Exploring Consumer Perspectives: The Market Viability and Applications of Multifiber Reinforced Acrylonitrile Butadiene Styrene (ABS) Composite in India's Advanced Engineering, Tooling, And Electric Vehicle Industry with Additive Manufacturing

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Abstract

This study delves into the relationship between consumer awareness of additively manufactured multifiber reinforced acrylonitrile butadiene styrene (ABS) Composite and their perception of its potential applications in various industries. It examines the market viability and applications of this material in India's advanced engineering, tooling, and electric vehicle industries with additive manufacturing. A systematic questionnaire was sent out to 200 respondents to obtain primary data, while secondary data came from a variety of reputable sources. Hypotheses were tested and the data was analyzed using statistical methods, such as regression and correlation. The results show that there is a strong relationship between customer knowledge and how they see its use in electric cars, sophisticated engineering, and tooling. Furthermore, the study emphasizes that in order to increase market acceptability and adoption of acrylonitrile butadiene styrene (ABS) composite, it is crucial to address consumer concerns and hurdles. These results show substantial increases in mechanical qualities, which is in line with earlier studies on post-processing approaches for additive manufacturing. Consumers' views have a significant impact on the multifiber reinforced acrylonitrile butadiene styrene (ABS) composite's commercial potential and industrial uses in India, according to the study.

Keywords: Consumer perspective, Market Viability, Advanced Engineering, Electric Vehicle, Additive Manufacturing, Acrylonitrile butadiene styrene (ABS)

1. Introduction

Innovation has been fuelled by the enormous developments in additive manufacturing in recent years, which have disrupted the sector and fuelled innovation. In light of the booming Indian market for state-of-the-art engineering, tools, and electric vehicles, it is crucial to examine the potential for and uses of additively made multifibre reinforced acrylonitrile butadiene styrene (ABS) composite (Wong and Hernandez,2012). The additive manufacturing technology, also known as 3D printing, is causing a massive change in the production and design of goods. An unparalleled level of design flexibility, precision, and efficiency is made possible by building three-dimensional things from digital design data layer by layer. A promising new direction in this dynamic area is the application of multifibre-reinforced ABS composites. The enhanced material properties, reduced weight, and expanded range of applications, these composites—made from a mix of ABS and reinforcing fibers—have the ability to radically change several sectors. The autopsy is positioned in an exciting environment by the thriving Indian market, particularly in the areas of advanced engineering, complex tooling, and electric cars. In India's fight for sustainable transportation—a movement that seeks to lessen the country's influence on the environment and its need on foreign oil—electric cars are gaining

prominence. The nation's innovation and competitiveness on the global stage depend on state-of-the-art engineering and technology (Huang, et. al., 2013).

1.1 Additive Manufacturing

Additive Manufacturing (AM), also known as 3D printing, is a game-changing manufacturing technique that has completely altered the product development process. AM constructs three-dimensional items layer by layer from digital design data, in contrast to conventional subtractive manufacturing procedures, which entail cutting or shaping material from a solid block. By building out an object layer by layer, designers are given more leeway in terms of design, personalization, and the ability to realize complicated geometries that would otherwise be difficult or impossible to realize (Romberg, et. al., 2019). Polymer AM has come a long way in the last several decades, but it is still far from being a viable option for producing finished products due to issues with material characteristics, production speed, and part size. When combined with polymer-based AM, carbon fiber's low density, low coefficient of thermal expansion, and excellent thermal conductivity make it an attractive material for expanding the capabilities of fused filament fabrication (FFF) manufacturing. When compared to traditional subtractive manufacturing methods, the time and effort needed to produce functional components can be drastically reduced when carbon fiber is used in AM's build process. Additionally, carbon fiber can help prevent warping, allowing for a more expansive build volume (Van de Werken, et. al., 2020). AM is a well-known technique for producing genuine three-dimensional objects, made of metal, ceramic, plastic, or a mix thereof, which may be cast to a wide range of uses. Research into making additive bio-manufacturing (ABM) techniques safer and more versatile is in high demand. To expand their usefulness and adaptability, researchers must focus on creating novel materials with improved durability, bioactivity, cell development, and mechanical qualities. This study's purpose is to summarize the most popular AM methods currently being used in the medical field. Because of its low cost, low impact on the environment, and flexibility concerning flexible filament material, the Fused Deposition Modelling (FDM) based AM technique has received a lot of interest (Bikas, et. al., 2016).

Additive manufacturing's guiding principles

i.Layer-by-Layer Deposition: Additive manufacturing works by adding layers of material in successively thinner cross-sections. After being carefully poured or cured, each layer is layered over the next to form the final product.

ii. Digital Design and CAD Modeling: The procedure kicks off with the development of a 3D model in Computer-Aided Design (CAD) software. The information included in this file be ultimately used to create the real thing. CAD files are transformed into stereolithography (STL) files for use in additive manufacturing methods. The CAD drawing is then roughly represented by triangles and "sliced" to include information about each layer that will be printed.

iii.Industrial and Commercial Applications: AM has evolved from its prototype roots to find widespread application across many sectors, including aerospace, automotive, healthcare, consumer products, and more industries. It is used for manufacturing finished goods, manufacturing tools, and even bioengineering tissues and organs.

iv. Customization and Complexity: With AM, it's simple to alter a product's appearance or functionality to suit specific needs. Intricate and sophisticated structures, such as those with internal channels and lattices, can be manufactured with this method (Singh, et. al., 2017).

1.1.1 Multifiber Reinforced ABS Composite: Definition and Properties

The most popular material for 3D printing is acrylonitrile-butadiene-styrene (ABS). The composite material presented herein makes use of both carbon and glass fibers as reinforcements in an ABS matrix. Mechanical characteristics and molding performance are two of ABS's many applications. Its

potential applications are constrained by its low-temperature resistance and poor mechanical performance when compared to other polymers. The term "multifiber reinforced ABS composite" is used to describe composites fabricated by fusing ABS thermoplastic with a variety of reinforcing fibers. The purpose of this composite material is to increase the mechanical and structural qualities of the material by combining the advantages of ABS and the reinforcing fibers (Olivera, et. al., 2016). Key definitions and features of multifiber-reinforced ABS composites are as follows:

Acrylonitrile Butadiene Styrene (ABS): ABS, or acrylonitrile butadiene styrene, is an engineering plastic in which the acrylonitrile and styrene molecules are interspersed with butadiene molecules. It is inexpensive and has high toughness, dimensional stability, processing ease, chemical resistance, and corrosion resistance. However, it has inherent weaknesses in mechanical strength and is susceptible to environmental conditions. What's more, it doesn't conduct electricity and frets easily. Metal plating applied to ABS can improve its strength, structural integrity, durability, and thermal resistance. ABS is said to be the best material for plating since it can have a metal coating deposited on it using a chemical pretreatment process without requiring any mechanical abrasion (Arnold,2004). Properties of ABS: The monomers acrylonitrile, butadiene, and styrene are systematically polymerized to create ABS, as depicted in Figure 1.
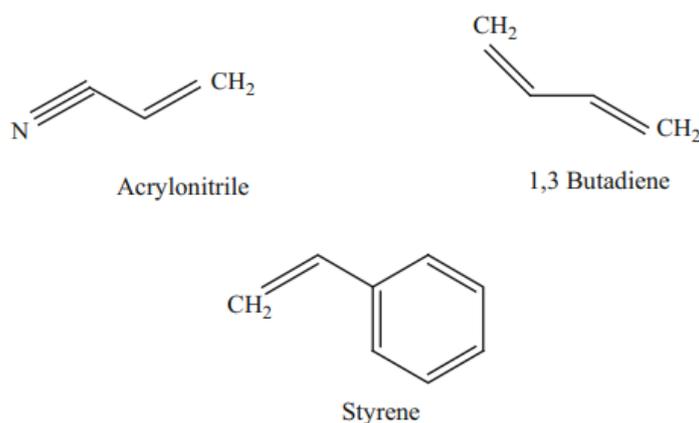

Figure 1. ABS monomer units

ABS is a terpolymer made up of two different types of molecules, as seen in Figure 2 (a), (b) a continuous styrene-acrylonitrile (SAN) phase, and a scattered polybutadiene phase. In terms of impact strength, surface gloss, and thermal distortion, commercially available ABS grades range from moderate to high (Hart and Wetzel, 2017).
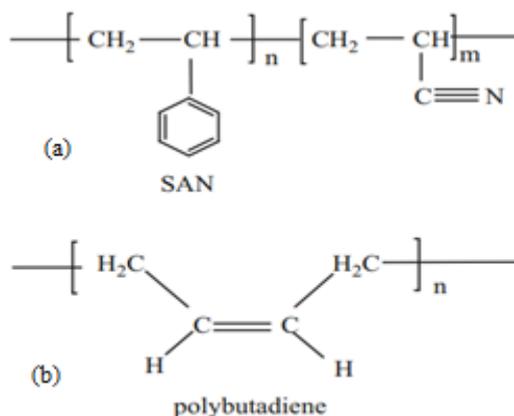

Figure 2. (a) SAN phase of ABS. (b) The butadiene rubber phase of ABS

ABS polymers are resistant to chemical assault and environmental stress cracking, as well as being strong, rigid, thermally stable, and exhibiting good mechanical strength (Kumara, et. al., 2020).

Multifiber Reinforcement: To improve the ABS matrix's mechanical qualities, multifiber reinforcement can be used. This entails incorporating many fiber types into the matrix. These fibers can be fabricated from a wide variety of materials, including glass, carbon, aramid (Kevlar), and composites. Use fiber materials, such as coconut coir, and carbon fibers, in large-scale applications without causing damage to the environment, including the building of reinforced concrete structures related to the process of percolation (Nguyen, et. al., 2019).

Properties of Multifiber Reinforcement: The composite's performance characteristics are highly sensitive to the reinforcing fibers used. Stronger, stiffer, and more resistant to impact are just some of the typical outcomes of multifiber reinforcement. The specific properties are determined by the fiber type, fiber orientation, and fiber volume fraction. Fibers are elastic and can be stretched. Together, they form a solid unit. They are less flammable and have a high abrasion resistance. They retain their form, elasticity, and resilience in the face of stretching. A high ratio of length to width characterizes fiber (Butler, et. al., 2018).

1.2 Advanced Engineering and Tooling

Modern industries depend heavily on advanced engineering to foster innovation, efficiency, and competitiveness. Here are some crucial areas where modern engineering methods and tools are having a big impact on a range of industries:

• Materials Science and Engineering: Product development is made possible by the development of advanced materials, such as superconductors, composites, and high-performance alloys. The development of improved materials with distinctive properties is made possible by nanomaterials and nanotechnology. Applications for intelligent materials that can react to outside stimuli include sensors, actuators, and adaptable structures (Riedl, 2019).

• Artificial Intelligence (AI) and Machine Learning: Algorithms developed using AI can improve efficiency, forecast when machinery will break down, and enable proactive servicing. Automatic learning improves such processes as quality assurance, pattern recognition, and choice-making. Support for customers can be greatly enhanced by AI-powered chatbots and virtual assistants. Artificial intelligence (AI) refers to the study and development of algorithms that perform actions or exhibit behaviors that would logically be deemed to require intelligence if a human were performing them. "Machine learning" (ML) refers to a specific approach to developing smart systems that involve the system based on data and modify its behavior accordingly. The recent boom in the commercialization of AI can be attributed largely to the efficacy of machine learning algorithms (Ngo, et. al., 2018).

• Additive Manufacturing (3D Printing): Quickly prototyping and mass-producing complex, individual parts are now possible with additive manufacturing. Lighter, more efficient designs are possible with 3D printing, which is used in industries such as aerospace, healthcare, and automotive. The main advantages of additive manufacturing (AM) or 3D printing are the flexibility of design, the ability to mass-customize, the reduction of waste, the ability to manufacture complex structures, and the speed of prototyping. AM's revolutionary potential in the fields of medicine, aerospace, construction, and security was discussed. Metal alloys, polymer composites, ceramics, and concrete were shown to illustrate the current state of materials development.

1.3 Evolving Electric Vehicle Market in India

The widespread adoption of renewable energy sources is facilitated by electric vehicles, which also reduce reliance on fossil fuels and the effects of ozone-depleting substances. Electric vehicle production and network modeling remain fluid and constrained despite extensive research on the attributes and characteristics of electric vehicles and the nature of their charging infrastructure.

Electric vehicles (EVs) are emerging as a viable means of addressing air pollution, energy stability, and economic growth in India considering the country's rapidly expanding automobile market. When a large amount of renewable energy generation is intermittent, a flexible load like an electric vehicle can help keep the grid stable (Kempton and Tomić,2005). The electric motor is what makes the electric vehicle possible; it draws power from the battery pack. When charged by renewable energy sources, electric vehicles become more eco-friendly. The electricity from the grid is used to charge the cells. The battery's primary role is to supply energy to the electric car, allowing it to function. Lithium-ion batteries are commonly used in EVs because of their high energy density and low weight minimal maintenance, etc. Compared to nickel-metal hydride and lead-acid batteries, the cost of producing Li-ion batteries is higher batteries (Goel, et. al., 2021).

The current study endeavours to investigate the dynamics, challenges, and potential of the additively produced multifibre reinforced ABS composites business in India from the consumer's point of view. It delves into the intricate web of interplay between technology, consumer demand, and government oversight to clarify the viability of introducing these cutting-edge materials to the Indian market. Transportation, healthcare, and consumer products are just a few of the many potential areas of application explored in this study. The possibilities for multifibre reinforced ABS composites to enhance product performance, provide novel concepts, and address multiple issues are explored in this study. The most common material for 3D printing is ABS, which stands for acrylonitrile, butadiene, and styrene.

The paper is divided into eight sections. Section 1 provides a brief introduction to the subject. An explanation of the evaluations of previous studies by various authors can be found in Section 2. Section 3 illustrates the objectives of the study. In Section 4, the research methodologies utilized for the investigation are described. In Section 5, the results are explained. In Section 6, the discussion and findings are presented. Section 7 comprises the conclusions and section 8 demonstrate implications, limitations, and recommendations for future research. Finally, references are presented.

2. Literature review

In the light of changing consumer preferences, Andrew, and Dhakal, (2022) stated that the most up-to-date biobased composite materials covered AM (Additive Manufacturing) methods, fused filament synthesis, environmental impacts, and uses, and supplied crucial details for high-performance uses. Kant, R., et. al., (2022) also discuss the worldwide environmental catastrophe that increased the need for environmentally friendly polymers and polymeric composites; the study addresses the methods, procedures, and materials involved in their manufacturing. Focusing on Zheng, P., et. al., (2019) review of Smart Product-Service Systems (SPS) which drew attention to issues like sustainability, IT infrastructure, human-centric views, and circular lifecycle management to address a gap in the current state of the art. Aheleroff, S., et. al., (2021) also explored a reference architectural model and Industry 4.0 technologies with a focus on mass personalization and the conversion of wetlands into apps utilizing digital twins.

Supporting Aheleroff, Lim, K. Y. H., et. al., (2020) stated that Digital twins (DT) made intelligent decision-making and real-time working circumstances possible, attracting interest for Industry 4.0. The study examined the advantages of DT, listed eight potential future uses, and laid out a road map for its advancement and implementation in both academic and business settings. With respect of the need of additive manufacturing Kleer and Piller, (2019) examined how additive manufacturing (AM) affected customer welfare, market structure, and competitive dynamics, drawing attention to the compromise between efficiency in central facilities and that of local production. Tofail, S. A., et. al., (2018) stated that the multi-use additive manufacturing (AM) process-built structures one layer at a time into the precise forms required by a wide range of industries. The transformation of AM into usable goods, however, faced obstacles. To support the argument, Kunovjanek, M., et. al., (2022) examined one thousand four hundred articles concerning supply chain additive manufacturing (AM),

illuminating developments, advantages, disadvantages, and possible uses. In addition, it unveiled where the literature was lacking and suggested avenues for future study. Eyers, D. R., & Potter, A. T. (2017) oversaw the implementation of AMS in commercial production settings, defined a four-part AMS for industrial use, and saw strategic possibilities.

Öberg, C. (2019) analyzed the effects of additive manufacturing's power struggle on design and supply chain operations. The study drew on information from 620 professionals in the field to shed light on the supply chain's disruptive nature and the power imbalances caused by indirect parties. Huang, X., & Ge, J. (2019) observed that Attitude, cognitive state, product perception, and incentive policy measures all played a role in favorably affecting consumer intentions, which is why the Chinese government actively encouraged the use of electric vehicles in Beijing. Hardman, S., et. al., (2018) investigated Customer preferences were focused on the placement of plug-in electric vehicle (PEV) charging infrastructure, with an emphasis on home, workplace, and public spaces. The policy had ramifications and implied further work toward convenient charging access and administration. In support, Kumar and Alok, (2020) analyzed that legislators were provided with insights from 239 articles on electric automobiles, which highlighted aspects such as total cost of ownership, marketing tactics, dealership experience, and the robustness of charging infrastructure.

Liao, F., et. al., (2017) reviewed the research agenda that was presented for enhancing EV consumer studies, economic and psychological techniques were compared, and the focus was on customer preferences for electric cars (EVs). Around the world, 55% of new car sales were projected to be electric by 2040, due to technological advancements, investments in the automotive industry, and government programs. To achieve efficient charging and lower emissions, investments in infrastructure were necessary as per Jones, P. B., (2018). On the other hand, Loengbudnark, W., (2022) examined various factors that influenced the adoption of electric vehicles in Australia, focusing on EVs powered by batteries and hydrogen fuel cells. The results demonstrated that the following factors influenced the intent to adopt age, method of transportation, range sufficiency, battery charging time, distrust of hydrogen explosions, and safety concerns. A preference for BEVs (Battery Electric Vehicle) was observed among part-time workers and FCEVs (fuel Cell electric Vehicle) were favored by apartment dwellers. Government and utility assistance boosted sales of electric vehicles by 2.6% in the US, suggesting that incentives played a role in influencing their adoption. The effectiveness of incentive schemes depends on two factors: the availability of HOV lanes and the level of customer knowledge according to Jenn, A., et. al., (2018). In support, Rezvani, Z., et. al., (2018) revealed that consumer's normative, hedonic, and gain-oriented motives had a profound impact on their pro-environmental behavior, particularly among individuals with strong social standards. This indicated that it would have been more successful to communicate those reasons specifically. Also, Degirmenci and Breitner, (2017) focused on the influence of environmental performance on EV buyers' attitudes and intents to buy was discovered to outperform both price value and range confidence as predictors of attitude and intent to buy.

3. Objectives of the study

i. To Evaluate the level of awareness and perception among consumers regarding additive manufactured Multifiber Reinforced ABS Composite and its potential applications in advanced engineering, tooling, and electric vehicles.

ii. To Investigate the barriers or concerns consumers may have in accepting and adopting products featuring the composite material.

Methodology and Data

"Exploring Consumer Perspectives: The Market Viability and Applications of Multifibre Reinforced ABS Composite in India's Advanced Engineering, Tooling, and Electric Vehicle Industry with Additive Manufacturing" was determined using a combination of primary and secondary data

gathering approaches. The electric vehicle (EV) market and composite material applications in India's automotive sector data is derived from a structured questionnaire that has been utilized for stratified random sampling. Demographic considerations and research variables (i.e.,) informed the questionnaire's development. Two hundred customers were polled with the questionnaires. A variety of "websites, Newspapers, Articles, and various Internet Media and other reliable sources" provided the study's secondary data. The research method used was a cross-sectional study. The data has been analyzed using Excel and SPSS. The study's hypothesis has been tested using statistical approaches including regression, correlation, standard deviation (SD), and mean.

4. Results

Table 1: Demographic Characteristics

Sr. No.	Demographic Characteristics	Category	N	%
1	Gender	Male	123	61.5%
		Female	77	38.5%
2	Age	18-24 years	49	24.5%
		25-34 years	43	21.5%
		35-44 years	56	28.0%
		Above 45 years	52	26.0%
3	Type of Residence	Urban	70	35.0%
		Semi-Urban	62	31.0%
		Rural	68	34.0%
4	What is your primary occupation or field of work?	Service	40	20.0%
		Business	43	21.5%
		Professional	49	24.5%
		Artist	33	16.5%
		Other	35	17.5%
5	In which industry segment are your working?	Education industry	32	16.0%
		Healthcare industry	24	12.0%
		Engineering industry	22	11.0%
		Retailing	32	16.0%
		Manufacturing	28	14.0%
		Logistics	35	17.5%
		Other	27	13.5%
6	In which region of India do you currently reside?	North	46	23.0%
		South	29	14.5%
		East	42	21.0%
		West	46	23.0%
		Central	37	18.5%
7	Do you currently own a 4-wheeler?	Yes	106	53.0%
		No	94	47.0%
8	Do you currently own a 2-wheeler?	Yes	109	54.5%
		No	91	45.5%

9	Have you ever used or encountered products made from advanced composite materials in your daily life?	Yes	79	39.5%
		No	121	60.5%

Table 1 shows the Demographic Characteristics of the respondents in the context of their Gender, Age group, Residence, Occupation, Industry Segment, Location, 2-wheeler,4 wheeler, and Usage of encountered products. According to Table 1, out of 385 respondents, 61.50% are male and 38.50 % are females. The maximum number (56) of respondents are from the age group of 35-44 years, i.e., 28.00%". The greatest figure (70) of respondents resides in Urban areas i.e., 35.00%. The further table shows that the primary occupation of the maximum number (49) of respondents is professional i.e., 24.50%, and the maximum number (35) of respondents work in logistics, i.e., 17.50%. The table also shows that the maximum number (46) of respondents live in two regions, that are North and west i.e., 23% and the maximum number (106) of respondents owns 4-wheeler i.e., 53.0% and maximum number (109) of respondents owns 2- wheelers i.e.,54.50% and the maximum number (121) of respondents do not have used the product i.e.,60.5%.

H0: There is no significant relationship between the level of consumer awareness regarding additive manufactured Multifiber Reinforced ABS Composite and their perception of its potential applications in advanced engineering, tooling, and electric vehicles.

H1: There is a significant relationship between the level of consumer awareness regarding Additively Manufactured Multifiber Reinforced ABS Composite and their perception of its potential applications in advanced engineering, tooling, and electric vehicles.

Table 2: Descriptive Statistics

Descriptive Statistics			
	Mean	Std. Deviation	N
Level of awareness regarding ABS Composite	17.5600	3.81433	200
Perception of Potential Applications (in advanced engineering, tooling, and electric vehicles)	15.9900	4.63111	200

The above table 2 defines the descriptive statistics of the Level of awareness regarding ABS Composite and Perception of Potential Applications (in advanced engineering, tooling, and electric vehicles). The mean score of Level of awareness regarding ABS Composite is 17.56 whereas the score of Perception of Potential Applications (in advanced engineering, tooling, and electric vehicles) is 15.99.

Table 3: Correlations

Correlations		Level of awareness regarding ABS Composite	Perception of Potential Applications (in advanced engineering, tooling, and electric vehicles)
Level of awareness regarding ABS Composite	Pearson Correlation	1	.313**
	Sig. (2-tailed)		.000
	N	200	200
Perception of Potential Applications (in advanced engineering, tooling, and electric vehicles)	Pearson Correlation	.313**	1
	Sig. (2-tailed)	.000	
	N	200	200
**. Correlation is significant at the 0.01 level (2-tailed).			

The above table 3 defines the correlation between the Level of awareness regarding ABS Composite and Perception of Potential Applications (in advanced engineering, tooling, and electric vehicles), they are statistically significantly correlated between the Level of awareness regarding ABS Composite and Perception of Potential Applications (in advanced engineering, tooling, and electric vehicles) because the sig value is 0.000 (i.e., the sig value is less than 0.05).

H0: Consumer concerns and barriers significantly do not impact the acceptance and adoption of products featuring Additively Manufactured multifiber-reinforced ABS Composite.

H2: Consumer concerns and barriers significantly impact the acceptance and adoption of products featuring Additively Manufactured multifiber-reinforced ABS Composite.

Table 4: Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.316ᵃ	.100	.095	3.59040
a. Predictors: (Constant), Consumer Concerns and Barriers regarding ABS Composite				

Table 4 defines the model summary, indicating a significant degree of connection. The "R-value for the simple correlation is 0.316", which reflects how much of the overall variance in the dependent variable, Consumer Concerns and Barriers regarding ABS Composite, the independent variable can be used to explain the results.

Table 5: Anova

ANOVAᵃ					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	283.110	1	283.110	21.962	.000ᵇ
Residual	2552.410	198	12.891		
Total	2835.520	199			
a. Dependent Variable: Accepting and Adopting Products Featuring the Composite Material					
b. Predictors: (Constant), Consumer Concerns and Barriers regarding ABS Composite					

The above table is the "ANOVA table 5, which reports how well the regression equation fits the data (i.e., predicts the dependent variable). This table indicates that the regression model predicts the dependent variable significantly well. This indicates the statistical significance of the regression model 0.000, which is less than 0.05, and indicates that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it is a good fit for the data)".

Table 6: Coefficients

Coefficientsᵃ					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model	B	Std. Error	Beta		
1 (Constant)	12.266	1.212		10.121	.000
Consumer Concerns and Barriers regarding ABS Composite	.344	.073	.316	4.686	.000
a. Dependent Variable: Accepting and Adopting Products Featuring the Composite Material					

The "Coefficients table 6" provided with "Consumer Concerns and Barriers regarding ABS Composite", as well as determine whether the "Accepting and Adopting Products Featuring the Composite Material" is "statistically significant to the model".

5. Finding and Discussion

As with the evolution of mobility and circumstances in the manufacturing industry pertaining to the motor vehicle and with the emergence of the electric vehicles in the market. Maiti, S., et. al., (2022) focused on a middle ground between biodegradability and performance in the creation of renewable-material fiber-reinforced polymer (FRP) composites. It also discussed current and future trends, problems, and viewpoints in the industry, delving into the production methods, characteristics, and possible uses. While, Jiang, R., et. al., (2017) conducted a Delphi poll to gather expert feedback helped in gaining a better understanding of additive manufacturing's potential future effects. It revealed 18 predictions that formed a most likely future scenario, providing useful information for businesses, governments, and researchers. The present study aimed to find a significant relationship between the level of consumer awareness regarding Additively Manufactured Multifiber Reinforced ABS Composite and their perception of its potential applications in advanced engineering, tooling, and electric vehicles.

On the other hand, Berkeley, N., et. al., (2017) utilized the Multi-Level Perspective framework to examine the uptake of BEVs in Europe, drawing attention to environmental factors that were supportive of BEVs while revealing long-standing obstacles that were preventing them from reaching the mass market. To encourage the broad use of BEVs and shake up the current automobility system, it emphasized the necessity of more comprehensive solutions and stronger regulatory backing. The present study investigated the consumer concerns and barriers significantly impacting the acceptance and adoption of products featuring Additively Manufactured multifiber-reinforced ABS Composite.

The finding of the current study revealed that there is a significant relationship between the level of consumer awareness regarding Additively Manufactured Multifiber Reinforced ABS Composite and their perception of its potential applications in advanced engineering, tooling, and electric vehicles as shown in Table 3. In support of the current study, Diniță, A., et. al., (2023) explored additive manufacturing (AM) post-processing methods for 3D printed objects. The results showed significant improvements in mechanical properties for various materials, with physical properties like crystallinity, viscosity, processability, and microstructural structure playing crucial roles.

Other findings derived through Tables 4, 5, and 6 provide the data about the link between customer concerns and hurdles regarding ABS composite and the adoption and acceptability of items utilizing this material. Several notable conclusions arise from this association. Table 4 shows that there is a moderate degree of linkage between the variables in the model. The independent variable accounts for around 10% of the variance in consumer concerns and obstacles for ABS composite, according to the R-value of 0.316. In Table 5, denotes that the dependent variable is strongly predicted by the regression model (F-value of 21.962, $p < 0.001$), according to the ANOVA findings. The data is well-fit by the regression model and that it yields useful insights into customer behaviour is evident from this. Table 6's coefficients, including a positive unstandardized coefficient of 0.344 ($p < 0.001$), indicate that consumer concerns and barriers about ABS composite are significant, and that as these concerns and barriers grow, so does the acceptance and adoption of products make with this composite. The significance of resolving customer concerns and obstacles to increase market acceptability and adoption of ABS composite goods is underscored by these findings.

6. Conclusion

In conclusion, this study's results provide important insight into the complex dynamics at play in India's electric vehicle, advanced engineering, and tooling markets about the connection between customer knowledge, attitudes, and the uptake of AMMFRC. Consumer education on the uses and

advantages of AMMFRC is crucial due to the strong correlation between consumer knowledge and their impressions of the material's possible applications. Furthermore, important insights into market acceptance and uptake were uncovered by analyzing customer concerns and obstacles related to ABS composite. It is essential to address customer concerns and constraints in order to enhance the market viability of ABS composite goods, since there is a moderate degree of connectivity between these factors. These results are useful for analyzing customer behaviour and directing marketing and product strategy decisions because of the regression model's strong predictive capacity. In essence, the findings of this study highlight the need for educational campaigns and other preventative actions to allay customer fears and encourage broad use of AMMFRC in India's manufacturing sector.

7. Implication, Limitations, and recommendations for further studies

Many players in India's electric car, advanced engineering, and tooling industries stand to benefit greatly from this study's conclusions. Manufacturers, lawmakers, and researchers may get valuable insight into the market demand, possible uses, and technological improvements required to harness multifibre-reinforced ABS composite by understanding consumer opinions on the material.

On top of that, India's global competitiveness may be boosted by using the study's insights to create sustainable manufacturing processes and creative goods.

It is important to note that there are certain limitations, even though the study was extensive. To begin with, the survey only looked at consumer views in one single location (India), thus it might not be representative of the wide range of beliefs held by people in other parts of the world. Another potential issue is that the study uses customer self-report data, which might be inaccurate or biased.

In addition, as the market and technology progress, the fast-paced nature of additive manufacturing and composite materials makes it difficult to draw firm conclusions.

Future research efforts should expand their samples to include a wider range of demographics and geographic locations in order to overcome the limitations that have been found. To get a more complete picture of what consumers think and want, researchers might use mixed-method techniques, which combine quantitative surveys with qualitative interviews. In addition, investigations that follow the uptake and use of multifiber reinforced ABS composite over time may provide light on its potential uses and marketability in the future. Also, research that compare various areas or nations might shed light on consumer mindsets and market trends from a cross-cultural viewpoint.

Lastly, research results must be kept current in the ever-changing industrial world by continuously monitoring technical breakthroughs in composite materials and additive manufacturing.

8. References

1. Aheleroff, S., Xu, X., Zhong, R. Y., & Lu, Y. (2021). Digital twin as a service (DTaaS) in industry 4.0: An architecture reference model. Advanced Engineering Informatics, 47, 101225.
2. Andrew, J. J., & Dhakal, H. N. (2022). Sustainable biobased composites for advanced applications: recent trends and future opportunities–A critical review. Composites Part C: Open Access, 7, 100220.
3. Arnold, J. R. (2004). High quality copper-nickel-chromium plating on plastics: a continuous process and its challenges. Plating and surface finishing, 91(1), 38-47.
4. Berkeley, N., Bailey, D., Jones, A., & Jarvis, D. (2017). Assessing the transition towards Battery Electric Vehicles: A Multi-Level Perspective on drivers of, and barriers to, take up. Transportation Research part A: policy and practice, 106, 320-332.
5. Bikas, H., Stavropoulos, P., & Chryssolouris, G. (2016). Additive manufacturing methods and modelling approaches: a critical review. The International Journal of Advanced Manufacturing Technology, 83, 389-405.
6. Butler, K. T., Davies, D. W., Cartwright, H., Isayev, O., & Walsh, A. (2018). Machine learning for molecular and materials science. Nature, 559(7715), 547-555.

7. Degirmenci, K., & Breitner, M. H. (2017). Consumer purchase intentions for electric vehicles: Is green more important than price and range?. Transportation Research Part D: Transport and Environment, 51, 250-260.

8. Diniță, A., Neacșa, A., Portoacă, A. I., Tănase, M., Ilinca, C. N., & Ramadan, I. N. (2023). Additive manufacturing post-processing treatments, a review with emphasis on mechanical characteristics. Materials, 16(13), 4610.

9. Eyers, D. R., & Potter, A. T. (2017). Industrial Additive Manufacturing: A manufacturing systems perspective. Computers in industry, 92, 208-218.

10. Gao, W., Zhang, Y., Ramanujan, D., Ramani, K., Chen, Y., Williams, C. B., ... & Zavattieri, P. D. (2015). The status, challenges, and future of additive manufacturing in engineering. Computer-Aided Design, 69, 65-89.

11. Goel, S., Sharma, R., & Rathore, A. K. (2021). A review on barrier and challenges of electric vehicle in India and vehicle to grid optimisation. Transportation engineering, 4, 100057.

12. Hardman, S., Jenn, A., Tal, G., Axsen, J., Beard, G., Daina, N., ... & Witkamp, B. (2018). A review of consumer preferences of and interactions with electric vehicle charging infrastructure. Transportation Research Part D: Transport and Environment, 62, 508-523.

13. Hart, K. R., & Wetzel, E. D. (2017). Fracture behavior of additively manufactured acrylonitrile butadiene styrene (ABS) materials. Engineering Fracture Mechanics, 177, 1-13.

14. Huang, S. H., Liu, P., Mokasdar, A., & Hou, L. (2013). Additive manufacturing and its societal impact: a literature review. The International journal of advanced manufacturing technology, 67, 1191-1203.

15. Huang, X., & Ge, J. (2019). Electric vehicle development in Beijing: An analysis of consumer purchase intention. Journal of cleaner production, 216, 361-372.

16. Jenn, A., Springel, K., & Gopal, A. R. (2018). Effectiveness of electric vehicle incentives in the United States. Energy policy, 119, 349-356.

17. Jones, P. B., Levy, J., Bosco, J., Howat, J., & Van Alst, J. W. (2018). The future of transportation electrification: Utility, industry and consumer perspectives. Lawrence Berkeley National Lab.(LBNL), Berkeley, CA (United States).

18. Kant, R., Chauhan, P. S., Patel, V. K., & Bhattacharya, S. (2022). Introduction to the fabrication of polymers and polymeric composites. Trends in Fabrication of Polymers and Polymer Composites, 1-1.

19. Kempton, W., & Tomić, J. (2005). Vehicle-to-grid power implementation: From stabilizing the grid to supporting large-scale renewable energy. Journal of power sources, 144(1), 280-294.

20. Kleer, R., & Piller, F. T. (2019). Local manufacturing and structural shifts in competition: Market dynamics of additive manufacturing. International Journal of Production Economics, 216, 23-34.

21. Kumar, R. R., & Alok, K. (2020). Adoption of electric vehicle: A literature review and prospects for sustainability. Journal of Cleaner Production, 253, 119911.

22. Kumara, E. B., Esvarb, V., Javithc, S. M., & Babud, S. M. (2020). MULTI FIBER REINFORCED CONCRETE. METHODOLOGY, 7(04).

23. Kunovjanek, M., Knofius, N., & Reiner, G. (2022). Additive manufacturing and supply chains– a systematic review. Production Planning & Control, 33(13), 1231-1251.

24. Liao, F., Molin, E., & van Wee, B. (2017). Consumer preferences for electric vehicles: a literature review. Transport Reviews, 37(3), 252-275.

25. Lim, K. Y. H., Zheng, P., & Chen, C. H. (2020). A state-of-the-art survey of Digital Twin: techniques, engineering product lifecycle management and business innovation perspectives. Journal of Intelligent Manufacturing, 31, 1313-1337.

26. Loengbudnark, W., Khalilpour, K., Bharathy, G., Taghikhah, F., & Voinov, A. (2022). Battery and hydrogen-based electric vehicle adoption: A survey of Australian consumers perspective. Case Studies on Transport Policy, 10(4), 2451-2463.

27. Maiti, S., Islam, M. R., Uddin, M. A., Afroj, S., Eichhorn, S. J., & Karim, N. (2022). Sustainable fiber-reinforced composites: A Review. Advanced Sustainable Systems, 6(11), 2200258.
28. Ngo, T. D., Kashani, A., Imbalzano, G., Nguyen, K. T., & Hui, D. (2018). Additive manufacturing (3D printing): A review of materials, methods, applications and challenges. Composites Part B: Engineering, 143, 172-196.
29. Nguyen, H., Staudacher, M., Kinnunen, P., Carvelli, V., & Illikainen, M. (2019). Multi-fiber reinforced ettringite-based composites from industrial side streams. Journal of Cleaner Production, 211, 1065-1077.
30. Öberg, C. (2019). Additive manufacturing–digitally changing the global business landscape. European Journal of Management and Business Economics, 28(2), 174-188.
31. Olivera, S., Muralidhara, H. B., Venkatesh, K., Gopalakrishna, K., & Vivek, C. S. (2016). Plating on acrylonitrile–butadiene–styrene (ABS) plastic: a review. Journal of materials science, 51, 3657-3674.
32. Rezvani, Z., Jansson, J., & Bengtsson, M. (2018). Consumer motivations for sustainable consumption: The interaction of gain, normative and hedonic motivations on electric vehicle adoption. Business Strategy and the Environment, 27(8), 1272-1283.
33. Riedl, M. O. (2019). Human-centered artificial intelligence and machine learning. Human behavior and emerging technologies, 1(1), 33-36.
34. Romberg, S., Hershey, C., Lindahl, J., Carter, W., Compton, B. G., & Kunc, V. (2019). Large-scale additive manufacturing of highly exothermic reactive polymer systems. Oak Ridge National Lab.(ORNL), Oak Ridge, TN (United States).
35. Singh, S., Ramakrishna, S., & Singh, R. (2017). Material issues in additive manufacturing: A review. Journal of Manufacturing Processes, 25, 185-200.
36. Van de Werken, N., Tekinalp, H., Khanbolouki, P., Ozcan, S., Williams, A., & Tehrani, M. (2020). Additively manufactured carbon fiber-reinforced composites: State of the art and perspective. Additive Manufacturing, 31, 100962.
37. Wong, K. V., & Hernandez, A. (2012). A review of additive manufacturing. International scholarly research notices, 2012.
38. Zheng, P., Wang, Z., Chen, C. H., & Khoo, L. P. (2019). A survey of smart product-service systems: Key aspects, challenges and future perspectives. Advanced engineering informatics, 42, 100973.