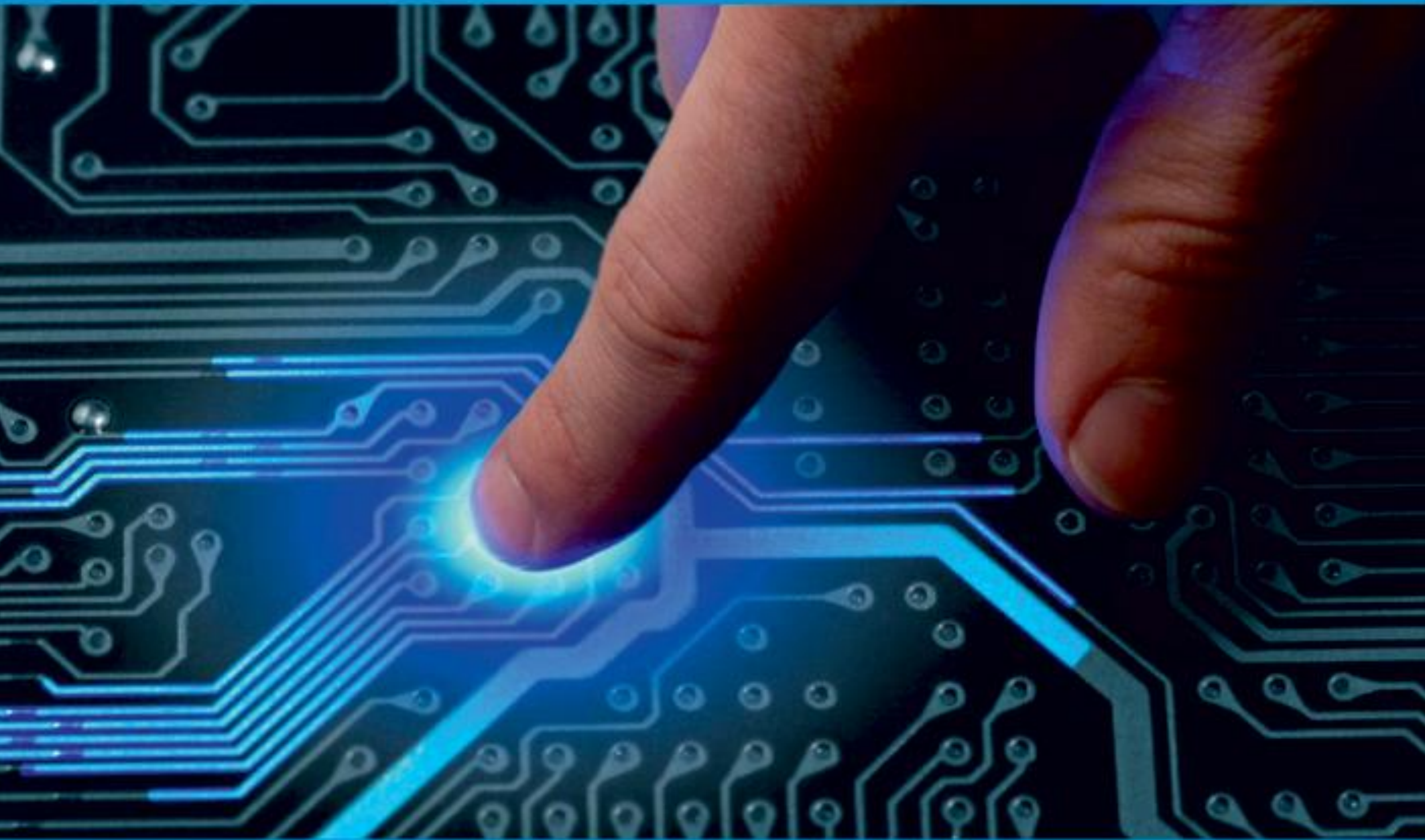
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 12, Issue 6, June 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 | A Monthly Peer Reviewed & Referred Journal |

|| Volume 12, Issue 6, June 2024 ||

| DOI: 10.15680/IJIRCCE.2024.1206090 |

Optimizing Laser Cutting Efficiency through Splitting Techniques: An Innovative Approach to Material Utilization

Bhuman Wadekar

UG Student, Department of E&TC, Dr. D. Y. Patil College of Engineering, Akurdi, Pune, India

ABSTRACT: Laser cutting is a precise and versatile technique widely used in manufacturing for cutting various materials, particularly sheet metal. However, optimizing material utilization and increasing cutting efficiency remain critical challenges. This paper presents a novel splitting method designed to address these issues by reducing the sheet material requirements and enhancing cutting efficiency. The proposed method involves strategically splitting complex cutting patterns into smaller, more manageable segments, which can be re-arranged to minimize waste and reduce overall material usage. This technique advantages advanced algorithms to optimize the placement of these segments on the material sheet, ensuring maximum utilization. Additionally, the method incorporates an efficient path planning strategy that minimizes the travel distance of the laser head, thereby reducing cutting time and energy consumption. Experimental results demonstrate that the splitting method significantly decreases material wastage and improves cutting speed, offering a promising solution for industries aiming to enhance productivity and sustainability in laser cutting operations.

KEYWORDS: Laser Cutting; Material Utilization; Efficiency; Splitting; Energy Consumption; productivity; sustainability.

I. INTRODUCTION

Laser cutting is essential in modern manufacturing for its precision and versatility, especially with sheet metal. However, optimizing material use and cutting efficiency remains challenging. This paper introduces a novel splitting method to address these issues. By breaking down complex cutting patterns into smaller segments, this method allows for more efficient material arrangement, reducing waste and sheet requirements. Advanced algorithms optimize segment placement, while improved path planning minimizes the laser head's travel distance, cutting time, and energy consumption. The following sections detail the method's development, implementation, and benefits, demonstrating significant improvements in material usage and cutting efficiency for laser cutting operations.

II. RELATED WORK

Research articles have explored developments in laser cutting technology, particularly focusing on the use of gases to achieve optimal cuts. Argon gas has been recommended to increase laser power for faster cutting, while oxygen significantly affects the cut quality. For CNC thermal cutting machines, optimization tools to reduce cutting time (Tout) have been developed, including frame number configuration and the integration of machine learning algorithms to predict cut quality. Multimodal sensor data is used to study the CNC laser-cutting machine's behavior under various conditions, such as speed and velocity, and circular interpolation. The feed drive model has been modified to account for the system's numerical features.

This research also highlights the use of laser cutting machines in manufacturing, where companies utilize certified power supplies, including battery-powered UPS, for the automatic cutting process. Ensuring competitive trade, safety management, ergonomic standards, and ecological regulations are emphasized. The expanding application areas of laser technology in both metals and non-metals are noted, addressing challenges such as climate change and product quality in steel production. The process involves continuous monitoring of drilling and cutting operations with sensors, transferring data to embedded systems for CNC machine control using specialized algorithms, aimed at reducing quality damage and minimizing time and cost losses in welding and cutting processes.

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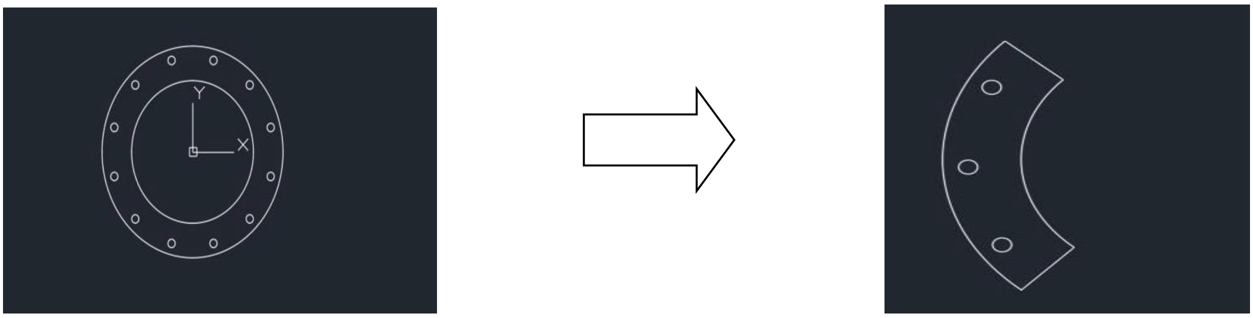
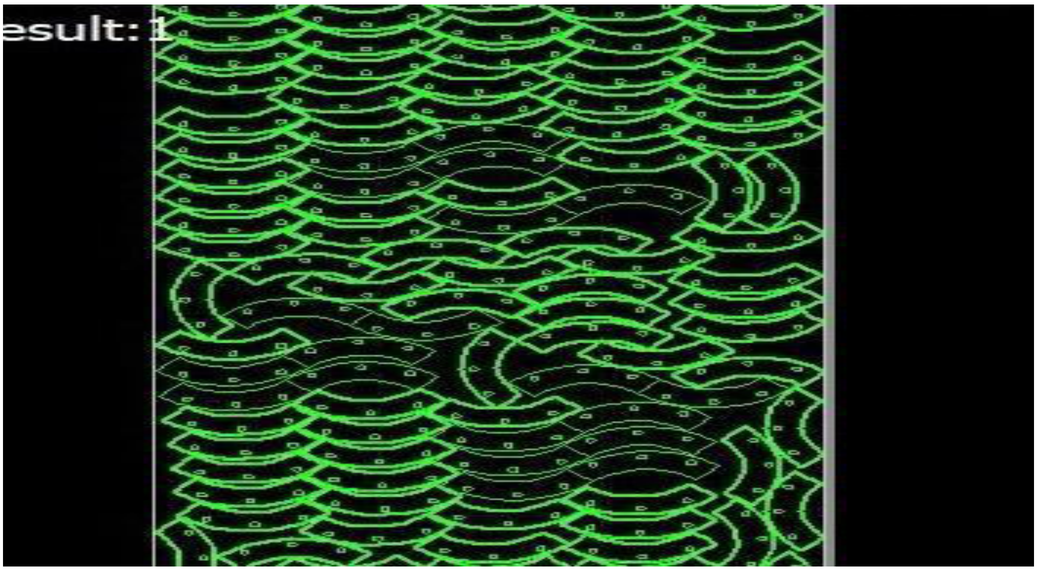
III. PROPOSED METHODOLOGY AND DISCUSSION

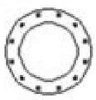
- **Pattern Decomposition:** Complex cutting patterns are decomposed into smaller, more manageable segments. This decomposition is performed using advanced algorithms that identify optimal split points to create segments that can be rearranged without compromising the integrity of the final product.



- **Segment Optimization:** The smaller segments are then strategically rearranged on the material sheet to maximize material utilization. This step uses nesting algorithms to ensure that the segments fit together with minimal waste, filling gaps that would otherwise remain unused.



- **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.

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**: The optimized cutting plan is implemented on the CNC laser-cutting machine. Continuous monitoring and real-time adjustments ensure that the process adheres to the optimized plan, further reducing waste and enhancing efficiency.

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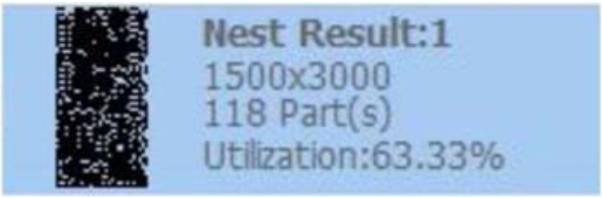
IV. SIMULATION RESULTS

The simulation effects reveal the extensive benefits of the proposed splitting technique in laser reducing. by means of increasing the number of components fitted onto a single sheet from 16 full circle arcs to 118 segmented elements, the approach optimizes material utilization, main to tremendous fee savings and decreased scrap waste, as a result enhancing environmental sustainability.

Greater material utilization:
Conventional laser cutting techniques becoming 16 full circle arcs in step with sheet result in full-size material waste due to geometric constraints. The proposed splitting technique decomposes the arcs into smaller segments and makes use of advanced nesting algorithms for top-quality association. Simulations showed this approach could in shape 118-segmented parts onto the identical sheet, immediately reducing fees and waste.

Decreased cutting Time:
Reducing time is critical for productivity and operational efficiency. Conventional strategies required about one hundred twenty minutes in line with sheet with 16 complete circle arcs because of inefficient path planning. The splitting approach optimizes the slicing route and minimizes unnecessary movements, decreasing the common slicing time to about 85 minutes in line with sheet, a 30% discount. This boosts productivity and lowers energy consumption, enhancing fee-efficiency and environmental blessings.



V. CONCLUSION

In conclusion, this project establishes a new benchmark for efficiency and precision in laser cutting by incorporating advanced features and user-friendly tools such as CYPCUT and CAD. It boosts design flexibility through robust parametric capabilities, facilitating the easy creation and modification of intricate geometries. Enhanced accuracy and efficiency are achieved via automated error detection, which minimizes human error and ensures precision, thereby reducing costly mistakes. Furthermore, the streamlined production workflow, achieved through seamless integration with existing laser cutting hardware, significantly accelerates the conversion of digital designs into physical products. By optimizing designs and implementing real-time error checking, the project also reduces material waste, promoting more sustainable manufacturing practices.

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