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Helmet-Riding to the Next Generation

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***Abstract:** A helmet is a type of head protection that is worn on the head. By decreasing the impact of a force or collision to the head, a helmet seeks to lessen the risk of significant head and brain injuries. The shell, EPS liner, Comfort liner, Cheek pads, Visor, and Retention or closing mechanism are the different sections of a helmet.*

The outer shell of a motorcycle helmet can be made lighter and more comfortable by using materials that reduce weight and absorb energy.

Metal foams are a type of cellular material that has a number of fascinating qualities, including high stiffness and low specific weight, as well as effective energy absorption. These distinct features make them suitable for a wide range of applications, from car bumpers to aircraft crash recorders.

***Keywords:** Helmet, Material Selection, CFRP, Bluetooth*

I. INTRODUCTION

The Material Selection process for a product entails taking into account a variety of factors such as the manufacturing process, the environment, availability, function, form, cost, context of usage, and other factors. The designer is expected to include all of the relevant criteria while picking materials in order to provide a favourable user experience. It might also mean swapping out the current materials for something else that offers the same or better benefits.

We've also put some extra features in our helmet. For our helmet, we've designed an app illustration that can be connected through Bluetooth. We've added a few more functions to our helmet using this technology. They are as follows:

1) *Music:* While riding, the rider will be able to listen to music with minimum sound.
2) *Navigation:* The rider will be provided instructions on how to get to his desired location. It also informs about traffic and journey time.
3) *Speed Limiter:* If the car reaches 80 mph, he will be notified, allowing him to travel safely.
4) *Call Receiver:* Using the touch sensor on the left bottom, the driver will be able to accept or deny calls.

II. METHODOLOGY AND EXPERIMENTAL WORK

Helmet shells come in a variety of materials. The most frequent material utilised in the construction of helmets is fibreglass. Kevlar, Carbon Fibre Reinforced Polymer, Polycarbonate, Nylon 6,6, ABS are some of the other materials we're looking into for determining the best material to replace fibreglass.

We used the Ashby chart to compare different properties of our chosen materials and then compare them to see which one is the best suited material to replace the current use material (Fibreglass), but we can't pick and choose which properties to compare, so the properties chosen for comparison must be those that are essential for a motorcycle helmet.

The properties which we are taking into consideration to find a substitute for fibreglass are:

1) Density vs Young's Modulus
2) Fracture Toughness
3) Hardness
4) Wear rate
5) Cost

III. CAD MODELLING / FEATURE ANALYSIS / LITERATURE REVIEW

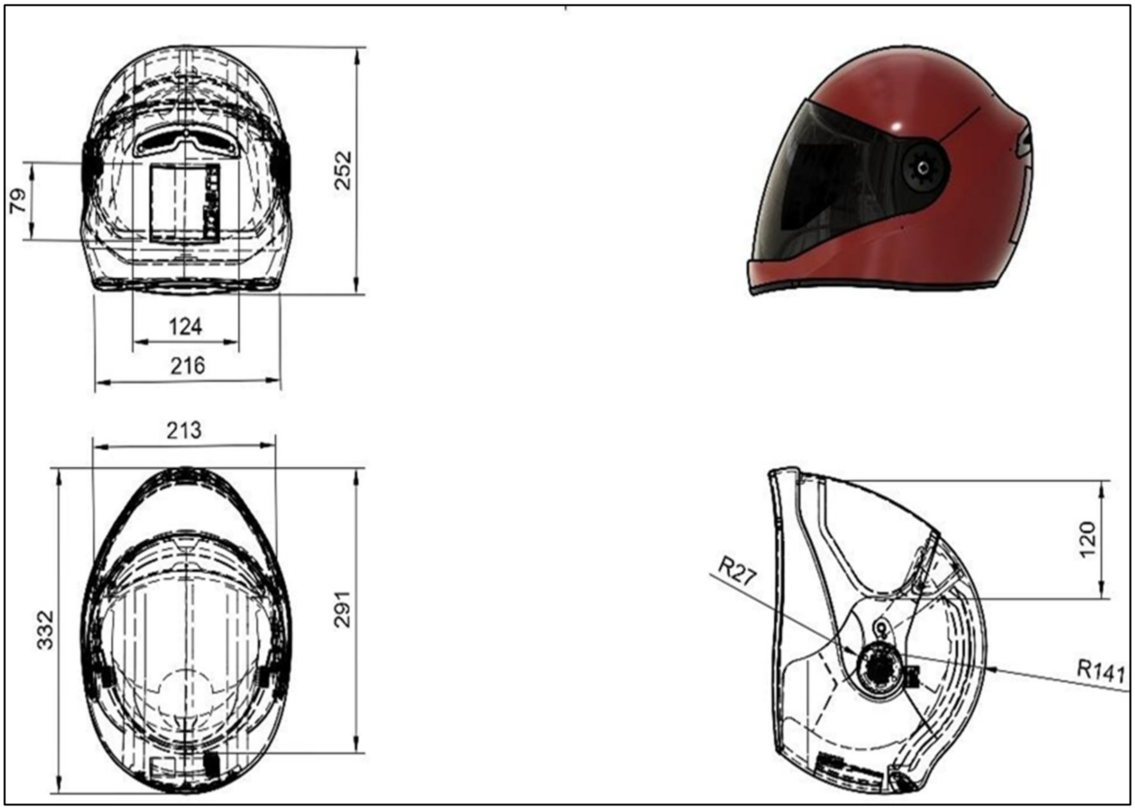

Fig1: 2D representation of helmet(top view, front view, side view)

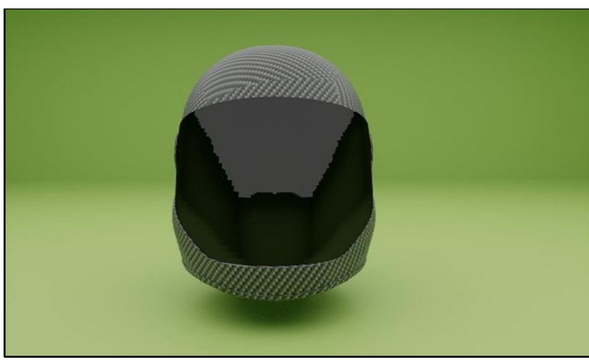

Fig 2: Front view of 3D CAD helmet model

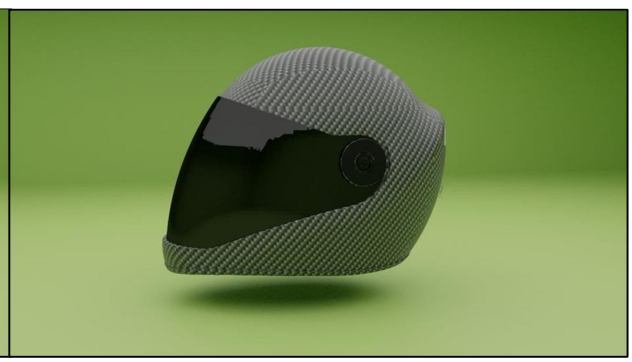

Fig 3: Side view of 3D CAD helmet model

Fig 4: Back view of 3D CAD helmet

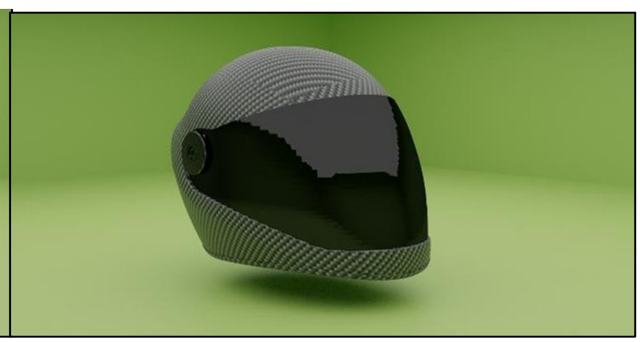

Fig 5: Isometric view of 3D CAD helmet

S.NO	MATERIALS	YOUNG'S MODULUS (E) (in GPa)	DENSITY (ρ) (in kg/m^3)	PERFORMANCE INDEX $E^{1/3}/\rho$
1	FIBRE GLASS	72	1860	2.24
2	POLYCARBONATE	2.3	1200	1.14
3	CARBON FIBRE REINFORCED POLYMER	110	1550	3.09
4	KEVLAR	76	1380	3.07
5	Nylon 6,6	2.52	1140	1.19
6	ABS	2.3	1060	1.24

Table 1: Comparing performance indexes based on Young's Modulus and Density

Because of its features like lightweight and strong strength, fibreglass is one of the most commonly utilised materials for constructing helmet shells. As a result, we may determine the rankings of other materials by using it as a reference material.

RANK	MATERIALS	YOUNG'S MODULUS (E) (in GPa)	DENSITY (ρ) (in kg/m^3)	PERFORMANCE INDEX $E^{1/3}/\rho$
	FIBRE GLASS	72	1860	2.24
1	CARBON FIBRE REINFORCED POLYMER	110	1550	3.09
2	KEVLAR	76	1380	3.07
3	POLYCARBONATE	17.45	1200	2.16
4	ABS	2.3	1060	1.24
5	Nylon 6,6	2.52	1140	1.19

Table 2: Arranging the materials based on their rank of performance indexes

From the above table, by comparing the performance indexes, it is visible that CARBON FIBRE REINFORCED PLASTIC (CFRP) is the most suitable material because of its good stiffness and light weight.

S.NO	MATERIALS	YOUNG'S MODULUS (E) (in GPa)	FRACTURE TOUGHNESS K_{Ic} (in $MPa.m^{1/2}$)	TOUGHNESS, G_c $K_{Ic}{}^2/E$
1	FIBRE GLASS	72	16	3.56
2	POLYCARBONATE	17.45	5.488	1.72
3	CARBON FIBRE REINFORCED POLYMER	110	29.32	7.81
4	KEVLAR	76	24	7.57
5	Nylon 6,6	2.52	4.34	7.47
6	ABS	2.3	1.9	1.56

Table 3 : Comparing toughness of various materials

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5	ABS	2.3	1.9	1.56

Table 4: Arranging materials in the order of their toughness

- By comparing the toughness of various materials in the table above, it is clear that CARBON FIBRE REINFORCED PLASTIC (CFRP) is the best suited material due to its great toughness.
- While CFRP has the highest toughness, Kevlar's (7.57) hardness is not far behind CFRP (7.81).

S.NO	MATERIALS	HARDNESS, H (MPa)	WEAR RATE CONSTANT K_a (1/MPa) ($x10^{-9}$)	WEAR RATE ($H \times K_a$)
1	FIBRE GLASS	4500	0.022	0.1
2	POLYCARBONATE	347	3.5	1.2145
3	CARBON FIBRE REINFORCED POLYMER	310.5	1.35	0.4194
4	KEVLAR	75	2.67	0.2
5	Nylon 6,6	90	2.85	0.2565
6	ABS	107	9	0.963

Table 5: Comparing wear rate of different materials

Rank	MATERIALS	HARDNESS, H (MPa)	WEAR RATE CONSTANT K_a (1/MPa) ($\times 10^{-9}$)	WEAR RATE ($H \times K_a$)
	FIBRE GLASS	4500	0.022	0.1
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4	ABS	107	9	0.963
5	POLYCARBONATE	347	3.5	1.2145

Table 6: Arranging materials according to their wear rates.

S. No.	MATERIALS	PERFORMANCE INDEX $E^{1/3}/\rho$	COST($/kg)	NORMALISED COST Ć ($/$)	PERFORMANCE INDEX $E^{1/3}/\rho$Ć
1	FIBRE GLASS	2.24	15		
2	POLYCARBONATE	1.14	7	0.467	2.44
3	CARBON FIBRE REINFORCED POLYMER	3.09	75	5	0.62
4	KEVLAR	3.07	6.27	0.418	7.35
5	Nylon 6,6	1.19	2.56	0.17	7.00
6	ABS	1.24	3.5	0.233	5.32

Table 7: Comparing costs of different materials

RANK	MATERIALS	PERFORMANCE INDEX $E^{1/3}/\rho$	COST($/kg)	NORMALISED COST Ć ($/$)	PERFORMANCE INDEX $E^{1/3}/\rho\acute{C}$
	FIBRE GLASS	2.24	15		
1	KEVLAR	3.07	6.27	0.418	7.35
2	Nylon 6,6	1.19	2.56	0.17	7.00
3	ABS	1.24	3.5	0.233	5.32
4	POLYCARBONATE	1.14	7	0.467	2.44
5	CARBON FIBRE REINFORCED POLYMER	3.09	75	5	0.62

Table 8: Arranging materials in the order of their Performance Indexes when cost is included

From the previous table, CFRP came out to be the best material in terms of weight and stiffness. But, after considering the cost, Kevlar came out to be the best material.

IV. COST ANALYSIS

The different parts of our helmet include cheek pads, visor, shell, EPS lining, Comfort lining etc

PART	COST(RUPEES)
CHEEK PADS	Rs. 350
VISOR	Rs. 25
OUTER SHELL	Rs.200
COMFORT LINING	Rs.100
EPS LINING	Rs. 75
TOTAL COST(Manufacturing)	Rs. 750

Fig 5: Cost analysis table helmet of the helmet

V. ADDITIONAL FEATURES OF OUR HELMET: APPLICATION ILLUSTRATION

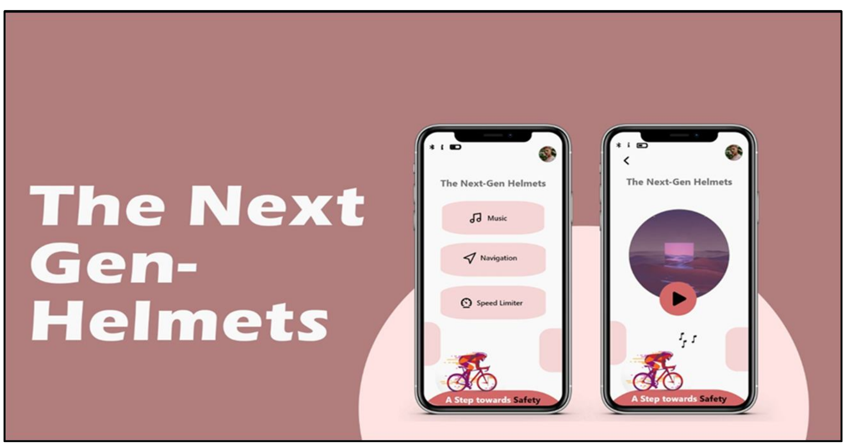

Fig 6: App demonstration of various features(Home page and music)

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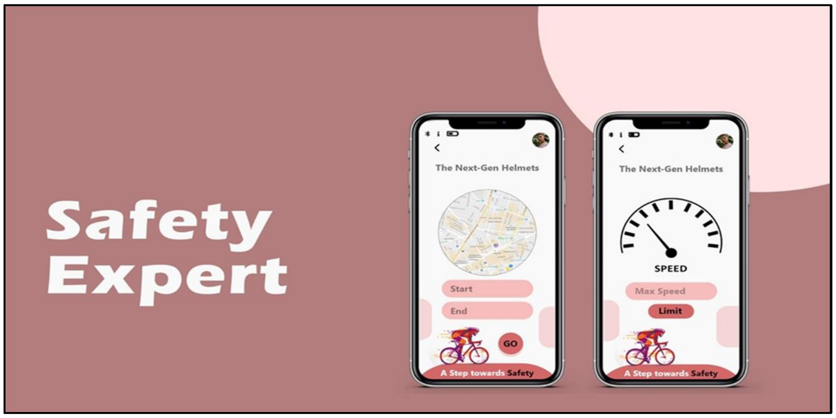

Fig 16: App demonstration of various features(map and speed limiter)

VI. RESULT AND DISCUSSION

A. *From Table 1*

1) When comparing the performance indices, it is clear that CARBON FIBRE REINFORCED PLASTIC (CFRP) is the most suitable material because of its good stiffness and light weight.
2) When comparing the performance indices, it is clear that CARBON FIBRE REINFORCED PLASTIC (CFRP) is the most suitable material because of its good stiffness and light weight.

B. *From Table 3*

1) When evaluating the toughness of various materials, it is clear that CARBON FIBRE REINFORCED PLASTIC (CFRP) is the best option due to its great toughness.
2) Although CFRP has the highest toughness, Kevlar's (7.57) toughness is not much lower than CFRP's (7.81).

C. *From Table 5*

1) When comparing the WEAR RATE, it is clear that KEVLAR is the most appropriate material due to its HIGHEST RESISTANCE TOWARDS WEAR AND TEAR UNDER SIMILAR CIRCUMSTANCES.
2) NYLON 6,6 and CFRP are ranked 2nd and 3rd, respectively, behind KEVLAR.

D. *From Table 7*

1) When comparing the COST, it is clear that KEVLAR is the most suited material due to its HIGHEST PERFORMANCE INDEX WHEN NORMALISED COST IS TAKEN INTO CONSIDERATION, as shown in Table-7.
2) NYLON 6,6 and ABS are ranked 2nd and 3rd, respectively, after KEVLAR.

We derive Young's Modulus – Density, Fracture Toughness – Density, and Wear rate – Hardness by comparing all the tables.

Test \ Material	Polycarbonate	Nylon 6,6	ABS	Carbon Fiber Reinforced Polymer	Kevlar
Young's Modulus – Density	3rd	5th	4th	1st	2nd
Fracture Toughness-Density	4th	3rd	5th	1st	2nd
Wear rate- Hardness	5th	2nd	4th	3rd	1st
Cost	4th	2nd	3rd	5th	1st

Table 9: Summary of analysis of various properties

VII. CONCLUSION

In this work, we attempted to design a helmet made of a superior material to replace fibreglass, as well as to combine new functionality via a Bluetooth connecting device. Due to its low weight, high rigidity, strongest resistance to wear rate, and low cost, Kevlar was determined to be the optimum material for the job. Bluetooth headset, touch sensor to receive and deny calls, navigations with directions and traffic information, and a speed controller are among the extra features included to improve the rider's safety and security. Because of its additional benefits not seen in traditional helmets, this helmet would be highly valuable for future generations.

Our model's future scope of improvement would be to produce a long-lasting battery so that the user does not have to constantly charge it. Other features may be added, such as a riders tiredness detection system that alerts the user if someone is attempting to steal the helmet, and a locking system for the motorbike.

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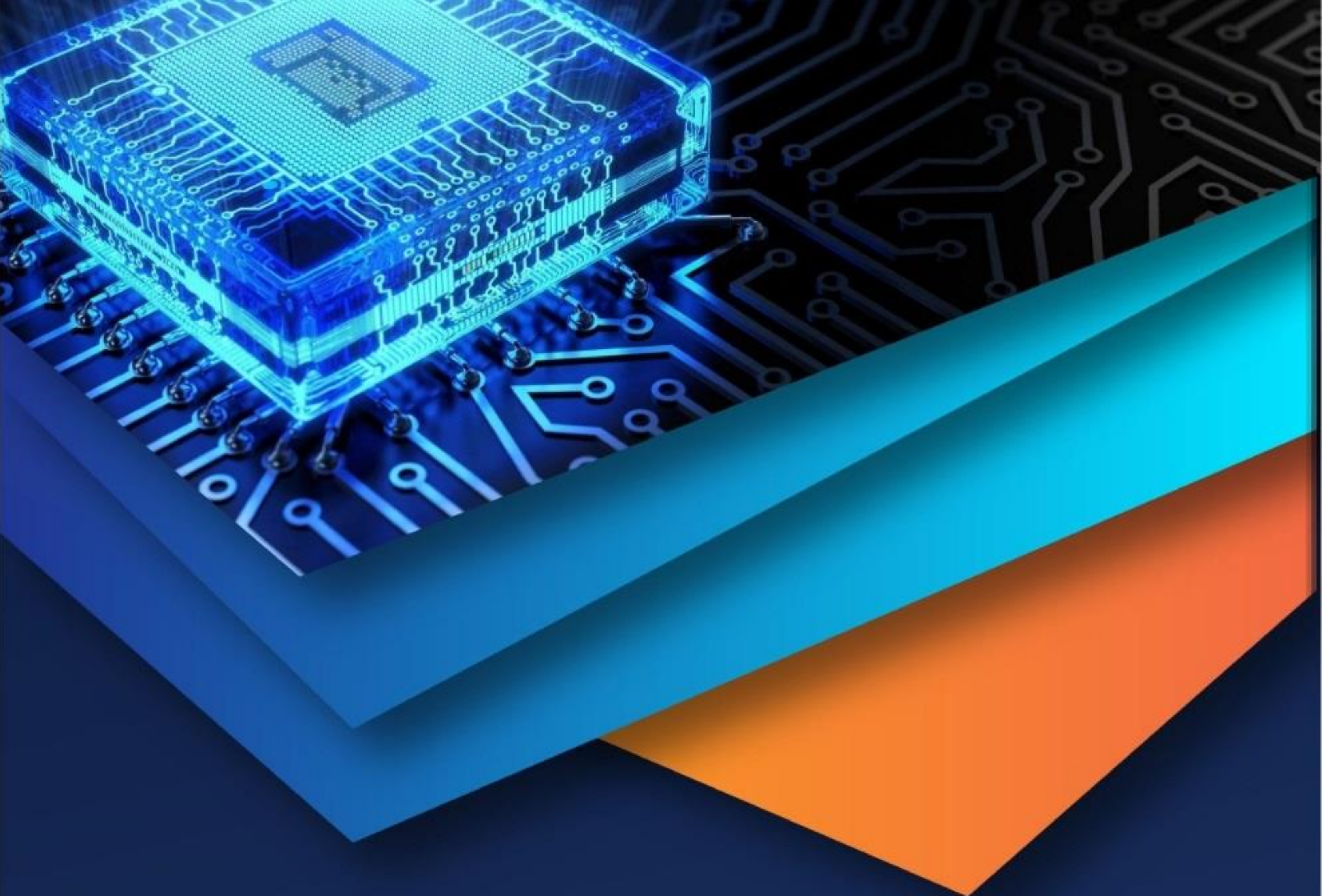

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