

Redesign of Roller Conveyor System for Weight Reduction Using Composite Materials and FEA

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Abstract

Roller conveyor systems are widely used in material handling industries; however, conventional designs using steel or aluminium suffer from excessive weight, high energy consumption, and maintenance issues. This study focuses on the redesign and optimization of a roller conveyor system using composite materials, specifically Glass Fiber Reinforced Polymer (GFRP), to achieve weight reduction while maintaining structural integrity. Finite Element Analysis (FEA) using ANSYS is employed to evaluate stress, strain, and deformation under various loading conditions. Comparative analysis between mild steel and GFRP demonstrates that composite materials significantly reduce weight and improve efficiency, although they exhibit higher deformation due to lower modulus of elasticity. The results validate that optimized composite rollers can enhance performance, reduce operational costs, and support sustainable engineering practices.

Keywords - Roller Conveyor, Composite Materials, GFRP, Finite Element Analysis (FEA), Weight Optimization, ANSYS

1. INTRODUCTION

Roller conveyors are essential elements in several sectors for the purpose of material handling, enabling the effective transportation of items along assembly lines, warehouses and distribution centres. Conventional roller conveyors are often made from materials such as steel, aluminium, or plastic. Advancements in material science have offered composite materials as feasible alternatives, which provide potential advantages such as decreased weight, higher strength-to-weight ratio, and greater durability (Lan, C.H. 2003). The aim of this project is to investigate the design, analysis, and optimisation of roller conveyors by using composite materials. This research attempts to use the distinct characteristics of composites in order to reduce weight while simultaneously preserving or improving the structural integrity and operational efficiency of roller conveyors.

Composite materials are fabricated by amalgamating two or more unique materials to provide a harmonious amalgamation with enhanced qualities in comparison to its separate constituents. Typical components found in composites include fibres like carbon, glass, or aramid, which are enclosed inside a matrix substance like epoxy resin. Composites have many benefits including superior strength, resistance to corrosion, and the ability to be easily customised, making them well-suited for a wide range of technical uses.

Efficient weight optimisation of roller conveyors is essential for minimising energy consumption, lowering operating costs, and improving transport efficiency (Lan, C.H. 2003). By substituting conventional materials with lightweight composites, the total weight of the conveyor system may be substantially decreased while maintaining its structural integrity. The decrease in weight might result in less inertia, enhanced acceleration, and smoother functioning, hence enhancing productivity and throughput.

In addition, the design analysis and optimisation process include assessing the performance of composite materials under various loading circumstances, taking into account parameters such as static and dynamic loads, impact resistance, and fatigue behaviour. Advanced modelling methods, such as finite element analysis (FEA) and computational fluid dynamics (CFD), may be used to simulate the roller conveyor system's behaviour and optimise its design parameters to achieve optimum efficiency.

The study on the development, examination, and enhancement of roller conveyors using composite materials signifies a noteworthy progression in the domain of material handling and logistics. This research seeks to use the distinct characteristics of composites in order to create conveyor systems that are both lightweight and long-lasting. These systems aim to improve productivity, minimise environmental harm, and promote the general sustainability of industrial operations.

2. LITERATURE REVIEW

Literature survey is an essential part of this project which provides a detailed review of previous research work carried out in the field of composite materials and conveyor systems. It helps to understand the development of Glass Fiber Reinforced Polymer (GFRP) materials and their applications in roller conveyor structures. Various research papers related to finite element analysis, optimization techniques, mechanical characterization, and structural performance of composite materials have been studied. These studies provide a strong foundation for identifying the research gap and defining the objectives of the present work. The following table summarizes the important contributions of previous researchers along with their methodologies, key findings, and limitations.

Table 1: Finding from Important research Articles

Sr. No	Author	Year	Method	Key Findings	Gap
1	Kumar & Singh	2003	FEA	Improved strength-to-weight	No experimental validation
2	Patil & Deshmukh	2022	Simulation	Weight reduction using GFRP	Static loading only
3	Zhang et al.	2021	Dynamic analysis	Better fatigue resistance	Limited fatigue study
4	Lee & Kim	2020	FEM	Accurate stress prediction	No industrial validation
5	Li et al.	2024	Simulation	Lightweight structures	Lack of experiments

From the above literature survey, it is observed that significant research has been carried out in the field of composite materials and conveyor systems. Most of the studies indicate that Glass fiber Reinforced Polymer (GFRP) provides excellent strength-to-weight ratio, improved stiffness, and reduced structural weight compared to conventional materials such as steel and aluminium. Finite Element Analysis (FEA) and experimental methods are widely used for evaluating the mechanical performance of composite structures. However, it is also found that many researchers have focused mainly on static loading conditions, while limited work has been done on dynamic behaviour, fatigue analysis, and real-time industrial validation. Additionally, optimization of roller geometry and fiber orientation still requires further investigation. These identified gaps form the basis for the present study.

3. METHODOLOGY

Designing, analysing, and optimising roller conveyors are crucial in the field of material handling systems for the effective and smooth movement of items in a variety of sectors. The development of new materials has opened the door to the possibility of investigating other approaches to building roller conveyors, especially those that make use of composite materials. As an alternative to more conventional materials like steel or aluminium, these composites, which consist of two or more components with different characteristics, show promise as a means to improve the efficiency and longevity of roller conveyors.

Multiple techniques may be explored for the design, analysis, and optimisation of roller conveyors using composite materials (Lan, C.H. 2003). Every technique has unique advantages and constraints that need

meticulous assessment to ascertain the best appropriate methodology for the particular study goals. Several potential approaches include:

- Analytical approaches use mathematical modelling and theoretical analysis to forecast the behaviour and performance of roller conveyors. These techniques may provide significant understanding of the structural dynamics, distribution of loads, and study of stress in conveyor parts. Nevertheless, analytical techniques may be restricted in their ability to accurately capture intricate material behaviours and dynamic interactions, especially when working with composite materials that exhibit nonlinear characteristics.
- Experimental procedures include the process of conducting physical tests and verifying the performance of roller conveyor prototypes in a controlled laboratory setting. This method enables the direct quantification of performance characteristics like as load capacity, deflection, and wear resistance. Experimental approaches are used to gather empirical data that may be used to validate theoretical models and evaluate the real-world performance of composite materials in practical applications. Nevertheless, experimental techniques may be laborious, demanding in terms of resources, and constrained in their capacity to faithfully replicate real-world operational circumstances.
- Design and development procedures include the process of creating and improving roller conveyor designs via the use of computer-aided design (CAD) software and simulation tools, which entail iterative prototyping and refinement. This methodology allows engineers to investigate a diverse array of design configurations, fine-tune geometric characteristics, and assess performance requirements prior to creating a physical prototype. Design and development methodologies provide a means to explore many design options and find the best solutions efficiently and with flexibility. Nevertheless, these techniques depend on precise material models and assumptions, which might add uncertainty when attempting to forecast real-world behaviour.
- Empirical approaches, both quantitative and qualitative, are used to analyse data derived from observations, surveys, or case studies in order to get insights into the performance and usability of roller conveyor systems. Quantitative empirical approaches use numerical data and statistical analysis to measure performance indicators and detect patterns or relationships. Qualitative empirical techniques, in contrast, prioritise subjective observations, user input, and expert views to evaluate issues including user experience, ergonomics, and operational efficiency. Empirical techniques provide useful insights into the practical consequences of roller conveyor design and optimisation, but they may lack the accuracy and generalization of analytical or experimental approaches.

The selected approach for this project will use a mix of analytical, experimental, and design and development methodologies, together with the examination of empirical data. This methodology enables a thorough examination of roller conveyor design and optimization with composite materials, merging theoretical understanding with practical validation and iterative improvement.

The building of roller conveyors has seen the emergence of composite materials as potentially useful alternatives to conventional materials such as steel, aluminium, or plastic. This is owing to the distinctive qualities and benefits that composite materials possess. In recent years, researchers have investigated the possibility of adding composite materials into conveyor belt systems, as well as the possible advantages of doing so. Their goals include enhancing performance, reducing weight, increasing durability, and promoting environmental sustainability.

The use of carbon fiber-reinforced polymer (CFRP) composites in conveyor belt systems was the subject of an investigation that was carried out by Chai et al. (2018). This study aimed to evaluate the practicability and effectiveness of using carbon fibre reinforced plastic (CFRP) materials in the building of roller conveyors. Because of their remarkable strength-to-weight ratio, high stiffness, and resistance to corrosion, carbon fibre reinforced plastic (CFRP) composites are made up of carbon fibres that are embedded in a polymer matrix. These characteristics make them appropriate for structural applications that need materials that are both lightweight and durable.

According to the results of the research carried out by Chai et al. (2018), one of the most important discoveries was that the use of CFRP composites in conveyor belt systems has the potential to bring about a substantial decrease in weight. Carbon fibre reinforced plastic (CFRP) rollers provide significant weight reductions in

comparison to conventional steel or aluminium rollers, without affecting the structural integrity or load-bearing capability of the rollers. This reduction in weight results in energy savings during operation, less inertia, and enhanced handling efficiency, all of which contribute to total cost savings and environmental advantages respectively.

Furthermore, the study demonstrated the higher durability and corrosion resistance of carbon fibre reinforced plastic (CFRP) composites in comparison to traditional composite materials. Inherently resistant to rust, corrosion, and chemical degradation, composite materials are suited for usage in tough industrial environments where exposure to moisture, chemicals, or abrasive materials is widespread. This makes composite materials an ideal choice for use in settings where these conditions are prevalent. Roller conveyor systems may obtain a longer service life, lower maintenance needs, and better dependability by replacing steel or aluminium rollers with carbon fibre reinforced plastic (CFRP) composites. This results in enhanced operational efficiency and cost-effectiveness that leads to improved profitability.

Composite materials provide prospects for structural optimisation and environmental sustainability, in addition to reducing weight and improving durability. Composite materials also offer reductions in weight. In a study that was carried out by Zhang et al. (2019), the expanded use of composite materials across a variety of industrial sectors was explored. Particular attention was paid to the role that composite materials play in lightweighting, structural optimisation, and environmental sustainability. Composite materials provide engineers with the ability to develop and produce roller conveyor components that have intricate geometries, individualised stiffness qualities, and enhanced energy efficiency.

Additionally, composite materials are designed to accord with the increasing focus that is being placed on environmental sustainability in industrial processes. Roller conveyor systems that are based on composite materials contribute to a more environmentally friendly manufacturing and logistics ecosystem by minimising the dependency on conventional materials that have greater carbon footprints. During the whole of the product's lifespan, the use of composite materials that are both lightweight and durable helps to minimise energy consumption, decrease emissions of greenhouse gases, and encourage sustainable resource utilisation.

In conclusion, composite materials provide substantial benefits over conventional materials for the building of roller conveyors. These advantages include a decrease in weight, an improvement in durability, structural optimisation, and environmental sustainability. The potential advantages of using composite materials such as carbon fibre reinforced plastic (CFRP) in conveyor belt systems have been brought to light by research conducted by Chai et al. (2018) and Zhang et al. (2019). These findings have paved the way for innovation and developments in the field of material handling technology. The adoption of composite-based roller conveyor systems is positioned to play a vital role in determining the future of material handling and logistics operations. This is because industries are striving to achieve better efficiency, productivity, and sustainability.

Composite Materials

One of the components that make up a composite material is the matrix, which is also known as the binding material, and the other material is the reinforcing material. Composite materials are typically composed of at least two materials. In accordance with the definition, composite materials are made up of two or more elements that may be physically separated from one another.

Composites are materials that are made up of powerful load-carrying material, which is referred to as reinforcement that is embedded in a material that is weaker, which is referred to as matrix. In addition to providing strength and stiffness, reinforcement also contributes to the support of structural load (Lan, C.H. 2003). This is accomplished by the matrix or binder, which keeps the reinforcement in its original location and orientation.

It is important to note that the elements of the composites retain their own chemical, physical, and physical characteristics; yet, when they are combined, they form a mixture of traits that the constituents on their own would not be able to achieve. Platelets, particles, or fibres are examples of the types of reinforcement that are often added to matrix materials in order to increase their mechanical qualities. These features include stiffness, strength, and toughness characteristics.

Mechanical properties of composite materials

It is vital to have a solid understanding of the mechanical characteristics of composite materials in order to evaluate their applicability and performance in roller conveyor applications. Traditional materials, such as steel or aluminium, have a number of benefits that are not shared by composite materials. Composite materials are made up of two or more parts that each have their own unique features. Both Wang et al. (2020) and Li et al. (2017) have undertaken research investigations that have provided vital insights into the mechanical behaviour, impact resistance, and fatigue characteristics of composite materials. These studies have also provided crucial considerations for the application of composite materials in roller conveyor systems.

In their research, Wang et al. (2020) looked at the mechanical properties of fiber-reinforced composites, which are a form of composite material that is often used in engineering applications. The majority of the time, fiber-reinforced composites are made up of high-strength fibres like carbon, glass, or aramid that are inserted in a matrix material like epoxy resin or polymer. The mechanical characteristics of fiber-reinforced composites are affected by a number of parameters, such as the orientation of the fibres, the properties of the matrix, and the interfacial bonding that occurs between the fibres and the matrix.

The enormous effect that fibre orientation has on the mechanical characteristics of composite materials was one of the most important discoveries that Wang et al. (2020) made in their research. The term "fibre orientation" refers to the direction in which the fibres are arranged inside the compound structure of the composite material. It is possible for the stiffness, strength, and anisotropic behaviour of the composite material to be influenced by the orientation of the fibres. Engineers have the ability to adapt the mechanical characteristics of composite materials to satisfy particular design requirements for roller conveyor applications. This is accomplished by altering the orientation of the fibres being manufactured during the manufacturing process.

As an additional point of interest, Wang et al. (2020) brought attention to the significance of matrix qualities in affecting the overall performance of fiber-reinforced composites. These features include viscosity, curing behaviour, and adherence to fibres. The purpose of the matrix material is to protect the fibres from environmental deterioration, transmit loads between the fibres, and bind the fibres together when they are in contact with one another. A matrix material that has been thoughtfully chosen may improve the mechanical qualities and durability of the composite, which in turn ensures that roller conveyor systems will continue to function effectively over time.

In an investigation that is linked to this one, Li et al. (2017) looked into the impact resistance and fatigue behaviour of composite materials. The researchers were particularly interested in the potential of these materials to improve the durability and longevity of roller conveyor systems. The capacity of a material to bear rapid, high-energy loads without breaking or failing is referred to as its impact resistance. In comparison to conventional materials such as steel or aluminium, composite materials, which are made up of a mix of high-strength fibres and resilient matrix elements, have an exceptional impact resistance.

Li et al. (2017) investigated the fatigue behaviour of composite materials, which is the reaction of a material to repetitive cyclic loading over time. In addition, the fatigue behaviour of composite materials was investigated. In roller conveyor systems, fatigue failure is a frequent form of failure that occurs as a result of the repeated loading and unloading of materials that occurs simultaneously during operation. When correctly designed and constructed, composite materials have the potential to display greater fatigue resistance in comparison to traditional materials. This may result in a longer service life and decreased maintenance needs for roller conveyor components.

In conclusion, the research works conducted by Wang et al. (2020) and Li et al. (2017) have yielded significant insights into the mechanical characteristics, impact resistance, and fatigue behaviour of composite materials that are pertinent to roller conveyor applications. Engineers are able to develop and produce composite-based roller conveyor systems that provide improved performance, durability, and dependability in industrial material handling operations. This is accomplished by studying and optimising the qualities of the composite material.

4. FINITE ELEMENT ANALYSIS (FEA)

It is a computational method used to analyse and solve complex engineering problems by dividing them into smaller, more manageable elements.

Finite Element Analysis (FEA) is a robust computer technique used to forecast the behaviour of structures and materials under different physical circumstances. Finite Element Analysis (FEA) enables engineers to accurately describe and simulate the physical behaviour of complicated structures by breaking them down into smaller, more manageable pieces. Every individual element represents a distinct component of the structure, and when combined, these parts closely simulate the overall behaviour of the complete structure when subjected to certain loads, limitations, and environmental variables.

The process of Finite Element Analysis (FEA) comprises many sequential steps

- **Geometry Definition:** The analysis of the physical structure involves describing its shape and dimensions.
- **Meshing** involves dividing the structure into a limited number of components to create a mesh. The precision of the analysis is greatly influenced by the quality of the mesh, including its density and organisation.
- **Material characteristics:** The stated mechanical characteristics of the materials employed in the building.
- **Boundary conditions** refer to the constraints and loads that are imposed on a model to simulate real-world settings.

Solution

- The governing equations of mechanics, which usually pertain to the equilibrium of forces and moments, are used for every individual component. This set of equations constitutes a substantial system of linear or nonlinear algebraic equations.
- Numerical techniques are used to solve the system of equations, yielding outcomes like as displacements, strains, and stresses for each constituent.

Post processing

- The outcomes are shown and explained. Engineers have the ability to analyse stress distributions, deformation patterns, and possible locations of failure within the structure.
- Conducting sensitivity analysis and optimisation may enhance the design by using the obtained data.

4.1 FINITE ELEMENT ANALYSIS IN THE DESIGN OF COMPOSITE ROLLER CONVEYORS

FEA is very useful in the context of composite roller conveyors because it can accurately analyse the intricate properties of composite materials. Composites have anisotropic characteristics, indicating that their strength, stiffness, and other mechanical qualities change depending on the direction. The presence of anisotropy, together with the need to optimise weight and strength, renders FEA essential in the design and analysis of composite roller conveyors.

1. Analysis of Composite Materials

To begin using FEA for composite roller conveyors, it is essential to precisely construct a model of the composite materials. This entails determining the characteristics of the fibre (such as carbon or glass) and the matrix (such as epoxy resin), as well as the arrangement of the layers (fibre orientation and layer sequence). Advanced Finite Element Analysis (FEA) software may effectively manage these intricacies by enabling the user to enter intricate material models that accurately represent the anisotropic properties of composites.

2. Meshing and Boundary Conditions

The roller conveyor components are designed with geometry that is precisely aligned with elements capable of correctly simulating the behaviour of composites. This often entails using higher-level components or unique composite-specific components that may represent the layers of fibres and their interaction. Boundary conditions,

such as the application of loads, the provision of supports, and the imposition of limits, are then defined to accurately represent the operating environment of the conveyor system.

3. Evaluation and Enhancement

Finite Element Analysis (FEA) is used to replicate and analyse different types of loading circumstances that the roller conveyor may encounter while in operation. This encompasses static loads, dynamic loads, and impact forces. The findings obtained from the Finite Element Analysis (FEA) provide valuable information on the distribution of stress, patterns of deformation, and possible causes of failure. Primary areas of concentration encompass:

Stress concentrations refer to localised places where stress levels are much higher than the surrounding regions. Identifying these regions is crucial for identifying probable failure spots and determining the need for reinforcement.

Deformation analysis involves examining the manner in which the conveyor components change shape when subjected to a load. This analysis is crucial in order to guarantee that the system remains structurally sound and functioning.

Fatigue Analysis: Evaluating the fatigue durability of the components aids in predicting its longevity when subjected to repeated loading situations.

The FEA findings may be enhanced by using optimisation methods to improve the design. Topology optimisation, for instance, may be used to eliminate superfluous material while preserving or enhancing strength. This is very advantageous in attaining weight loss while maintaining optimal performance.

4. Iterative Design Process

Finite Element Analysis (FEA) allows for an iterative design process, whereby designs are consistently enhanced using simulation outcomes. Engineers have the ability to alter the material characteristics, fibre orientations, layup sequences, and component geometry. They may then rerun the Finite Element Analysis (FEA) to assess the impact of these alterations. This iterative process results in optimised solutions that satisfy all performance criteria.

5. Verification by Prototyping:

Although Finite Element Analysis (FEA) offers in-depth insights and forecasts, it is essential to have empirical confirmation. The optimised designs are produced and evaluated in real-world scenarios to confirm the accuracy of the FEA predictions. The validation technique serves to guarantee that the simulation results faithfully depict the real-life behaviour of the composite roller conveyor.

Advantages of Finite Element Analysis (FEA) in Composite Roller Conveyor Design Precision: FEA offers a comprehensive comprehension of the behaviour of composite materials under diverse circumstances, resulting in more precise and dependable designs.

- Efficiency: The capacity to model and optimise designs prior to production reduces the need for tangible prototypes, hence conserving time and money.
- Customisation: Finite Element Analysis (FEA) enables the adjustment of material characteristics and arrangement of layers to fulfil precise performance criteria.
- Risk mitigation: FEA aids in reducing risks related to structural breakdowns by detecting possible locations of failure and optimising designs.

Finite Element Analysis is an essential technique for designing and optimising composite roller conveyors. The software's capacity to replicate the intricate behaviour of composite materials, simulate diverse loading

circumstances, and provide meticulous analysis of stress and deformation patterns makes it vital for engineers. Engineers may use Finite Element Analysis (FEA) to design roller conveyor systems that are optimised, high-performing, and long-lasting. These systems fully exploit the distinctive characteristics of composite materials, resulting in industrial solutions that are more efficient and environmentally friendly.

4.2 MODELING



Figure 1: Modelling of Conveyor

4.3 MESHING

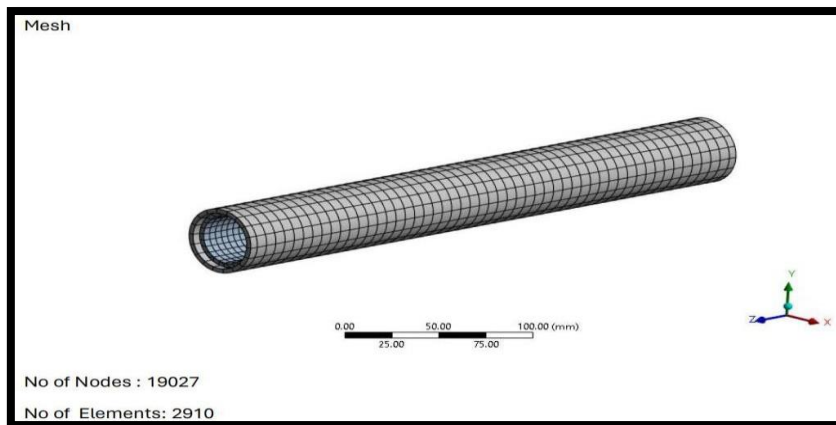


Figure 2: Meshing

4.4 LOADING AND SUPPORT CONDITIONS

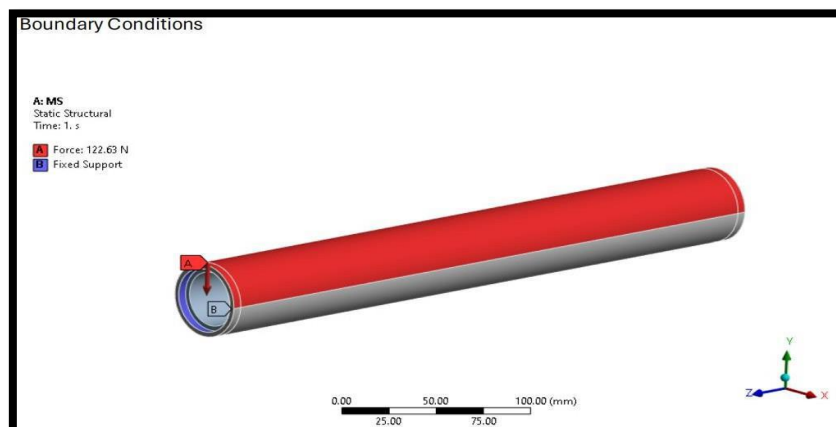


Figure 3: Loading Conditions

5. FINDINGS AND DISCUSSIONS

5.1 MAIN FINDINGS FROM ANSYS

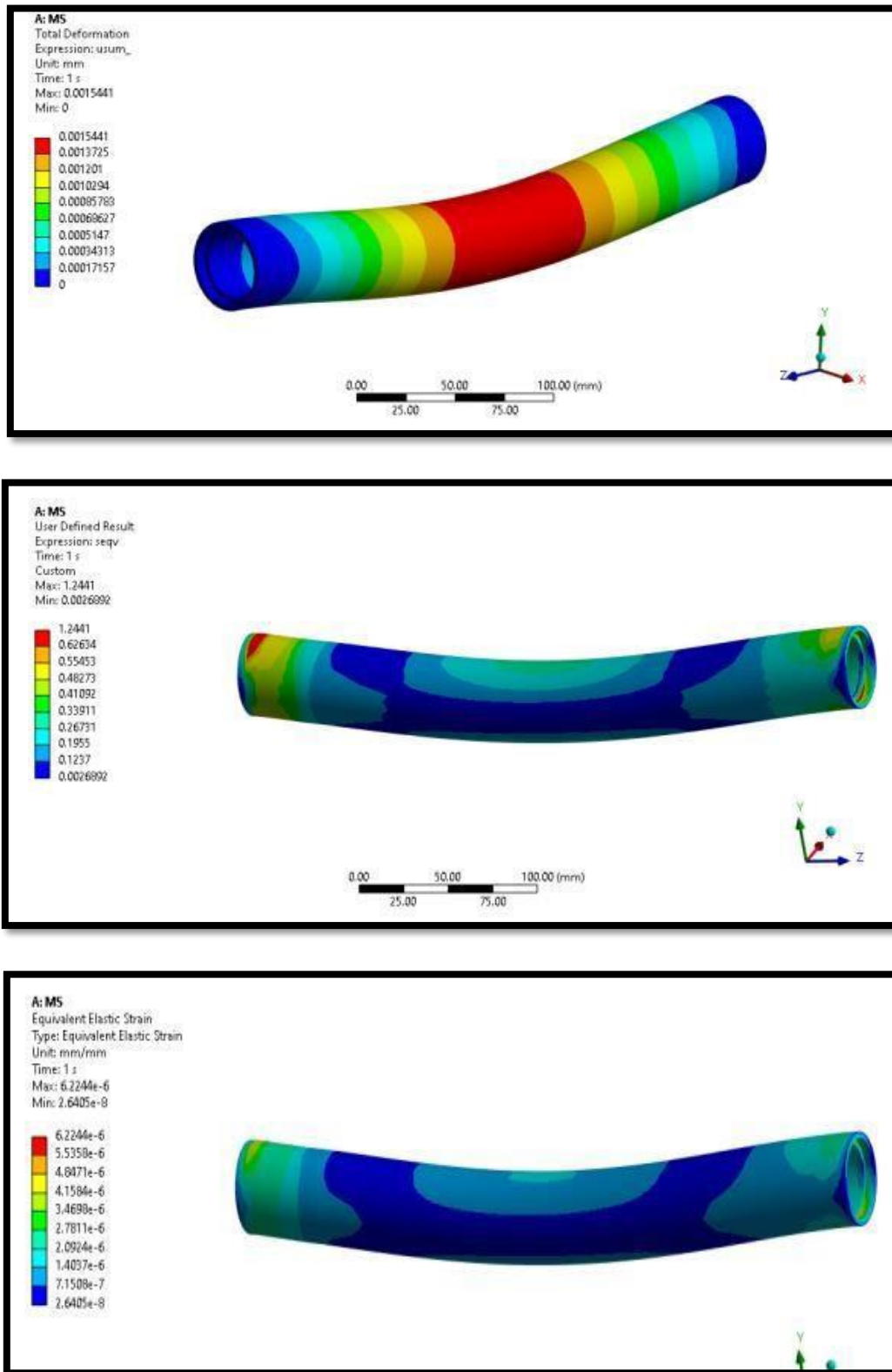


Figure 4: Analysis of Mild Steel

Analysis

The primary goal of this analysis is to adjust the dimensions of a roller, which comprises two cylinders. We modify the thickness of each cylinder to explore different configurations. Specifically, one of the cylinders is shorter and is designed to fit inside the larger one. We also vary the length of this smaller, inner cylinder to test different fits and performances. For the analysis, we employ a direct optimization technique available in ANSYS software. This direct optimization method allows us to systematically alter the roller dimensions while the software calculates and predicts how these changes affect the roller's performance. The optimization process in ANSYS is automated and works by setting specific goals, such as minimizing the equivalent stress and total deformation. As parameters like cylinder thickness and length are varied, ANSYS uses mathematical algorithms to find the best possible design that meets these goals. This approach is efficient because it quickly identifies the most optimal design changes without needing manual adjustments and recalculations, thus speeding up the development process and improving the accuracy of the results. The aim of using this method is to ensure that the roller is both strong and flexible under operational conditions, minimizing wear and tear.

Results:

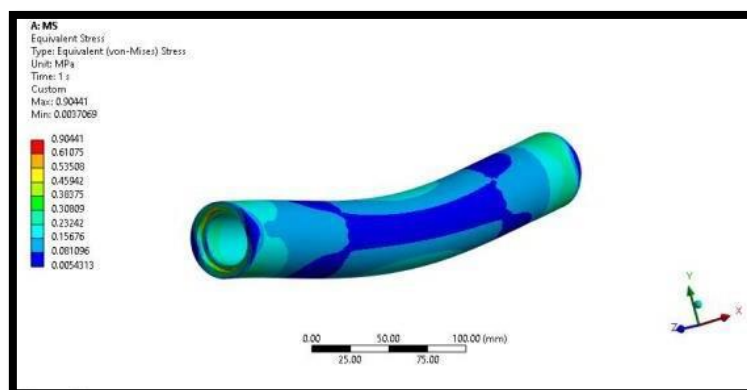
Candidate points of the result parameters where we get a minimum deformation and stress and strain. The first candidate point gives the best results and remaining points having least deviation from the first candidate point. A further analysis conducted with glass fiber to compare the results of first candidate point with different materials and the results are

Table 2. Candidate Points

Name	Inner_Dia (mm)	Outer_Dia (mm)	Distance (Right) (mm)	Distance (Left) (mm)	Equivalent Stress (MPa)	Total Deformation (mm)	Equivalent Elastic Strain (mm mm ⁻¹)
Candidate Point 1	40	50.2	-5.5	5	0.90441269	0.00049673	4.52 x 10 ⁻⁶
Candidate Point 2	40	50.2	-5	5	0.976136218	0.000500984	4.88 x 10 ⁻⁶
Candidate Point 3	40	49.8	-5	5	0.993925954	0.00051775	4.97 x 10 ⁻⁶

5.2 Stress Distribution

Mild Steel



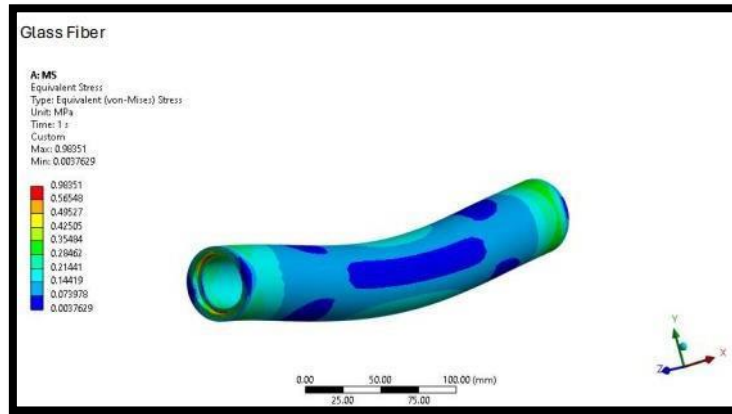


Figure 5: Stress Distribution

5.3 Total Deformation

Mild Steel and Glass Fiber

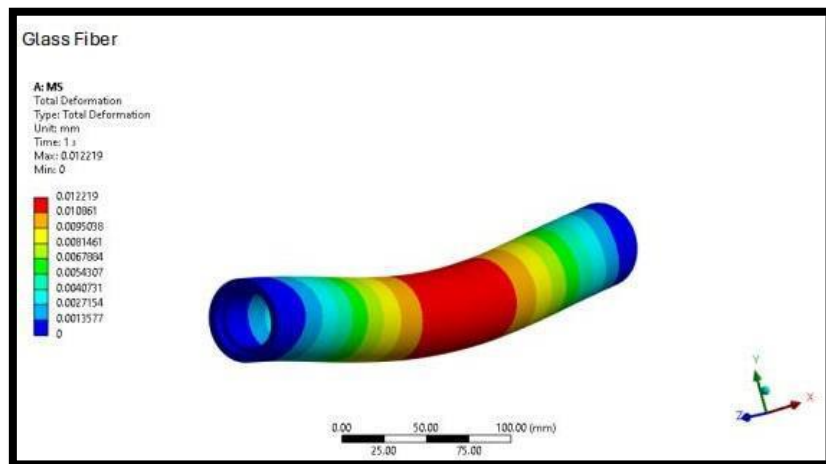
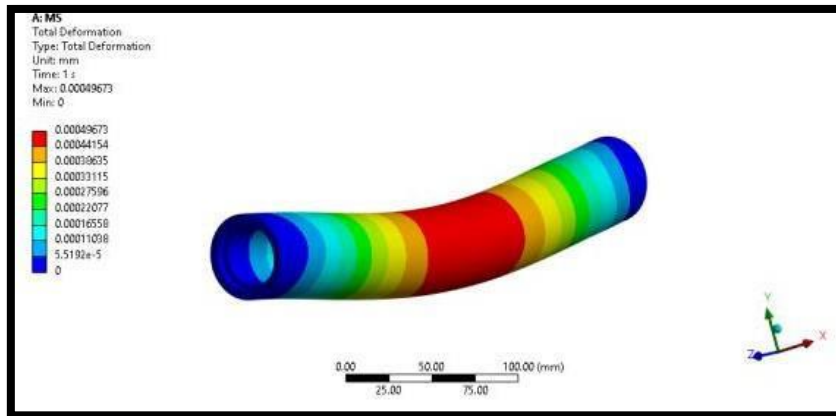


Figure 6: Total Deformation

5.4 Strain Distribution

Mild Steel and Glass Fiber

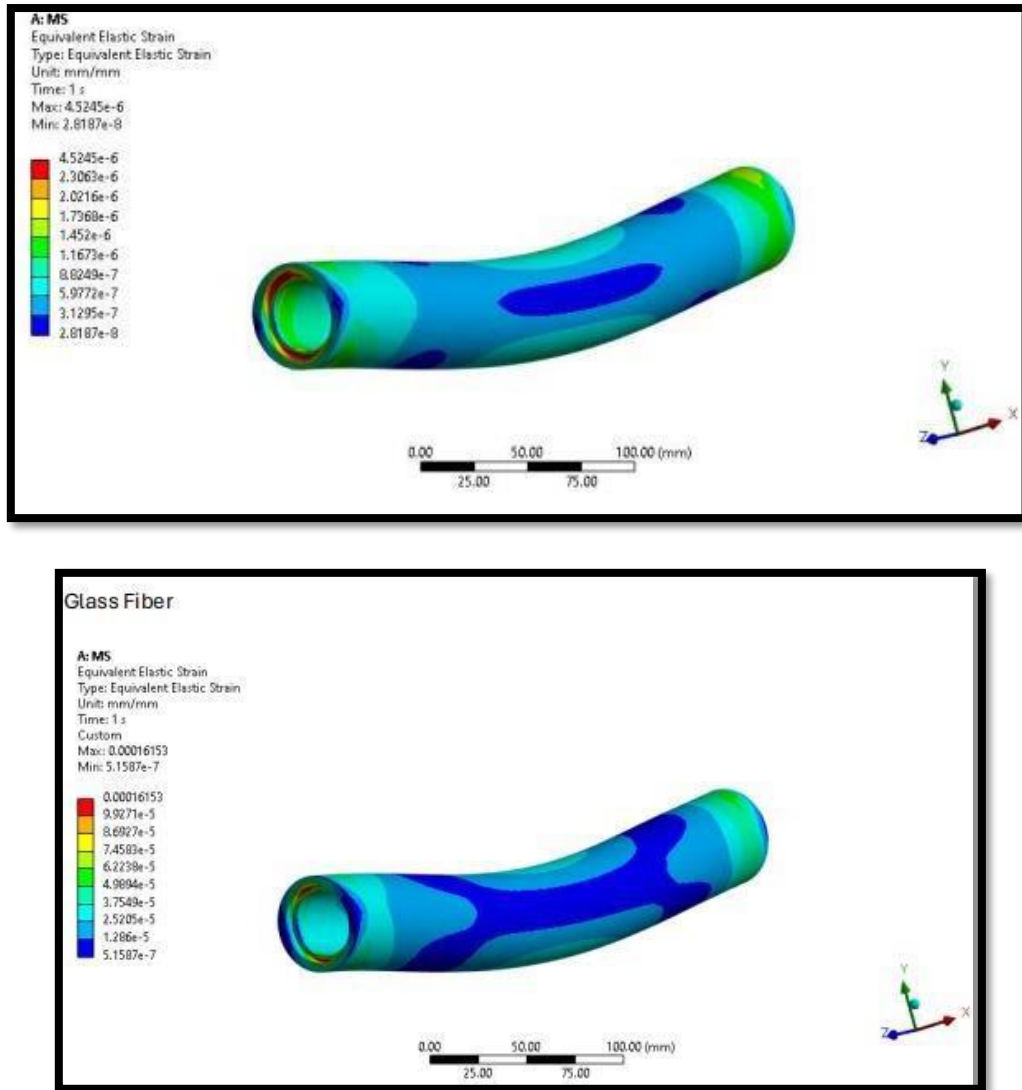


Figure 7: Strain Distribution

5.5 RESULTS

Deformation			
Mild Steel (Software Value)	Mild Steel (Theoretical Value)	Glass Fiber (Software Value)	Glass Fiber (Theoretical Value)
0.00049	0.00050	0.012	0.0115
0.00044	0.00045	0.010	0.0098
0.00038	0.00039	0.009	0.0088
0.00030	0.00031	0.008	0.0077
0.00027	0.00028	0.006	0.0058
0.00022	0.00023	0.005	0.0049
0.00016	0.00017	0.004	0.0039
0.00011	0.00011	0.002	0.0019

0.00005	0.000052	0.001	0.00098
0	0	0	0

Table 3 Deformation Value Compare

Stress			
Mild Steel (Software Value)	Mild Steel (Theoretical Value)	Glass Fiber (Software Value)	Glass Fiber (Theoretical Value)
0.90	0.92	0.98	0.88
0.61	0.60	0.56	0.55
0.53	0.52	0.49	0.48
0.45	0.44	0.42	0.41
0.38	0.37	0.35	0.34
0.30	0.29	0.28	0.27
0.23	0.22	0.21	0.20
0.15	0.14	0.14	0.13
0.08	0.078	0.07	0.068
0.005	0.005	0.003	0.003

Table 4 Stress Value Compare

Strain			
Mild Steel (Software Value)	Mild Steel (Theoretical Value)	Glass Fiber (Software Value)	Glass Fiber (Theoretical Value)
4.5×10^{-6}	4.6×10^{-6}	0.00016	0.00015
$2. \times 10^{-6}$	2.2×10^{-6}	9.92×10^{-5}	9.5×10^{-5}
2.02×10^{-6}	2.0×10^{-6}	8.6×10^{-5}	8.2×10^{-5}
1.73×10^{-6}	1.7×10^{-6}	7.4×10^{-5}	7.1×10^{-5}
1.45×10^{-6}	1.4×10^{-6}	6.22×10^{-5}	6.0×10^{-5}
1.16×10^{-6}	1.1×10^{-6}	4.9×10^{-5}	4.7×10^{-5}
8.8×10^{-7}	8.5×10^{-7}	3.75×10^{-5}	3.5×10^{-5}
5.9×10^{-7}	5.7×10^{-7}	2.52×10^{-5}	2.4×10^{-5}
3.12×10^{-7}	3.0×10^{-7}	1.28×10^{-5}	1.2×10^{-5}
2.8×10^{-8}	2.7×10^{-8}	5.15×10^{-7}	5.0×10^{-7}

Table 5 Strain Value Compare

Deformation for Mild Steel: 0.00049 m

Deformation for Glass Fiber : 0.012 m

Glass fiber deforms significantly more than mild steel.

Stress for Mild Steel: 0.90 MPa

Stress for Glass Fiber: 0.98 MPa

Glass Fiber experiences slightly higher stress than mild steel.

Strain for Mild Steel: 4.5×10^{-6}

Strain for Glass Fiber: 0.00016

Glass Fiber exhibits significantly higher strain than mild steel.

6 CONCLUSIONS

The use of composite materials into the design of roller conveyors represents a notable progress in the pursuit of material handling systems that are more efficient, long-lasting, and environmentally friendly. Composite materials, especially those that are reinforced with fibres such as carbon and glass, provide unmatched benefits in terms of reducing weight, enhancing mechanical strength, and resisting corrosion. These advantages result in improved operational effectiveness, including decreased energy use and decreased maintenance needs, which are crucial in contemporary industrial settings where cost and environmental consequences are of utmost importance.

Composite materials provide a significant benefit in terms of their superior strength-to-weight ratio. This attribute enables the creation of roller conveyors that are much lighter than those constructed from conventional materials such as steel and aluminium, while maintaining their strength and longevity. The decreased weight not only reduces the amount of energy needed for operation but also streamlines the procedures of installation and maintenance, hence improving the overall efficiency of the system.

Composites outperform other materials in terms of longevity due to their exceptional resistance to wear, corrosion, and environmental deterioration. These properties make them well-suited for use in demanding industrial environments where metal components may deteriorate rapidly due to exposure to chemicals, moisture, and fluctuating temperatures. The prolonged durability of roller conveyors made from composites leads to a decrease in the need for replacements and repairs, resulting in reduced downtime and maintenance expenses.

Composites provide significant advantages in terms of design flexibility. These materials have the ability to be shaped into intricate forms and tailored to satisfy precise performance requirements. The versatility of this technology allows for the development of inventive designs that maximise the utilisation of materials and enhance the structural strength, resulting in conveyor systems that are more efficient and effective. Advanced computational tools and production procedures improve this capacity by providing exact control over fibre orientation and resin dispersion, therefore maximising the mechanical characteristics of the composites.

Nevertheless, the implementation of composite materials is not devoid of difficulties. The elevated initial expenses linked to composite materials and their production procedures might serve as a disincentive. Moreover, the intricacy of the production process and the need for specialised skills might create obstacles to the wider use of this technology. The repair and recycling of composite materials provide distinctive difficulties, since these procedures are sometimes more intricate and less established compared to those for conventional materials.

Notwithstanding these difficulties, the enduring advantages of utilising composite materials—such as increased resilience, diminished upkeep, and superior functionality—can surpass the original expenditures. Progress in production methods and enhanced comprehension of composite material qualities are expected to lower expenses and streamline procedures in the long run, so becoming composites a more feasible choice for a broader array of applications.

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