Design and Finite Element Analysis of Side Wall Supported Luggage Racks in Locomotives Under Loaded Conditions

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Abstract— This research paper explores the design and structural analysis of side wall-supported luggage racks specifically tailored for locomotives. Luggage racks in locomotives play a crucial role in providing storage solutions for passenger's belongings. The study employs Finite Element Analysis (FEA) to assess the structural performance of the designed luggage racks under loaded conditions, aiming to enhance their robustness, safety, and overall functionality in the context of locomotive transportation.

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

I. INTRODUCTION

Luggage racks in locomotives are essential for optimizing space utilization and ensuring passenger comfort during travel. The design of these racks must address challenges unique to locomotives, including dynamic loading conditions, spatial constraints, and safety considerations. This research focuses on the development and structural analysis of side wall-supported luggage racks to meet the specific requirements of locomotive applications.

II. LITERATURE REVIEW

Existing literature underscores the importance of luggage rack design in various transportation modes. However, limited research has been conducted on luggage racks tailored for locomotives. The literature review emphasizes the need for designs that consider dynamic loading conditions and spatial constraints inherent to locomotive environments.

J. KALIVODA, L. O. NEDUZHA in their research work they focused mainly on mechanics behaviour of locomotives considering non-linear behaviour. M A Zulkifli et al investigated towards simulation of wheel.

Dr. Sanjay Shukla and Manish Pandey, in their research, primarily focused on designing freight rolling stock with higher axle loads for high-speed, dedicated freight tracks. Their work involved performing transient analysis on the CAD model, and based on the results, they proposed various improvements.

Xiufang Jia and Zhe Liu, in their research, investigated the rise of electrified railways and the increase in AC-DC electric locomotives, which resulted in harmonic issues within power systems. Their study simplified the structural design, analyzed the working principles, and developed a PSCAD/EMTDC simulation model to mitigate these problems. The accuracy of the model was validated by comparing simulation results with theoretical calculations and real-world 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 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.

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 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.

In Deepak Sehgal's work, the document detailed the operation of locomotives through motion transfer mechanisms. It explored the evolution of steam locomotives in both appearance and functionality, while highlighting the adoption of diesel engines for passenger and freight trains. Although the concept of electric locomotives remained significant, the field of transportation engineering had seen rapid advancements.

After reviewing multiple research projects, we found there is very less research has been done on the locomotive rack side and this provides a research gap to focus in this area.

III. METHODOLOGY

4.1. Design Methodology:

The design methodology comprises a systematic process for creating side wall-supported luggage racks suitable for locomotives:

A. Requirements Identification: Defining the functional requirements, spatial constraints, and safety considerations specific to locomotive environments.
B. Conceptual Design: Developing initial design concepts that address the unique FEA Analysis.

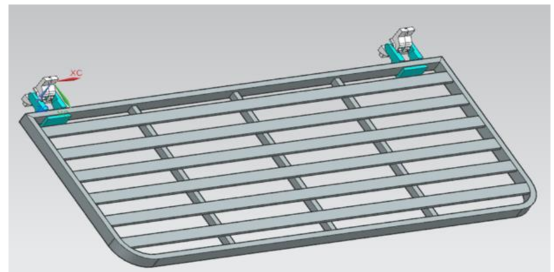

Fig1: CAD 3D Model of locomotive rack.

4.2. FEA Analysis:

FEA analysis involves subjecting the luggage racks to dynamic loading scenarios representative of real-world locomotive conditions. The study assesses stress distribution, deformation, and other critical factors to validate and refine the design. Results are analyzed to identify potential failure points and guide further design improvements.

S. No.	Description	Numbers
1	Total No. of Elements	191976
2	Number of nodes in the mesh	370755
3	Tetra10 elements	191976

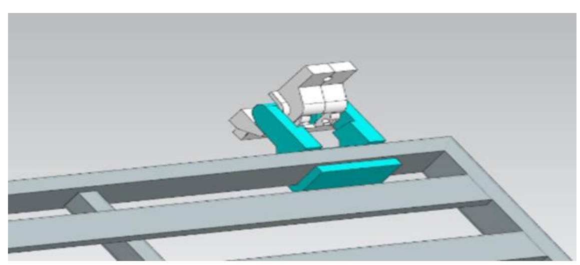

Fig2: 3D CAD model of hinge of locomotive rack.

IV. RESULTS

The research findings demonstrate the effectiveness of the proposed design in meeting the unique challenges of locomotive environments. FEA analysis provides valuable insights into the structural performance of the luggage racks, ensuring they can withstand dynamic loading conditions and contribute to passenger safety and comfort.

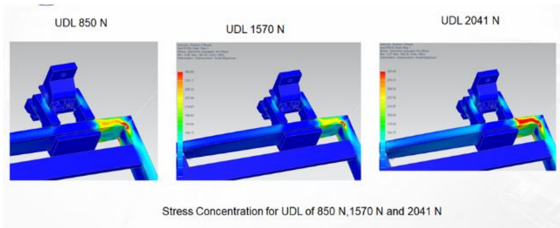

Fig3: Stress Analysis Result of hinge of locomotive rack.

S. No.	Maximum von-Mises stress (MPa)		
Load	UDL 1571N	UDL 2042 N	Edge Load 851 N
Stress	384.64	500.03	433.31

CONCLUSION

This research paper presents a comprehensive approach to the design and FEA analysis of side wall-supported luggage racks tailored for locomotives. The optimized design addresses locomotive-specific challenges, contributing to the overall efficiency and safety of luggage storage in locomotive transportation.

RECOMMENDATIONS

The study recommends the implementation of the optimized luggage rack design in locomotives, taking into consideration factors such as material selection and manufacturing processes. Future research could explore additional aspects, including integration with existing locomotive interiors and feedback from passengers, to further refine and adapt the design for diverse locomotive applications. Collaboration between researchers and industry stakeholders is encouraged to facilitate the practical implementation of these optimized luggage racks in real-world locomotive environments.

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