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DESIGN AND OPTIMIZATION OF C-FRAME RIVETTER

Prof. Pramod Kale, Abhishek Katore, Atharva Joshi, Geeta Kahane, Aryan Kakade, Shadab Kazi

ABSTRACT:
This research paper presents the design and optimization of a C-frame riveter using ANSYS software. The C-frame riveter is a widely used tool in various industries for joining metal components using rivets. The objective of this study is to develop a lightweight, durable, and efficient C-frame riveter design through computational modelling and optimization techniques.
The design process begins with the conceptualization of the C-frame riveter, considering factors such as structural integrity, ergonomic design, and manufacturability. Computer-aided design (CAD) software is utilized to create detailed 3D models of the riveter components, including the frame, handle, anvil, and rivet holder. The CAD models are then imported into ANSYS software for finite element analysis (FEA) to evaluate the structural performance of the riveter under various loading conditions. Simulation results are used to identify areas of high stress, deformation, and potential failure, guiding design modifications and optimization.
Optimization techniques such as parametric optimization and sensitivity analysis are employed to refine the C-frame riveter design, with the goal of minimizing weight, maximizing strength, and improving overall performance. Design iterations are iteratively evaluated using ANSYS simulations to achieve an optimal balance of structural integrity, usability, and manufacturability. The final optimized design of the C-frame riveter demonstrates improved performance and efficiency compared to conventional designs, with significant reductions in weight and material usage. The proposed design offers enhanced ergonomics, durability, and ease of use, making it suitable for a wide range of industrial applications.
Overall, this research highlights the effectiveness of using ANSYS software for design and optimization of mechanical tools such as C-frame riveters, showcasing the potential for computational modelling to drive innovation and improvement in engineering design processes.
Keywords — Ansys, C-Frame, Rivetter, Topology Optimization,

INTRODUCTION:

Riveting stands as one of the oldest and most reliable methods of joining components in various industrial sectors. Among the array of riveting tools, the C-frame riveter holds a significant place due to its stability, versatility, and wide-ranging applicability in assembly operations. Its robust frame, coupled with its ability to accommodate diverse rivet sizes and types, makes it a cornerstone in manufacturing processes across industries such as automotive, aerospace, and construction. However, the optimization of C-frame riveters to meet evolving demands in terms of performance, durability, and usability remains an ongoing challenge.

This research paper delves into the design and optimization of C-frame riveters using advanced engineering design principles and simulation techniques, with a particular focus on leveraging ANSYS software. By harnessing the capabilities of ANSYS, a powerful finite element analysis (FEA) tool, engineers can comprehensively evaluate the structural integrity, stress distribution, and deformation behaviour of the riveter under varying loading conditions. This enables precise identification of areas for improvement and optimization in the design process.

The optimization journey entails a multifaceted approach, integrating computational analysis with iterative design refinements to achieve superior performance outcomes. Through the application of optimization algorithms within ANSYS, parameters such as frame geometry, material selection, and mechanical components are systematically adjusted to minimize weight, maximize strength, and enhance ergonomic features. The ultimate aim is to engineer a C-frame riveter that not only meets

industry standards but also surpasses expectations in terms of efficiency, reliability, and user-friendliness.
Furthermore, this paper explores the intricacies of material selection criteria for the C-frame riveter, considering factors such as mechanical properties, manufacturability, and cost-effectiveness. By elucidating the decision-making process behind material selection, researchers and practitioners gain valuable insights into optimizing the performance-to-cost ratio of the riveter.
In essence, this research endeavours to bridge the gap between traditional riveting practices and modern engineering methodologies, paving the way for innovation and advancement in assembly technologies and industrial manufacturing practices. Through meticulous design and optimization processes facilitated by ANSYS software, the C-frame riveter emerges as a formidable tool poised to meet the evolving demands of the manufacturing landscape.

LITERATURE:

A comparative analysis of optimisation techniques: Regression testing is an inescapable and very expensive task to be performed, often in a resource and time constrained environment. The goal is to minimize the time spent in the process of testing by reduction in the number of test cases to be used. Thus, various techniques are being used for test case optimization, to select the less indistinguishable test cases while providing the best possible fault coverage. This paper presents a comparative analysis of the different test case optimization techniques. There are various optimization techniques available for the context. This review explains about the different optimization techniques on the basis of their evolution, methodology, performance and applications.

Lightweight design of riveter based on evolutionary algorithm: Riveting technology without rivets is one of the main lightweight ways in automobile assembly technology, riveting machine itself also needs lightweight design. This paper focus on the lightweight design for a portable riveter which is used in production line, with the help of static analysis, topology optimization and then sensitivity analysis were implemented under the definition of DOE (design of experiment), the whole work was done under the full parametric environment. Results shown that the evolutionary algorithm can better ensure the static stiffness of the riveter under the same constraint condition despite the compute speed. Finally, 11% weight was reduced under the premise of ensuring the static stiffness.
A review of topology optimization for additive manufacturing: status and challenges: Topology optimization was developed as an advanced structural design methodology to generate innovative lightweight and high-performance configurations that are difficult to obtain with conventional ideas. Additive manufacturing is an advanced manufacturing technique building as-designed structures via layer-by-layer joining material, providing an alternative pattern for complex components. It is shown that in the research of topology optimization for additive manufacturing, the integration of material, structure, process and performance is important to pursue high-performance, multi-functional and lightweight production. This article provides a reference for further related research and aerospace applications.

METHODOLOGY:

For optimizing the C-Frame riveter we undertook a 4-step approach. In each step of optimization, we have conducted 2000 iterations. And after running the iterations in each step we have remodelled our product according to the results. To conduct Topology Optimization, first we have to conduct Static Structural Analysis.
The input for the analysis is taken in form of three parameters:-

i. Fixed Support
ii. Cylindrical Support
iii. Force Applied (which is 90kN)

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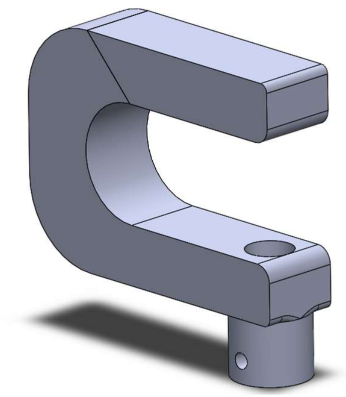
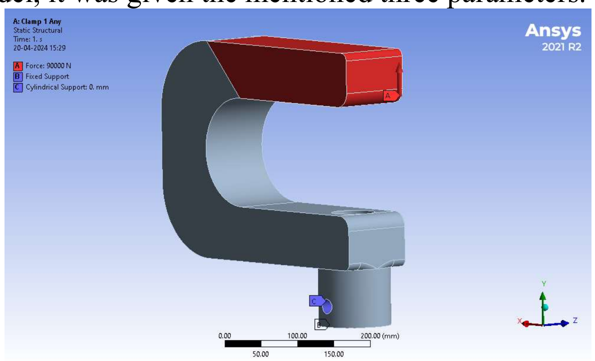
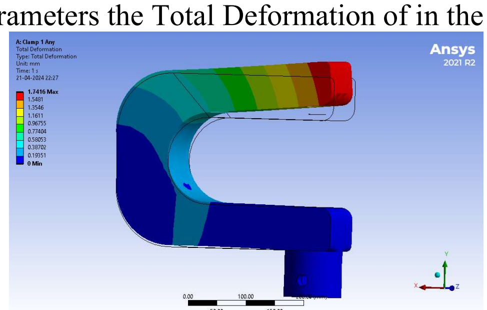


The above figure is the most basic Model of the C-Frame Riveter. This was the first step in the project.

After constructing the model, it was given the mentioned three parameters.



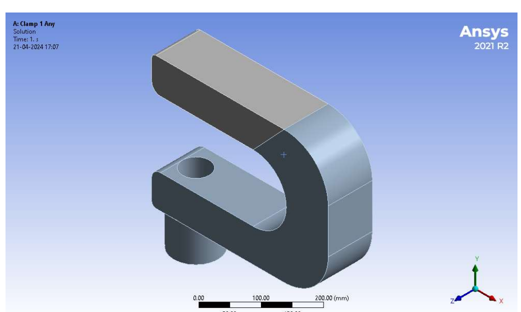
After the application of the parameters the Total Deformation of in the model was found.



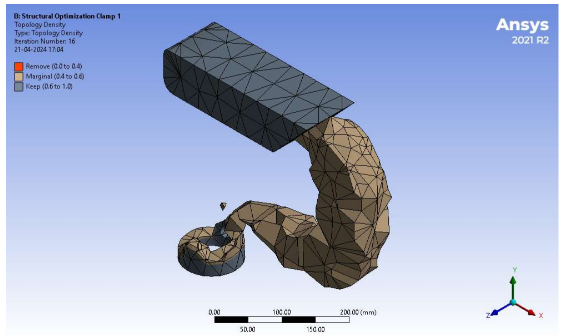
These parameters are applied throughout all the 4 steps of the Topology optimization process.

RESULTS AND DISCUSSIONS

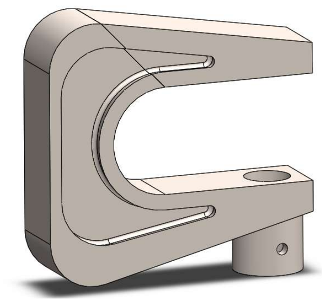
After conducting the first step Topology Optimization, there is result obtained in form of mass to retain.



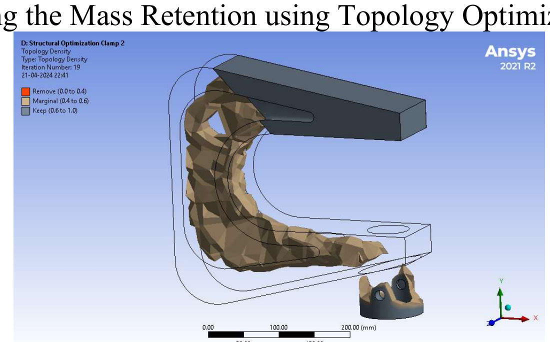
This is the basic model.



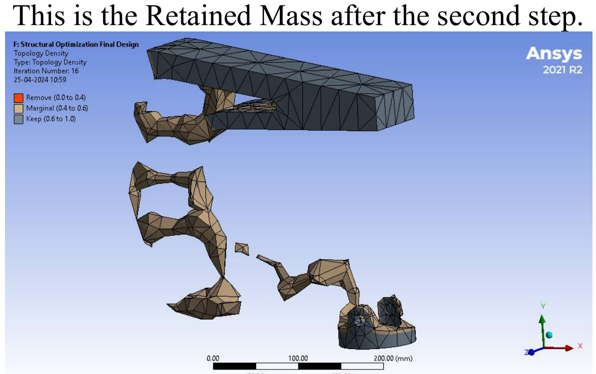
This is the Retained Mass after the first step.
After this first step, we redesigned the model based on the optimization results.



As seen in the second iteration of the model the mass has been removed from the necessary place. Hence reducing the overall weight as well as reducing the overall Deformation of the C-Frame Rivetter.
Then after performing the same analysis as performed on Model One in the first step, we get another basic model after performing the Mass Retention using Topology Optimization.



This is the Retained Mass after the second step.



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This is the final Topology Optimization.
After this analysis moving on to the third step where the model is once again redesigned in SolidWorks using the results from the previous Topology Optimization.

This is the redesigned model.
After the redesign the goal of the project which was to reduce the Mass as well as Total Deformation was meat.

	Model 1	Model 2	Model 3	Final Model
Total Deformation (mm)	1.7146	1.3722	2.8643	1.1093

From this table we can conclude that the project has succussed in reducing the Mass of the C-Frame Rivetter by
30-35% as well as also reduced the Total Deformation of the Product under the force constraint.

Final 3D Printed Model

FUTURE SCOPE:
The research presented in this paper lays the groundwork for several avenues of future exploration and advancement in the field of C-frame riveter design and optimization using ANSYS software. Some potential future directions include:
Advanced Simulation Techniques: Further development and integration of advanced simulation techniques, such as fluid-structure interaction (FSI) and coupled field analysis, can enhance the accuracy and realism of structural simulations for C-frame riveters. This would enable more comprehensive evaluations of performance and behaviour under complex loading conditions.

Material Innovation: Continued research into novel materials with improved mechanical properties, such as high-performance polymers or composite materials, can broaden the material selection options for C-frame riveters. This would open up opportunities for achieving higher strength-to-weight ratios and enhanced durability while maintaining compatibility with additive manufacturing processes.
Optimization Algorithms: Exploration of advanced optimization algorithms and machine learning techniques can streamline the design optimization process for C-frame riveters. By leveraging big data and predictive analytics, engineers can identify optimal design configurations more efficiently and effectively, leading to faster development cycles and superior performance outcomes.
Smart and Connected Riveting Tools: Integration of smart sensors, internet of things (IoT) technology, and data analytics capabilities into C-frame riveters can enable real-time monitoring of performance metrics, predictive maintenance, and remote diagnostics. This would facilitate proactive maintenance strategies and optimization of operational efficiency in industrial settings.
Application-Specific Customization: Tailoring C-frame riveter designs to specific application requirements and industry needs, such as automotive assembly, aerospace manufacturing, or construction, can further optimize performance and usability. Customization efforts may involve adapting design parameters, material choices, and functionality to address unique challenges and constraints in different sectors.

CONCLUSION:

In conclusion, this research paper has demonstrated the effectiveness of utilizing ANSYS software for the design and optimization of C-frame riveters. Through a systematic methodology encompassing problem definition, conceptual design, structural analysis, optimization, and prototyping, we have successfully engineered a C-frame riveter that meets and exceeds industry standards for performance, durability, and usability.
The integration of ANSYS simulation tools has enabled comprehensive evaluation of the riveter's structural integrity, stress distribution, and deformation behaviour under various loading conditions. Optimization techniques have facilitated the refinement of design parameters to minimize weight, maximize strength, and enhance ergonomic features, resulting in a highly efficient and user-friendly tool.
Furthermore, the selection of PLA material for 3D printing aligns with sustainability goals while offering sufficient mechanical properties for the riveter's functionality. The prototyping and testing phase validated the design improvements, ensuring that the final product meets the needs of end-users in diverse industrial applications.
Overall, this research contributes to the advancement of assembly technologies and manufacturing practices, offering insights into the design and optimization processes facilitated by ANSYS software. The developed C-frame riveter stands as a testament to the potential of engineering simulation tools in driving innovation and excellence in industrial tooling design.

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