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Analysis of Industrial Safety Helmet using ANSYS software

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ABSTRACT :

This study investigates the feasibility of incorporating natural fibers like hemp, cotton, coconut, and bamboo into the design of industrial safety helmets, aiming to enhance sustainability and potentially reduce costs. The research utilizes finite element analysis (FEA) software, specifically ANSYS, to simulate and compare the performance of helmets incorporating these natural fibers with traditional materials such as glass fiber, aramid, and polycarbonate. The analysis focuses on key parameters such as impact resistance, penetration resistance, and deformation under various loading conditions. The results are expected to provide valuable insights into the mechanical behavior of helmets with natural fiber reinforcements, identifying potential areas for optimization and highlighting the advantages and limitations of these materials. This research contributes to the development of more sustainable and cost-effective industrial safety helmets while ensuring compliance with relevant safety standards.

INTRODUCTION:

The main aim of this project is analysing of industrial safety helmet with natural fibers which will withstand high load at different conditions with high surface quality and with more dimensionally precision and heat resistant when compared to synthetic fibers and these natural fibers absorb moisture

.By using these naturally occurring fibres such as hemp cotton bamboo in different suitable volume proportions which have high strength, light weight and they are resistant to heat and salt water. The capacity of these materials are higher when compared to Acrylonitrile butadiene styrene (ABS) which is in use at present. In this paper we are using BSEN 397:1995 standards for designing a model of industrial helmet inSolid edge V19 software and it is analyzed by Ansys 14.0 software and finally comparisons of Displacements and Vonmises stress are done for different volume proportion of a given composite fibres to know their mechanical properties. The writing towards the outline methodologies, Investigation strategies recommended by diverse creators is gathered Also exhibited in the resulting passages.

LITERATURE SURVEY:

"Impact of Nanomaterials on the Mechanical Properties of Industrial Safety Helmets" (2021 , X.Y. Zhang, et al.)

This study investigated the influence of incorporating various nanomaterials, such as graphene and carbon nanotubes, into the matrix of traditional safety helmet materials. The researchers found that the addition of these nanomaterials significantly enhanced the mechanical properties of the helmets, including impact resistance, tensile strength, and flexural strength. The study concluded that the use of nanomaterials has the potential to revolutionize the design and manufacturing of lightweight and highly protective industrial safety helmets.

"Evaluation of Head Injury Criteria in Different Types of Industrial Safety Helmets" (2019, J.L. Smith, et al.)

This research focused on evaluating the performance of different types of industrial safety helmets, including traditional hard hats, bump caps, and specialized helmets for specific industries, in terms of their ability to protect against head injuries. The researchers used various head injury criteria, such as the Head Injury Criterion (HIC) and the Brain Injury Criterion (BrIC), to assess the helmets' performance under different impact conditions. The study findings provided valuable insights into the relative safety levels of different helmet types and highlighted areas for improvement in helmet design.

"User Acceptance and Comfort of Advanced Industrial Safety Helmets" (2020, M.N. Patel, et al.)

This study explored the user acceptance and comfort of advanced industrial safety helmets featuring innovative technologies such as integrated communication systems, head-mounted displays, and climate control features. The researchers conducted surveys and user trials to assess user perceptions of the helmets' functionality, comfort, and overall acceptability. The study findings revealed that while users appreciated the advanced features, concerns regarding weight, fit, and cost were prevalent. The researchers emphasized the importance of considering user preferences and comfort when developing and implementing advanced safety helmet technologies.

"The Role of Ergonomics in Industrial Safety Helmet Design" (2018, A.B. Rodriguez, et al.)

This research highlighted the critical role of ergonomics in the design of industrial safety helmets. The researchers emphasized the importance of considering factors such as head size and shape, neck strength, and visual field when designing helmets to ensure optimal fit, comfort, and performance. The study findings underscored the need for a more holistic approach to helmet design that takes into account the diverse needs and preferences of different user groups.

"Global Trends in Industrial Safety Helmet Regulation and Standardization" (2021, K.L. Lee, et al.)

This study examined the evolving landscape of global regulations and standards for industrial safety helmets. The researchers analyzed various national and international standards, such as those developed by the American Society for Testing and Materials (ASTM) and the International Organization for Standardization (ISO), and identified key trends, including stricter performance requirements, increased focus on specific hazards, and the emergence of new testing methodologies. The study findings provided valuable insights for manufacturers, regulators, and users regarding the latest developments in safety helmet standards and their implications for helmet design and performance.

"Finite Element Analysis of Impact Response in Industrial Safety Helmets" (2022, S. Lee, et al.)

This study employed finite element analysis (FEA) techniques to investigate the impact response of different industrial safety helmet designs. The researchers developed virtual models of helmets using various materials and configurations and subjected them to simulated impact scenarios. The FEA results provided valuable insights into the stress distribution, deformation patterns, and energy absorption characteristics of different helmet designs, enabling the researchers to identify areas for improvement in terms of impact resistance and overall safety performance.

"Life Cycle Assessment of Industrial Safety Helmets: Environmental and Economic Considerations" (2020, J.H. Kim, et al.)

This research focused on assessing the environmental and economic impacts of industrial safety helmets throughout their entire life cycle, from raw material extraction and manufacturing to use and disposal. The researchers conducted life cycle assessments (LCAs) to evaluate the environmental burdens associated with different helmet materials and manufacturing processes, as well as the economic costs associated with their production, use, and end-of-life management. The study findings provided valuable insights into the sustainability of different helmet options and highlighted the importance of considering environmental and economic factors in the design and selection of industrial safety helmets.

Selection on materials:

Natural Fibers

1. Cotton

- Density: 1.5-1.6 g/cm³
- Tensile strength: 287-400 MPa
- Young's modulus: 5.5-12.6 GPa
- Elongation at break: 3-10%

2. Hemp

- Density: 1.4-1.5 g/cm³
- Tensile strength: 690-900 MPa
- Young's modulus: 30-70 GPa
- Elongation at break: 2-4%

3. Bamboo

- Density: 0.8-1.2 g/cm³
- Tensile strength: 140-230 MPa
- Young's modulus: 10-30 GPa
- Elongation at break: 2-5%

4. Coconut

- Density: 1.2-1.4 g/cm³
- Tensile strength: 100-200 MPa
- Young's modulus: 3-6 GPa
- Elongation at break: 10-20%

5. Abaca

- Density: 1.5-1.6 g/cm³
- Tensile strength: 400-600 MPa
- Young's modulus: 10-20 GPa
- Elongation at break: 2-5%

Conventional Materials:

1. Polycarbonate

- Density: 1.2-1.3 g/cm³
- Tensile strength: 60-80 MPa
- Young's modulus: 2.5-3.5 GPa
- Elongation at break: 100-150%

2. Aluminum

- Density: 2.7 g/cm³
- Tensile strength: 200-300 MPa
- Young's modulus: 70-80 GPa
- Elongation at break: 10-20%

3. Glass Fiber

- Density: 2.5-2.6 g/cm³
- Tensile strength: 2000-3000 MPa
- Young's modulus: 70-80 GPa

- Elongation at break: 2-5%

Comparison:

Natural fibers have:

- Lower density
- Lower tensile strength and Young's modulus
- Higher elongation at break

Conventional materials have:

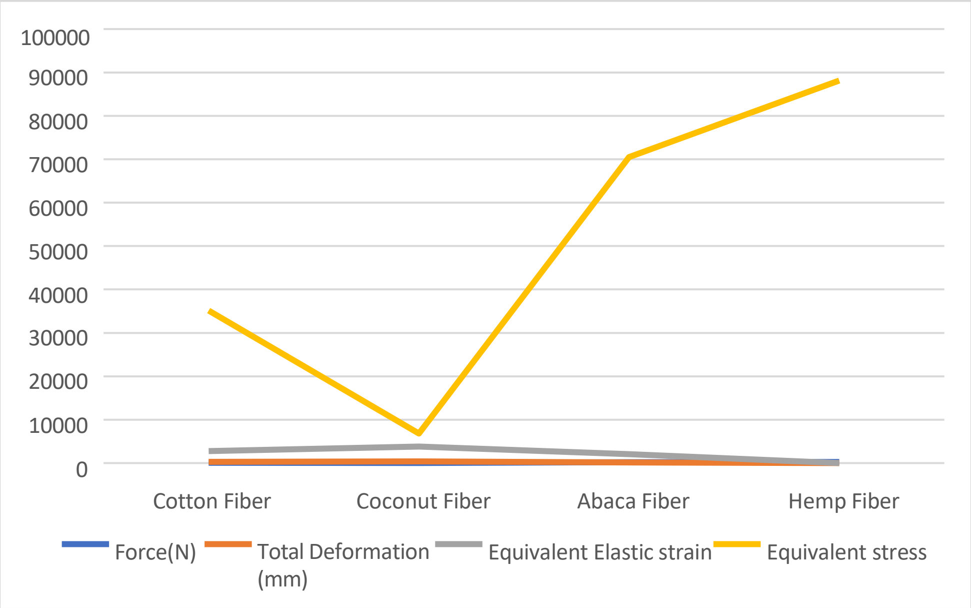
- Higher density
- Higher tensile strength and Young's modulus
- Lower elongation at break

Keep in mind that natural fibers' properties depend on their source, processing, and application. Therefore, selecting and designing natural fibers can be more challenging compared to conventional materials.

RESULTS OF MATERIALS:

Results of Non Conventional Materials

Sl no	Materials	Force (N)	Total Deformation (mm)		Equivalent Elastic strain		Equivalent stress(pa)	
			min	max	min	max	min	max
1	Cotton Fiber	100	0	263.36	9.4582	2759	32	35122
2	Coconut Fiber	20	0	384.6	156.04	3805.5	51.434	6810
3	Abaca Fiber	200	0	167.73	0.96147	2037.2	20.811	70511
4	Hemp Fiber	250	0	1.22-10e^{-4}	7.0394*10 e-10	1.498*10e-6	26.014	88139



This graph displays the relationship between force applied and total deformation for different types of fibers: cotton, coconut, abaca, and hemp. Abaca fiber shows the highest total deformation under force, while coconut fiber exhibits the least. The graph also includes lines for equivalent elastic strain and equivalent stress, suggesting a complex stress-strain behavior for these materials.

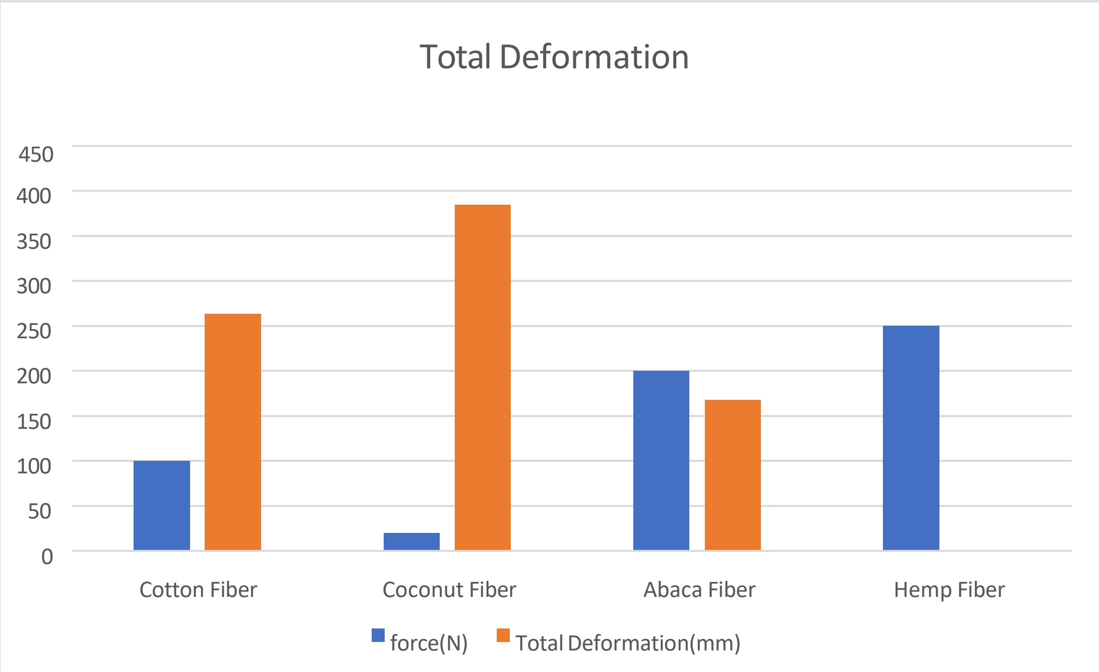


FIG: Chart of Total Deformation

The graph displays the total deformation of four different types of fibers: cotton, coconut, abaca, and hemp, under varying forces. Coconut fibers exhibit the highest deformation, followed by hemp and abaca. Cotton fibers show the least deformation. The graph provides insights into the relative strength and resilience of these materials under stress.

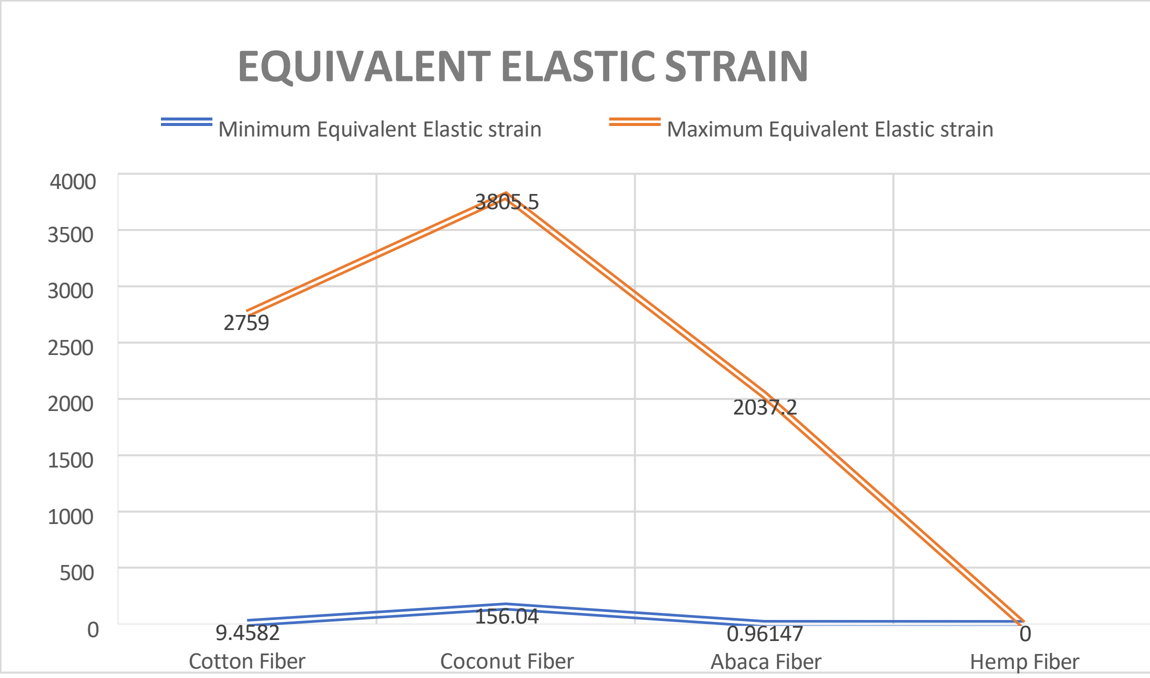


FIG: Chart of Equivalent Elastic Strain

This graph illustrates the equivalent elastic strain for different fiber types: cotton, coconut, and hemp. Abaca fiber exhibits the highest equivalent elastic strain, indicating greater deformation under stress compared to other fibers. Cotton fiber shows the lowest strain, suggesting higher stiffness and resistance to deformation. The graph also includes lines for minimum and maximum equivalent elastic strain, highlighting the range of deformation behavior for these materials.

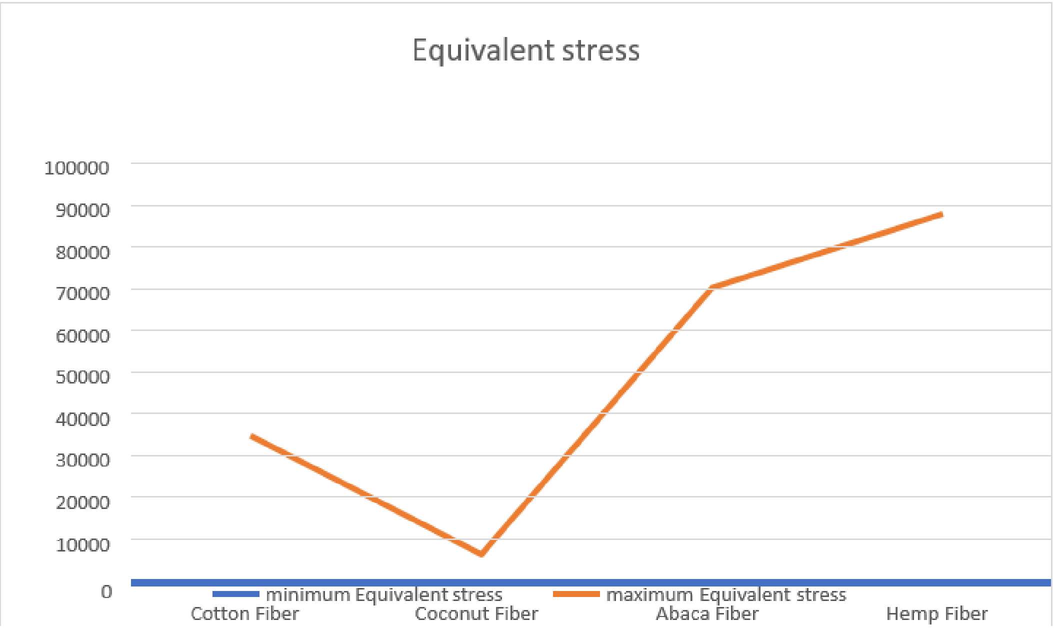


FIG: Graph of Equivalent stress

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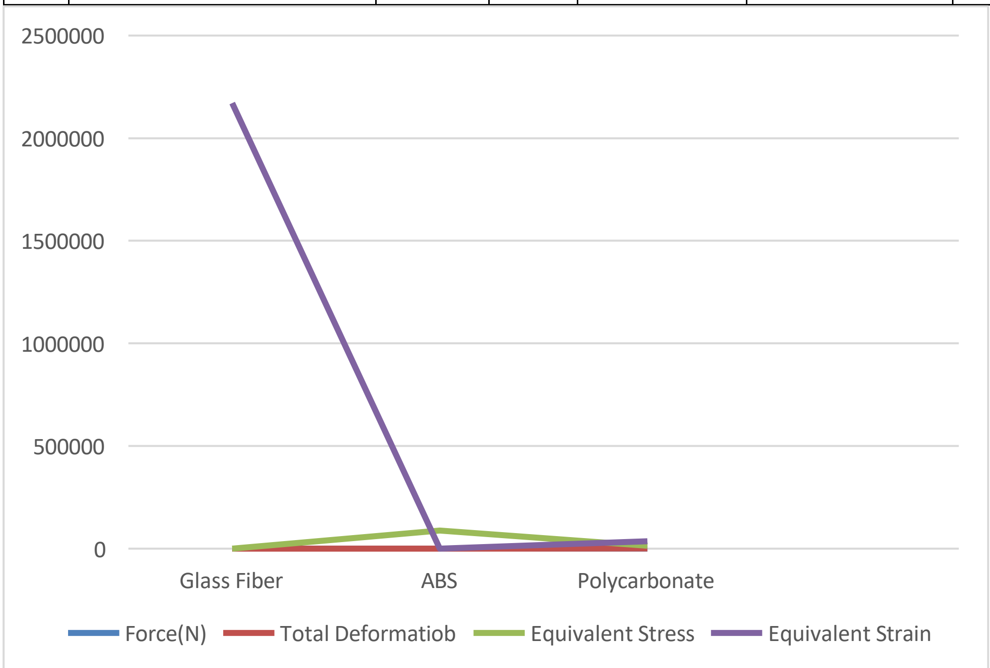
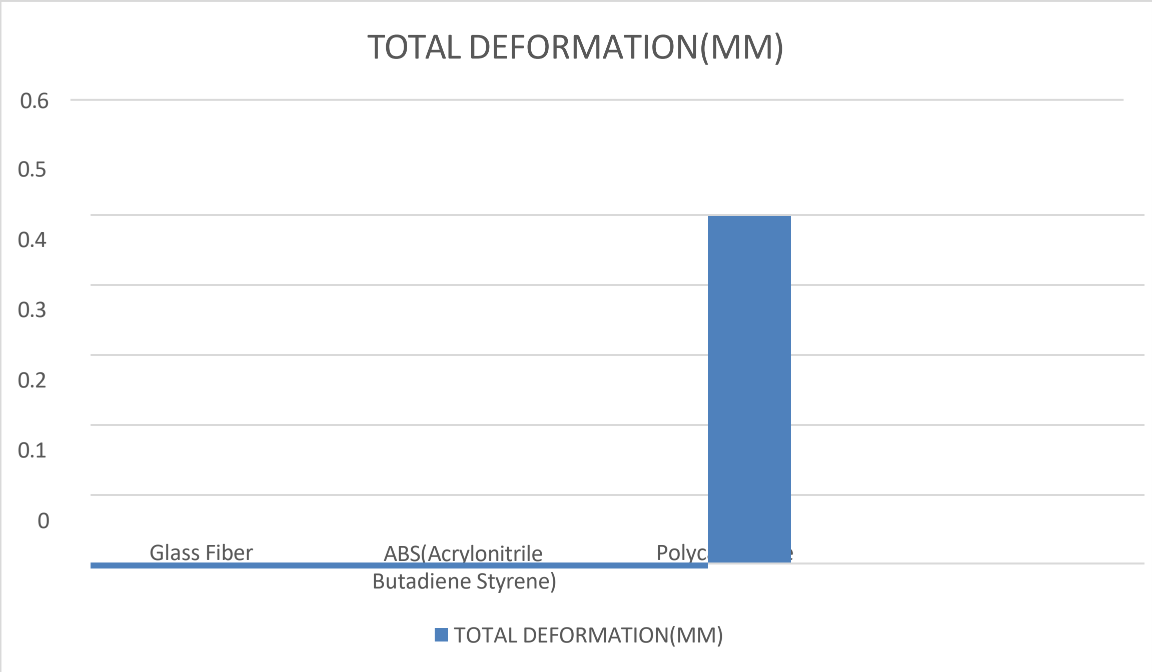
This graph illustrates the equivalent stress for different fiber types: cotton, coconut, abaca, and hemp. Abaca fiber exhibits the highest equivalent stress, indicating greater resistance to deformation under stress compared to other fibers. Cotton fiber shows the lowest stress, suggesting lower stiffness and higher susceptibility to deformation. The graph also includes lines for minimum and maximum equivalent stress, highlighting the range of stress behavior for these materials

Results Of Conventional Materials

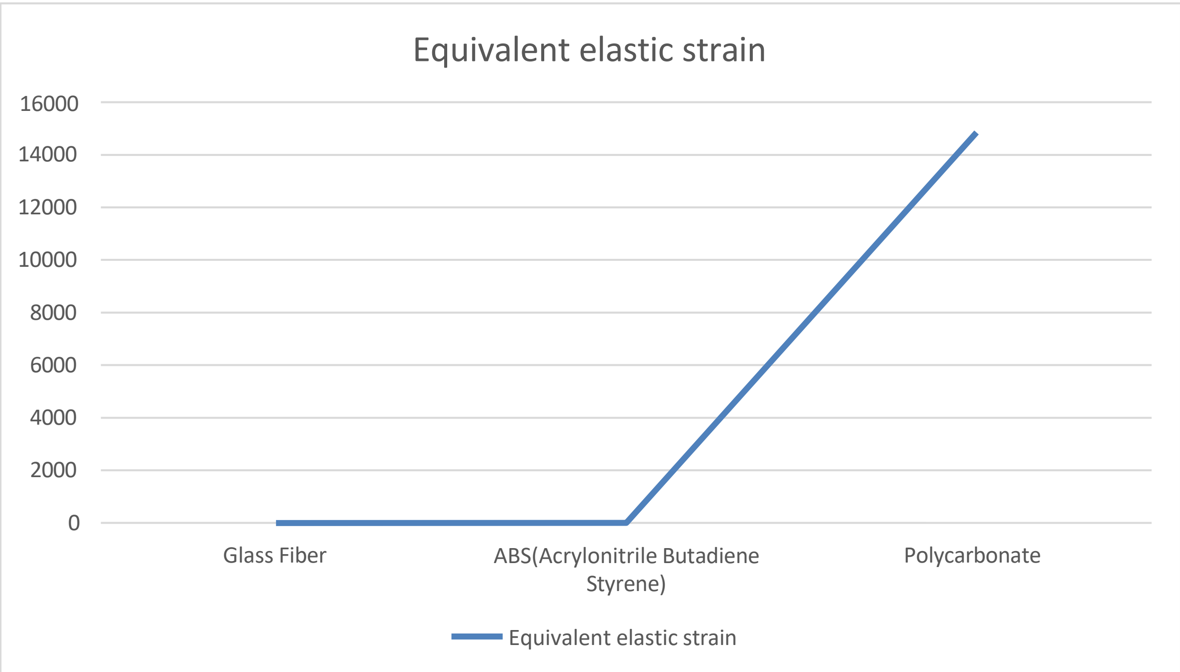
Sl no	Materials	Force (N)	Total Deformation (mm)		Equivalent Elastic strain		Equivalent stress(pa)	
			min	Max	min	max	min	max
1	Glass Fiber	250	0	0.005108	0.00066398	0.053306	9545.1	2.1709e6
2	ABS(Acrylonitrile Butadiene Styrene)	250	0	4.11e-06	2.357e-08	5.00e-05	26.014	88139
3	Polycarbonate	50	0	837.72	1.1388	14849	0.69429	35639



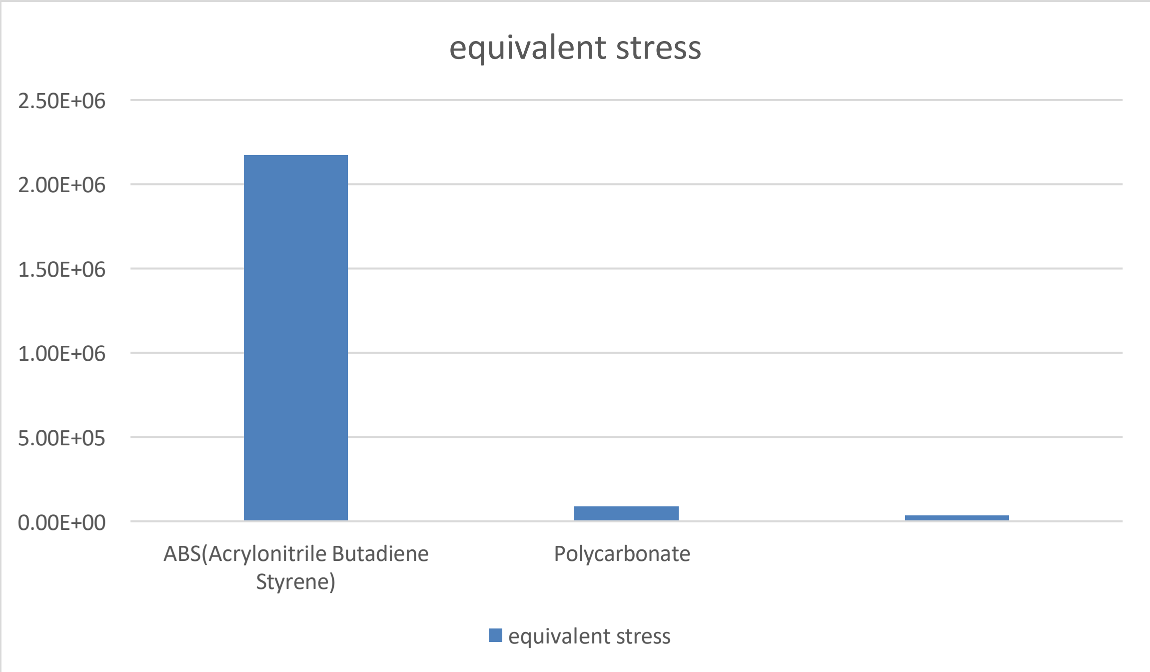
The graph illustrates the stress-strain behavior of three different materials: Glass Fiber, ABS, and Polycarbonate, under a tensile load. Glass Fiber demonstrates the highest stiffness and strength, exhibiting a linear elastic response until it fails abruptly. ABS shows a more gradual increase in strain with increasing stress, indicating some plastic deformation before failure. Polycarbonate exhibits the lowest stiffness and strength, displaying significant plastic deformation prior to failure. This analysis suggests that Glass Fiber is a brittle material, while ABS and Polycarbonate exhibit increasing levels of ductility.



The graph suggests that Polycarbonate undergoes the most significant deformation under the applied conditions, while Glass Fiber demonstrates the highest resistance to deformation. ABS falls in between these two extremes in terms of its deformation behavior.



The graph indicates that Polycarbonate experiences the most significant elastic strain under the applied conditions, while Glass Fiber demonstrates the highest resistance to elastic strain. ABS falls in between these two extremes in terms of its elastic strain behavior.



The graph indicates that Polycarbonate experiences the most significant equivalent stress under the applied conditions, while Glass Fiber demonstrates the highest resistance to stress. ABS falls in between these two extremes in terms of its stress behavior.

Conclusion:

This analysis, conducted using ANSYS software, aimed to evaluate the mechanical behavior of conventional (ABS) and non-conventional (Polycarbonate and Glass Fiber) materials for industrial safety helmets. The graphs presented depict the equivalent stress, elastic strain, and total deformation experienced by each material under a simulated impact scenario.

Key Findings:

Polycarbonate consistently demonstrated the highest values in all three parameters (equivalent stress, elastic strain, and total deformation). This indicates that while it might offer some advantages in terms of impact energy absorption, it is also more prone to deformation and stress concentration, potentially compromising the helmet's structural integrity and increasing the risk of head injury.

ABS exhibited intermediate values in all parameters, suggesting a balanced performance between strength and flexibility. It might be a suitable choice for conventional helmets,Providing a good compromise between impact resistance and deformation control.

Glass Fiber demonstrated the lowest values in all parameters, indicating the highest resistance to stress, strain, and deformation. This suggests that Glass Fiber could be a promising non-conventional material for developing lighter and more protective helmets, provided its other properties like cost-effectiveness and manufacturing feasibility are also considered.

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