Materials Economics and Sustainability

REPORT

SEAT LIGHTWEIGHTING PROJECT

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Introduction:

Automotive lightweighting is a strategy that aims to reduce the weight of vehicles.
This is crucial for improving fuel efficiency, enhancing performance, and increasing safety. By using lighter materials, optimizing designs, and improving manufacturing processes,

car manufacturers can achieve these goals. However, lightweighting also presents challenges such as higher material costs and manufacturing complexities. Despite these challenges, the benefits of lightweighting make it a vital trend in the automotive industry. As technology continues to advance, we can expect to see even more innovative solutions for reducing vehicle weight and improving overall performance.

Car seat design:

•Frame
•Foam
•Sensors and wires
•Ventilated Seats
•Harness Straps
•Buckle
•Lower anchor attachments

Dimension and weight relation:

The dimensions and weight of a car seat are interrelated. While larger car seats may offer more comfort, they also tend to be heavier. The choice of materials and design optimization can help balance these factors to create car seats that are both safe and efficient.

Importance of weight reduction:

Reducing the weight of car seats offers several significant benefits.

•Improved Fuel Efficiency

•Enhanced Vehicles Performance

•Improve Vehicles safety

Lightweighting & Pugh Analysis :

S.No.	Part	Role	Material	Weight
1.	Base Frame Assy	Provides structural support for the car seat, ensuring rigidity and stability.	Mild steel	5.782

2.	Back frame assy	Supports the backrest and helps maintain its shape under the weight of the passenger.	Mild steel	4.236
3. 4.	Slider Assy Backrest Foam	Allows for the adjustment of the seat position forward or backward. Provides cushioning and comfort for the passenger's back.	Mild steel PU foam	3.75 1.35
5.	Seat Base Foam	Offers comfort and padding for the seat base where the passenger sits.	PU foam	1.36
6.	Handrest Foam	Cushions the armrests, providing a soft surface for resting the arms.	PU foam	0.526
7.	Hand Rest Cover	Protects the foam inside the armrest and provides a finished look	Polyester	0.044
8.	Seat Base cover	Covers the foam of the seat base to protect it from wear, tear, and environmental exposure.	Polyester	0.28
9.	Backrest cover	Shields the backrest foam, adding durability and a finished appearance.	Polyester	0.458

Lightweighting suggestions:

1)First suggestion:

- The First material which we are aiming to replace is PU foam. ● It can be replaced with materials like
  - ➢ Aerogel foam
  - ➢ EPP foam (expanded poly-propylene)
- These foams are more durable and both are eco-friendly materials which can be recycled .

Pugh Analysis:

		Current - PU foam		Material 1- EPP		Material 2-Aerogel foam	
Weighting factor	Criterion	Rating	Functionality	Rating	Functionality	Rating	Functionality
10	Weight	3	30	6	60	9	90
9	Raw materials cost	8	72	7	63	3	27
5	Manufact uring cost	9	45	6	30	4	20
5	Ease of manufacturing	9	45	7	35	4	20
8	Performance	6	48	8	64	8	64
	Functiona - lity sum		240		252		221

Justification:

☐ Difference in the weight is significance in these foam:

- Density of pu foam =(48 - 961) kg/m^3
- Density of EPP foam =(28-100) kg/m^3
- Density of Aerogel foam =(10-28) kg/m^3

☐ Raw Material cost

- PU foam = Low to Moderate
- EPP foam = Moderate
- Aerogel foam = Very high

☐ Ease of manufacturing

- PU foam production is highly versatile , cost effective and widely adopted.

☐ Performance

- EPP is best in energy absorption and durability as compared to PU foam and Aerogel foam.

2)Second Suggestion:

- The Second material which we are aiming to replace is Steel frame.

- It can be replaced with materials like

  1. Aluminium Alloy
  2. Magnesium Alloy

- These foams are more durable and both are eco-friendly materials which can be recycled.

Pugh Analysis:

		Current -Steel base		Material 1 - Magnesium		Material 2 Aluminium	
Weighting factor	**Criterion**	**Rating**	**Functionality**	**Rating**	**Functionality**	**Rating**	**Functionality**
10	Weight	4	40	9	90	8	80
9	Raw materials cost	8	72	5	45	7	63
5	Manufacturing cost	9	45	6	30	7	35
5	Ease of manufacturing	9	45	6	30	8	40
8	Performance	7	56	9	72	8	64
	Functiona -lity Sum		258		267		282

Justification:

- [ ] The lower the density, the higher the rating for weight savings
    - Density of the mild steel – 7850 kg/m^3
    - Density of the Magnesium Alloy – 1738 kg/m^3 and Density of the Aluminum Alloy – 2700 kg/m^3

- [ ] Raw Material cost
    - Mild steel = (50 - 80) per kg
    - Magnesium = (200 - 300) per Kg
    - Aluminium = (600 - 1200) per kg

☐ Manufacturing cost: Based on typical machining, welding, and forming difficulty

- Mild steel – Low
- Aluminium – Moderate
- Magnesium – High
- Magnesium is high due its low melting point, fatigue, highly reactive which makes it difficult to stamp and weld. In order to do so we required specified tools like gas tungsten arc welding

☐ Ease manufacturing: Considering weldability and machining/forming ease,

- Mild steel – Ease
- Aluminium – Moderate
- Magnesium – Difficult

☐ Performance: Considering strength-to-weight ratio, fatigue resistance, and corrosion resistance,

- Mild steel - Strong, but prone to rust without treatment
- Magnesium- High strength-to-weight ratio, poor fatigue resistance and Aluminium - Good strength-to-weight ratio, excellent corrosion resistance

3)<u>Third Suggestion:</u>

- The Third material which we are aiming to replace is Back Frame Assy.
- It can be replaced with materials like
  ➢ Glass Fiber Reinforced Plastic
- As the back frame does not require to carry more load , we can replace the steel frame with GFRP as it has a good weight to strength ratio.

Pugh Analysis:

		Current - Mild Steel		Material 1 - GFRP	
Weighting factor	Criterion	Rating	Functionality	Rating	Functionality
10	Weight	4	40	9	90
9	Raw materials cost	8	72	5	45
5	Manufacturing cost	9	45	5	25
5	Ease of manufacturing	9	45	7	35
8	Performance	5	40	9	72
	Functionality sum		242		267

Justification:

☐ The lower the density, the higher the rating for weight savings

- Density of the Mild Steel – 7850 kg/m^3 ● Density of GFRP - 1800 kg/m^3

☐ Raw Material cost

- Mild Steel = (50 - 80) per kg
- GFRP = (150 - 300) per kg

☐ Manufacturing cost: Based on typical machining, welding, and forming difficulty

- Mild steel - Low
- GFRP - High
- The manufacturing process for GFRP involves more complex and costly methods such as resin infusion, curing, and mold preparation. These specialized processes increase the overall manufacturing cost.

- ☐ Ease manufacturing: Considering weldability and machining/forming ease,
  - Mild steel – Ease
  - GFRP – Moderate
  - GFRP manufacturing is more complex, involving detailed mold design, precise handling, and curing processes

- ☐ Performance: Considering strength-to-weight ratio, fatigue resistance, and corrosion resistance,
  - Mild steel - Mild steel offers good performance in terms of strength and durability but is heavier and less resistant to corrosion compared to advanced materials like GFRP
  - GFRP - GFRP has a high strength-to-weight ratio, excellent corrosion resistance, and good fatigue resistance.

Conclusion:

- EPP Foam scores the highest, being lighter, more durable, cheaper, and more environmentally friendly, though it may compromise comfort slightly compared to PU foam.
- By replacing PU foam results in reduction of weight significantly. We can't get it in figure as density of foams varies.
- By replacing mild steel with Aluminium alloy and back frame assy with Glass Fiber Reinforced Plastic the overall weight is reduced by 70% of car seat.