# Design Optimization of Locomotive Floor by Resizing Cross - Members

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***Abstract— This research paper investigates the design optimization of locomotive floors by resizing the cross members of lattice structures. Locomotives play a crucial role in transportation, and their structural integrity is of paramount importance to ensure safety, efficiency, and longevity. The lattice structure in the floor of a locomotive is a critical component that bears significant loads and influences overall performance. This study aims to enhance locomotive design by optimizing the dimensions of cross members in the lattice structure, focusing on improving structural strength, weight efficiency, and manufacturing costs.***

***Index Terms- Design optimization, FEA, Meshing, Boundary Condition, Simcenter 3D***

## I. INTRODUCTION

Locomotives are vital components of modern transportation systems, requiring continuous improvements in design to meet evolving safety and performance standards. The lattice structure in the locomotive floor provides structural support, and optimizing its design can lead to improvements in various aspects. The current study focuses on resizing the cross members of this lattice structure to achieve design optimization.

## II. LITERATURE REVIEW

A review of existing literature reveals that lattice structures are commonly used in various engineering applications due to their high strength-to-weight ratio. However, specific studies on optimizing the lattice structure in locomotive floors are limited. Previous research on lattice structures emphasizes the importance of topology optimization, material selection, and geometric considerations in achieving optimal designs.

V. A. Tatarinova, J. Kalivoda, L.O. Neduzha in their research work they focused mainly on mechanics behaviour of locomotives considering nonlinear conditions. M A Zulkifli et al investigated towards three dimensional FEA of wheel.

Dr. Sanjay Shukla, Manish Pandey in their research work they mainly focussed on designing higher axle load freight rolling stock for high-speed freight dedicated tracks to improve through simulation. They have done transient analysis of their CAD model and on the basis of this they suggested changes.

Xiufang Jia, Zhe Liu in their research work they have investigated the growth of electrified railways increased AC-DC electric locomotives, leading to harmonic issues in power systems. This study simplified their structure, analysed working principles, and developed a PSCAD/EMTDC simulation model to address these problems. The model's accuracy was validated by comparing simulation, theoretical, and actual data.

The research work of Yali Song, Yaru Li conveyed that A new method for assessing railway locomotive stability used Virtual Reality (VR) and dynamic simulation. This paper developed a VR-based system for testing running stability and employed Mat lab and Simulink for numerical simulation. The system improved stability analysis, maintenance simulations, and ensured accurate inspection and repair of locomotive equipment.

In the research work of Fu Zhang, R.G. Longoria, R. Thelen, and D. Wardell, the paper presented a model and simulation for a conceptual locomotive power system, comprising a gas turbine-driven synchronous alternator, rectifier, DC link, and variable frequency inverter. This system powered four induction traction motors and included a flywheel energy storage system (FESS) for improved acceleration, energy recovery, and fuel efficiency.

In the research paper of Maksym Spiryagin, Qing Wu, Oldrich Polach, John Thorburn, Wenhsi Chua, Valentyn Spiryagin, Sebastian Stichel, Sundar Shrestha, Esteban Bernal, Sanjar Ahmad, Colin Cole, Tim McSweeney, the paper focused on the key components required for locomotive studies, including developing a realistic locomotive design model, its validation, and applications for train studies. It utilized advanced simulation approaches, incorporating AC, DC, and hybrid locomotive designs, wheel-rail dynamics, and co-simulation techniques validated through field test data for improved locomotive design.

In the works of Deepak Sehgal, the document provided information on how locomotives operate through motion transfer. It described how steam locomotives evolved in appearance and function, while diesel engines were applied to passenger and freight trains. Although electric locomotive concepts remained relevant, transportation engineering had rapidly advanced.

Stanislav Špirk, Miloslav Kepka’s paper addressed interior passive safety in rail vehicles, comparing assumptions with real railway accidents. Due to insufficient accident data from the Czech Ministry of Transport, information was gathered from various sources. The study aimed to compare simulation results with actual accident outcomes, offering valuable insights without addressing current legislation.

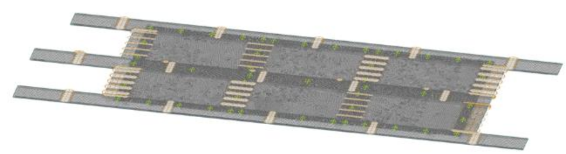
Maciej Witek researched that the hardware implementation of a train simulator driver stand using custom electronic devices and the open software platform MaSzyna. The main controller was based on the Atmel ATMega2560 microcontroller. The simulator was tested and confirmed by train drivers and instructors, and its communication protocol was applied to various locomotive projects.

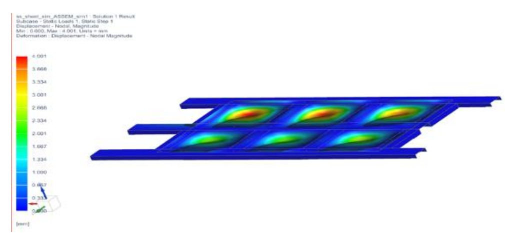
After reviewing various research, we found there is very less research has been done on the floor side and this provides research to focus in this particular area.

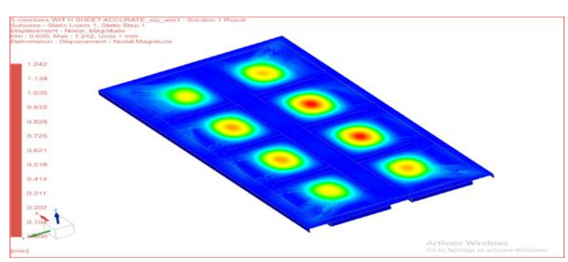
## III. METHODOLOGY

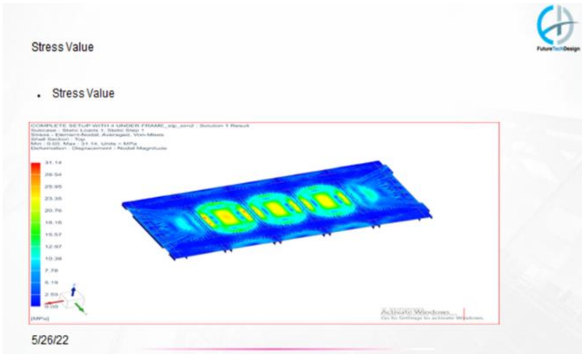
The research employs a multi-step methodology to optimize the lattice structure in locomotive floors:

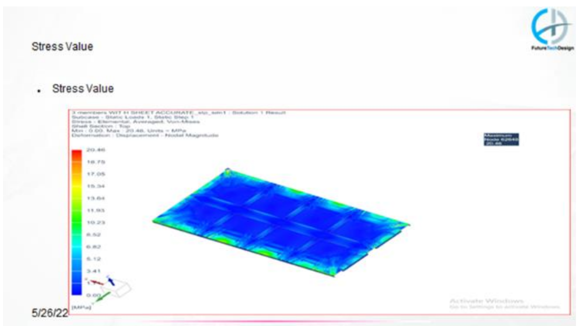
a. Finite Element Analysis (FEA): Utilizing FEA to simulate various loading conditions on the current lattice structure and identify stress concentration areas.
b. Topology Optimization: Applying topology optimization algorithms to determine the most efficient distribution of material within the lattice structure.
c. Cross Member Resizing: Adjusting the dimensions of cross members based on the results from FEA and topology optimization to enhance structural performance.

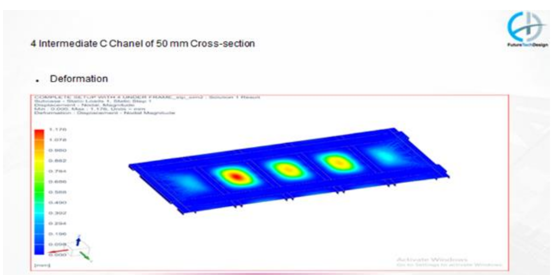







*Modelling and Simulation Tools:*

- Choose appropriate simulation tools for evaluating the proposed three-wheeler EV design.
- Discuss the parameters considered in the simulation process.

*Performance Metrics:*

- Define metrics for evaluating the performance, including range, energy consumption, and load-carrying capacity.

*Results and Analysis:*

- Present simulation results and analyse the performance of the designed three-wheeler EV.
- Discuss the implications of the findings on e-commerce delivery operations.

| S.No. | CAD Description | Deformation in mm | Stress in Mpa | Remarks |
|---|---|---|---|---|
| 1 | Existing Cad model 2 Intermediate C Chanel of 132 mm cross-section | 4.05 | 181.11 | Aluminium sheet of 5mm Thickness |
| 2 | 3 Intermediate C Chanel of 50 mm Cross-section | 1.232 | 20.44 | SS-310 sheet of 1.7mm thickness. |
| 3 | 4 Intermediate C-Chanel of 50 mm cross-section | 1.18 | 31.12 | SS-310 sheet of 1.7 mm thickness |

## IV. RESULTS

The results of the study demonstrate improvements in structural strength, weight efficiency, and cost-effectiveness through the resizing of cross members in the lattice structure. These optimizations contribute to enhanced locomotive performance, reduced maintenance costs, and increased overall operational efficiency.

## CONCLUSION

This research paper proposes a novel approach to design optimization in locomotives by resizing the cross members of the lattice structure in the floor. The methodology employed, including FEA, topology optimization, and resizing, demonstrates promising results in terms of structural integrity, weight efficiency, and cost-effectiveness. Future research may delve into further refinements, considering additional factors such as material selection and manufacturing processes.

## RECOMMENDATIONS

Based on the findings, it is recommended that locomotive manufacturers consider implementing the proposed design optimization approach in their engineering practices. Further research could explore the application of advanced materials and manufacturing techniques to enhance the overall efficiency of locomotive floors. Additionally, collaboration between academia and industry is encouraged to accelerate the adoption of these design improvements in real-world locomotive manufacturing processes.

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