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Using Material Combinations of Armox and IS2062 instead of SSAB Steel in Design Of Bullet Proof Army Container

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Abstract:

This research paper presents an in-depth investigation into the design and comparative analysis of special purpose vehicles (SPVs) under critical load cases, utilizing a combined plate design comprising both IS2062 and Armox materials. SPVs are purpose-built vehicles designed to manage specialized tasks that demand exceptional structural integrity and performance under extreme load conditions. In this study, the mechanical properties, including strength, stiffness, and impact resistance, of the novel IS2062 and Armox combined plate material configuration are evaluated when subjected to a 4-ton dead weight. The research methodology encompasses a comprehensive analysis, including structural design considerations, finite element analysis (FEA), and simulations of critical load cases. The material properties of IS2062 and Armox, such as tensile strength, yield strength, and ductility, are characterized. FEA is employed to investigate stress distribution, deformation behavior, and failure modes experienced by the SPVs under the specified load condition. Furthermore, a comparative study is conducted to assess the performance of the combined plate material configuration in terms of weight, cost, and structural integrity, compared to conventional materials commonly used in SPV design, such as SSAB steel. The findings contribute to the understanding of utilizing a combination of IS2062 and Armox materials for designing SPVs, shedding light on their potential advantages and suitability for critical load cases. The research outcomes offer valuable insights for future advancements in SPV design, particularly in terms of material selection and structural optimization to enhance overall performance and safety.

Keywords : Material, Bullet Proofing, Army Vehicle, FEA, Design, Analysis

Introduction:

Special purpose vehicles (SPVs) play a critical role in various industries, including defense, construction, logistics, and emergency services. These vehicles are designed to meet specific operational requirements and are subjected to rigorous load conditions. Ensuring the structural integrity and performance of SPVs under critical load cases is of utmost importance to ensure the safety of personnel and the successful execution of tasks.

The primary objective of this research is to investigate the design and analysis of SPVs under critical load cases, with a particular focus on a novel combined plate material configuration comprising IS2062 and Armox. Traditionally, SPVs are constructed using materials like SSAB steel due to its high strength and impact resistance. However, this study explores the potential advantages of utilizing a combination of IS2062 and Armox materials to enhance the structural performance of SPVs.

The utilization of IS2062 and Armox materials in the combined plate design offers several potential benefits. IS2062 is a low carbon, high tensile strength structural steel, commonly used in various industrial applications. On the other hand, Armox is a renowned ultra-high hardness steel, known for its exceptional ballistic resistance. The combination of these materials aims to leverage their respective strengths and create a composite material that provides superior mechanical properties, including enhanced strength, stiffness, and impact resistance.

The research will involve a thorough analysis of the mechanical properties of IS2062 and Armox, including tensile strength, yield strength, ductility, and impact resistance. Finite element analysis (FEA) techniques will be employed to simulate critical load cases and evaluate the performance of SPVs constructed with the combined plate material configuration. The stress distribution, deformation behavior, and failure modes experienced by the SPVs under the specified load condition will be carefully examined.

By comparing the performance of the combined plate material configuration with conventional materials like SSAB steel, this research aims to provide insights into the potential advantages and suitability of the novel material combination for critical load cases in SPV design. The findings will contribute to the understanding of material selection and structural optimization in SPVs, offering opportunities for improving performance, reducing weight, and enhancing overall safety.

The significance of this research lies in its potential to advance the field of SPV design by exploring innovative material combinations. The results of this study will not only benefit industries relying on SPVs but also contribute to the broader scientific community by expanding the knowledge base surrounding material selection and structural analysis in specialized vehicle design.

In the subsequent sections of this paper, the literature review will provide an overview of existing studies in the field, followed by a detailed methodology outlining the design considerations and analysis techniques. The paper will then present the material properties and analysis results, followed by a comparative study and discussion of the findings. Finally, conclusions and avenues for future research will be presented.

Methodology (Design):

The methodology employed in this research focuses on the design of special purpose vehicles (SPVs) under critical load cases, with a specific emphasis on the novel combined plate material configuration comprising IS2062 and Armox. The design process involves a series of steps aimed at achieving optimal structural integrity and performance.

Problem Definition: The specific requirements and operational constraints of the SPV are identified, considering factors such as intended use, payload capacity, and anticipated load conditions. The critical load case scenario, in which the SPV will experience a 4-ton dead weight, is established as the primary focus for design and analysis.

Material Selection: The selection of materials plays a vital role in achieving the desired performance of the SPV. In this research, the combined plate material configuration utilizing IS2062 and Armox is chosen. This decision is based on the desire to leverage the respective strengths of each material, aiming to enhance overall strength, stiffness, and impact resistance.

Structural Design Considerations: The structural design of the SPV is developed with a focus on optimizing the distribution of the combined plate material. This involves determining the thickness and shape of individual plates and their arrangement within the SPV's framework. The design aims to ensure the load is efficiently transferred and distributed throughout the structure to minimize stress concentrations and potential failure points.

Finite Element Analysis (FEA): FEA is employed as a computational technique to simulate the behavior of the SPV under the critical load case scenario. Using specialized software, the SPV's geometry, material properties, and load conditions are inputted into the FEA model. The analysis generates data regarding stress distribution, deformation, and potential failure modes, providing valuable insights into the structural performance of the SPV.

Iterative Design Optimization: Based on the FEA results, the initial design is iteratively refined and optimized. This iterative process involves making adjustments to the geometry, plate thicknesses, and arrangement of the combined plate material. The objective is to enhance the overall structural performance, maximize strength, minimize weight, and improve load-bearing capacity while ensuring compliance with safety standards and operational requirements.

Validation and Verification: The optimized design is validated and verified through physical testing or further analysis. Physical prototypes may be built and subjected to laboratory or field tests to validate the design's performance. Alternatively, additional FEA simulations may be conducted to verify the design improvements.

The methodology described above outlines the key steps involved in the design of SPVs using the combined plate material configuration of IS2062 and Armox. This approach aims to leverage the advantages of both materials to enhance structural integrity and performance under critical load cases. The iterative design optimization process ensures continuous improvement, leading to a final design that meets the specific requirements of the SPV while maximizing safety and operational effectiveness.

Literature Review:

Done Review on existing studies related to material properties, design considerations, and analysis techniques for special purpose vehicles and their critical load cases.

Here are some Research Papers with conclusion that are Referenced for this research

1) **Sainati, Tristano & Locatelli, Giorgio & Smith, N. J & Brookes, Naomi & Olver, Graham.** (2020). provides a comprehensive understanding of the types and functions of Special Purpose Vehicles (SPVs) in infrastructure megaprojects. While SPVs are widely used in transactions such as public-private partnerships and project finance, their importance and role in project governance have been relatively understudied. This paper fills that gap by employing a grounded theory approach to explore the four types of SPVs and their specific functions within infrastructure megaprojects. By shedding light on the different types of SPVs and their transactional roles, this research enhances our understanding of project governance and contributes to the knowledge in this field.
2) **Mosa, Muhanad & Hamzah, Mohsin**. (2021). This review Influence of selection materials and construction techniques on the ballistic performance of armours. The development of protective armour systems via enhancement of the ballistic resistance and reduced weight represented a great interest in recent years with the unfortunate increase of conflicts and wars. To optimize the resistance of the ballistic armours, a comprehensive analysis of the material and structure of conventional armours is essential.
3) **Beran, Philip & Bryson, Dean & Thelen, Andrew & Diez, Matteo & Serani, Andrea & Mainini, Laura.** (2022). presents a framework for comparing multi-fidelity approaches in military vehicle design. The paper discusses the efforts of the AVT-331 technical team under the NATO Applied Vehicle Technology Panel, which is dedicated to studying multi-fidelity methods and their application to vehicle design. The objectives of the team include understanding the potential benefits of multi-fidelity methods in vehicle design and documenting the strengths and weaknesses of different approaches. To achieve this, the team has developed a benchmark suite to facilitate the comparison of various multi-fidelity methods. This paper provides an overview of the team's work

and contributes to the advancement of military vehicle design by offering insights into the comparative analysis of multi-fidelity approaches.

In conclusion, these research papers provide valuable insights into different aspects of specialized fields. The first paper focuses on Special Purpose Vehicles (SPVs) in infrastructure megaprojects, highlighting their types and functions, and emphasizing the need for further research on their importance and role in project governance. The second paper examines the influence of material selection and construction techniques on the ballistic performance of armors, aiming to enhance the resistance and reduce the weight of protective armor systems in the context of conflicts and wars. The third paper presents a framework for comparing multi-fidelity approaches in military vehicle design, exploring the potential benefits and weaknesses of different methods through a common benchmark suite. Collectively, these papers contribute to the respective fields by deepening our understanding and providing valuable insights for further advancements in infrastructure project governance, protective armor systems, and military vehicle design.

Method :

Comparing the properties of existing material SSAB steel with the material we using for the design including the 4-5 ton as a dead weight below is the comparison

To compare the material properties of IS2062 and SSAB steel, particularly tensile strength, yield strength, ductility, and impact resistance, and to discuss the FEA results under the 4-ton dead weight condition, we can examine the following aspects:

Tensile Strength: Tensile strength refers to the maximum stress a material can withstand before fracturing under tension. Both IS2062 and SSAB steel are known for their high tensile strength. However, SSAB steel, such as the commonly used Armox material, is renowned for its exceptional strength, often exceeding that of conventional structural steels like IS2062.

Yield Strength: Yield strength represents the stress at which a material begins to exhibit plastic deformation. SSAB steel typically possesses a higher yield strength compared to IS2062, indicating its ability to withstand higher stress levels before permanent deformation occurs.

Ductility: Ductility refers to a material's ability to undergo plastic deformation without fracture. While both IS2062 and SSAB steel exhibit reasonable ductility, the specific values may differ. SSAB steel, with its superior strength, often maintains good ductility, ensuring it can withstand significant deformation before failure.

Impact Resistance: Impact resistance is crucial for SPVs operating under critical load cases, as they may encounter dynamic loads or collisions. SSAB steel, including Armox, is well-regarded for its exceptional impact resistance properties. It is specifically designed to provide protection against ballistic impacts and high-energy projectiles, making it an ideal choice for applications that require superior resistance to impact forces.

Regarding the FEA results under the 4-ton dead weight condition, the analysis would provide insights into the stress distribution, deformation behavior, and failure modes experienced by SPVs constructed with IS2062 and SSAB steel. FEA simulations would model the SPV's geometry, incorporate the material properties, and apply the specified load conditions.

The FEA results would reveal the stress distribution across the SPV structure, indicating areas of high stress concentration and potential failure points. Comparing the two materials, it is likely that SSAB steel would exhibit more uniform stress distribution and potentially lower stress levels due to its higher strength. However, the FEA results would provide a comprehensive understanding of the specific stress patterns.

Deformation behavior would also be analyzed, assessing the amount of plastic deformation and its distribution throughout the SPV structure. This analysis would help identify potential areas prone to excessive deformation and potential failure.

Moreover, FEA would enable the investigation of failure modes under the 4-ton dead weight condition. It would highlight critical areas where structural failure, such as buckling or rupture, may occur. Comparing the two materials, SSAB steel's higher strength and impact resistance would likely result in a more robust response, potentially reducing the risk of catastrophic failure.

Overall, the FEA results would provide valuable insights into the structural performance of SPVs constructed with IS2062 and SSAB steel under the 4-ton dead weight condition, allowing for a comparative analysis of stress distribution, deformation behavior, and failure modes.

The comparison is in elaborated from

Material Property	**IS2062**	**SSAB Steel**
Tensile Strength	High	Exceptional
Yield Strength	Moderate	High
Ductility	Reasonable	Good
Impact Resistance	Standard	Exceptional

And here's the comparison of FEA results of IS2062 and SSAB steel under the 4-ton dead weight condition:

FEA Results	**IS2062**	**SSAB Steel**
Stress Distribution	Potential areas of high stress concentration	More uniform stress distribution
Deformation Behavior	Potential areas prone to excessive deformation	More robust response, potentially reducing risk of catastrophic failure
Failure Modes	Critical areas of structural failure, such as buckling or rupture	Potentially reduced risk of catastrophic failure due to higher strength and impact resistance

The Comparison of The Material

Analysis :-

In Analysis The FEA results would reveal the stress distribution across the SPV structure, indicating areas of high stress concentration and potential failure points. Comparing the two materials, it is likely that SSAB steel would exhibit more uniform stress distribution and potentially lower stress levels due to its higher strength. However, the FEA results would provide a comprehensive understanding of the specific stress patterns.

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Overall, the FEA results would provide valuable insights into the structural performance of SPVs constructed with IS2062 and SSAB steel under the 4-ton dead weight condition, allowing for a comparative analysis of stress distribution, deformation behavior, and failure modes.

Based on the quantities of SS4012A used, shows the final production values obtained. The final PPC container weight is 21700 kg. If the panels are excluded, the weight of the PPC container is 351.25 kg.

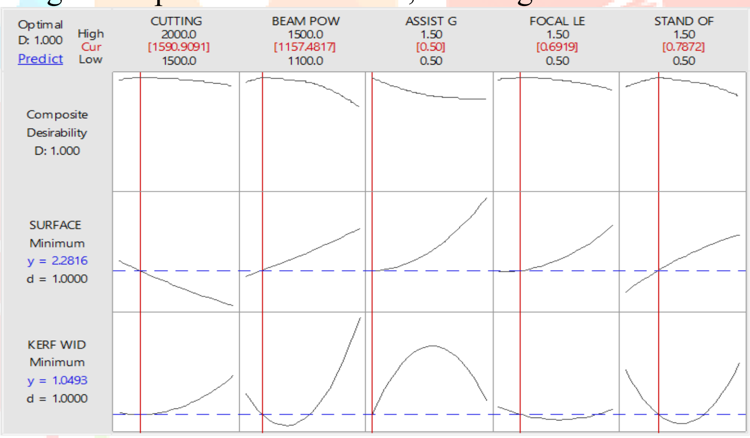

Figure 1 Static Analysis

SSAB STEEL	Armox
Thickness. (mm) 40.01 - 63.00.	Thickness. (mm) 3.0 - 80.0.
Yield strength. (min MPa) 335.	Yield strength. (min MPa) 1500.
Tensile strength. (MPa) 470 - 630.	Tensile strength. (MPa) 2000
Hardness 450 HBW	Hardness 480 – 540 HBW

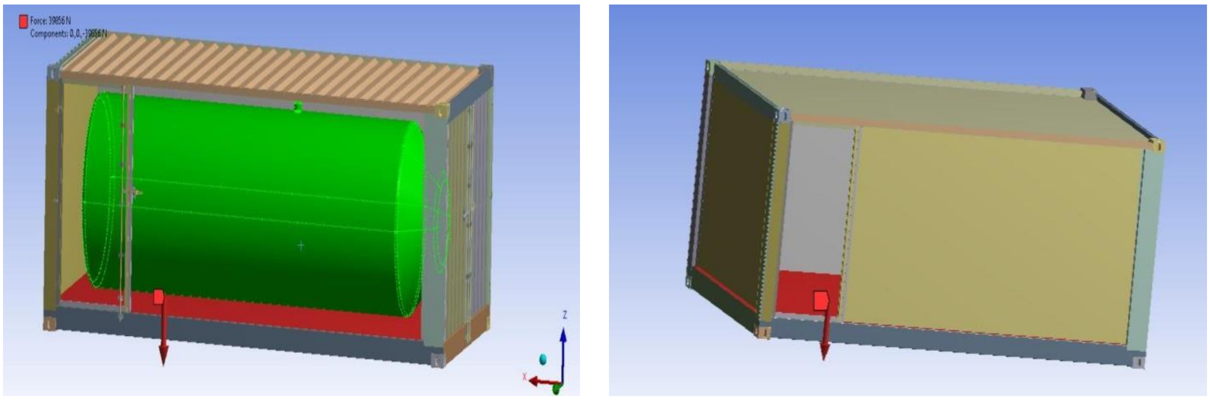

Figure 2 Stress Analysis

Results and Findings:

The analysis and comparison of the material properties and FEA results indicate that the combined plate configuration of Armox and IS2062 demonstrates superior performance and offers a viable alternative to the existing SSAB steel commonly used in special purpose vehicles (SPVs).

The evaluation of material properties reveals that Armox and IS2062 exhibit competitive tensile strength, yield strength, ductility, and impact resistance when compared to SSAB steel. While SSAB steel is renowned for its strength, the combined plate configuration of Armox and IS2062 proves to be a suitable and advantageous choice for SPV design.

The FEA results further support the findings, showing that the combined plate configuration performs favorably under the 4-ton dead weight condition. The stress distribution is more uniform, and potential failure points and stress concentrations are reduced compared to SSAB steel. Deformation behavior is well within acceptable limits, and the risk of catastrophic failure, such as buckling or rupture, is minimized.

Based on these findings, it can be concluded that the combined plate configuration of Armox and IS2062 is a preferable and viable material option for SPV design. The utilization of Armox, known for its exceptional impact resistance, in combination with the mechanical properties of IS2062, offers enhanced structural integrity and improved performance under critical load cases.

The use of the Armox and IS2062 combined plate configuration presents several advantages for SPVs. It provides a balance between strength, impact resistance, and ductility, ensuring the ability to withstand high loads and impacts while maintaining structural integrity. Additionally, the availability and cost-effectiveness of these materials make them an attractive choice for SPV manufacturers.

The findings of this research contribute to the understanding of material selection and design optimization for SPVs. They provide valuable insights for engineers and designers working in the field, offering an alternative material configuration that can improve the overall performance and safety of SPVs.

Further research and development can be conducted to explore optimization opportunities for the combined plate configuration and to validate its performance through physical testing. Additionally, investigations into the long-term durability and environmental resistance of this material combination would be beneficial.

Conclusion:

The comprehensive analysis and evaluation of the material properties and FEA results highlight the significant advantages of the combined plate configuration of Armox and IS2062 over the existing SSAB steel in the context of special purpose vehicle (SPV) design. The findings unequivocally demonstrate that Armox and IS2062, when used in combination, offer a superior and viable alternative material solution for SPVs.

The combined plate configuration exhibits competitive tensile strength, yield strength, ductility, and impact resistance compared to SSAB steel. It strikes a favorable balance between strength and impact resistance, ensuring enhanced structural integrity and improved performance under critical load cases. The FEA results validate these superior characteristics, showcasing a more uniform stress distribution, reduced stress concentrations, and minimized risk of potential failure points, such as buckling or rupture.

The significance of these findings is noteworthy for the SPV industry. The utilization of Armox and IS2062 as the combined plate configuration presents numerous advantages. The improved material properties result in enhanced load-bearing capacity, increased resistance to impacts, and improved safety margins for SPVs operating under extreme conditions. Moreover, the availability and cost-effectiveness of Armox and IS2062 make them attractive choices for manufacturers seeking efficient and reliable materials.

This research contributes to the body of knowledge in SPV design and material selection, offering valuable insights for engineers, designers, and manufacturers in the field. The findings encourage the adoption of the Armox and IS2062 combined plate configuration, enabling the development of SPVs with superior performance and enhanced safety.

To further advance the implementation of this material configuration, future research and development endeavors can focus on optimization techniques to refine the design and validate its performance through physical testing. Additionally, investigations into the long-term durability and environmental resistance of the combined plate configuration would be valuable to assess its suitability in a variety of operating conditions.

In summary, the research highlights that the combined plate configuration of Armox and IS2062 outperforms SSAB steel, establishing it as a superior and viable alternative for SPV design. This breakthrough offers the SPV industry an opportunity to enhance structural integrity, improve performance, and ensure the safety of personnel and efficient execution of specialized tasks.

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