

Original Article

# Mechanical Characterization of E Glass (Woven Fabric) Fiber Reinforced Composite Material

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**Abstract:** Glass fiber reinforced polymer composites are the most common of all reinforcing fibers for polymeric matrix composite for several applications. This paper describes the fabrication of E-glass woven fabric mat fiber composites with different types of woven mat and different types of orientation and investigations of the same. Mechanical characterization of the composites were done by testing the composite lamina for tensile, compressive, flexural, and impact strength. The composites manufactured by hand layup process with the volume fraction of fiber up to 0.60. It was found that the E-glass 400 woven composite proved better properties than the 600 woven composite alone in flexural strength. However, the E-glass 600 woven composite is superior to 400 woven composite in its tensile, compressive and impact strength. The fracture surface structure of the composite was observed under Scanning Electron Microscope (SEM) and the cracks, holes and fiber delamination have also been analyzed.

**Keywords:** E-Glass, Resin, Composite, SEM, Woven Fabric.

## INTRODUCTION

Glass fibers are the most common of all reinforcing fibers for Polymeric Matrix Composites (PMC). The primary advantages of glass fibers are low cost, high tensile strength, chemical resistance and insulating properties. E-glass has the lowest cost of all commercially available reinforcing fibers, which is the reason for its widespread use in the Fiber Reinforced Polymer (FRP) industry. Many authors have previously investigated the features of glass composite, Tasdemirci et al [1] determined the quasi-static and high strain rate compression behaviours of an E-glass/polyester composite in longitudinal, transverse, and through-thickness directions. Giovanni Belingardi et al [2] studied the mechanical tests and micro structural investigations. The impact test results of nano composite materials were improved with the addition of nanoclay in epoxy matrix. Singh et al [3] studied the preparation and mechanical properties of nanoclay composites with different weight ratio and suggested that water resistance property was improved by the addition of glass fiber and nanoclay. Lingesh et al [4] studied the mechanical behaviours of the short glass fiber of polyamide 66 and polypropylene composites. Pradeep et al [5] investigated the enhancement of mechanical properties of glass fiber composite, when increasing blast furnace slag percentage improves mechanical properties. Irina et al [6] studied the mechanical performance for hybrid composites of glass fiber and plain woven carbon fiber. Thomas Bru et al [7] investigated the mechanical properties of uni-weave carbon fibre.

Satnam Singh et al [8] investigated the mechanical behaviour of glass fiber reinforced epoxy composites when increasing 20 % of weight fraction of glass fibers over pure epoxy, the tensile strength and flexural strength increased. Jaganatha et al [9] studied tensile properties and also measured breaking load. The inclusion of carbon fiber mat reinforced polymeric composite significantly enhanced the ultimate tensile strength, yield strength and peak load of the composite. Patil Deogonda et al [10] examined the bending load, bearing strength of composite fiber by increasing the addition of filler. Vijaya ramnath et al [11] used natural fibers and woven roving at low cost polymer composite developed with realistic mechanical properties. Ravi ranjan et al [12] investigated the banana and sisal fiber improving mechanical properties. Heo et al [13] studied manufacturing bipolar plates using moulding technique improves mechanical properties. Donnell et al [14] vacuum-assisted resin transfer molding used to manufacture bio-based composite with high strength for automobile industry. Oksman et al [15] studied the natural fibers as reinforced polymer to improve mechanical properties for polylactic acid/flax composites. Akermo et al [16] modelling and experimental work performed using compression moulding. Singleton et al [17] studied the mechanical properties and also evaluated the tensile and impact loading for composite material using natural fiber. Elanchezhan et al [18] investigated the mechanical properties and behaviour of kenaf based hybrid composite. Shubhan et al [19] studied the



mechanical properties of epoxy laminated composites with and without carbon nanotubes. Narendra kumar attili et al [20] analysed the mechanical properties of chopped strand mat of e-glass(450gsm) of five different types of composite to fabricate 0%wt, 5%wt, 10%wt, 15%wt and 20%wt of silica powder. Pavithran et al[21] improved the properties of coir-polyester composites by using glass as the intermediate layer between the coir layers. In the present work, an attempt has been made to fabricate E-glass(200,400,600) fiber woven mat composite and analyse the mechanical properties.

## **MATERIALS AND EXPERIMENTAL TECHNIQUES**

### **E-Glass Fibers**

Raif sakin et al [22] investigated the glass fiber woven (800g/m<sup>2</sup>, 500g/m<sup>2</sup>, 300g/m<sup>2</sup> & 200g/m<sup>2</sup>) and glass fiber mat (225g/m<sup>2</sup>, 450g/m<sup>2</sup> & 600g/m<sup>2</sup>) for fatigue behaviours. Glass fiber woven (800g/m<sup>2</sup>) has the highest fatigue and fiber mat over the others. In the present investigation we are chosen E-glass fiber (200g/m<sup>2</sup>, 400g/m<sup>2</sup>, 600g/m<sup>2</sup>) woven fiber composites because of which are made from extremely fine fibers, lightweight and strong.

### **Epoxy Resin and Hardener**

Epoxy resin (LY556) possesses good binding properties between the fiber layers to form the matrix. The epoxy resin is used at room temperature. Hardener (HY951) is employed to improve the interfacial adhesion and impart strength to the composite. A resin and hardener mixture taken in the ratio 10:1 is used to obtain optimum matrix composition as it provides the suitable interfacial bonding between the fibers.

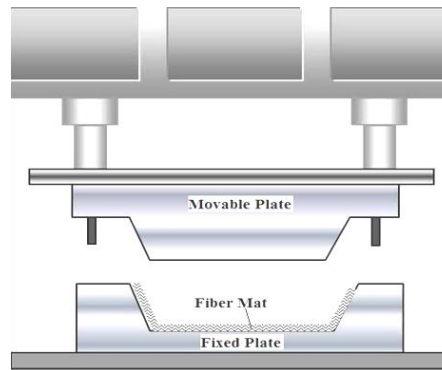
### **Fabrication Procedure for Composite Laminate**

The composite materials were fabricated using compression moulding technique. They are stacked layer by layer of about 10 layers to attain the thickness as per the American Standard for Testing of Materials (ASTM) Specimen. Bonding agent (epoxy resin) was applied to create bonding between fiber sheets. Compression moulding is a well known technique to develop variety of composite products. It is a closed moulding process with high pressure application. Two matched metal moulds are used to fabricate composite product. In compression moulder, base plate is stationary while upper plate is movable. Reinforcement and matrix are placed in the metallic mold and the whole assembly is kept in between the compression moulder. Heat and pressure is applied as per the requirement of composite for a definite period of time. The material placed in between the moulding plates flows due to application of pressure and heat and acquires the shape of the mould cavity with high dimensional accuracy which depends upon mould design.

Curing of the composite may be carried out either at room temperature or at some elevated temperature. Here ten piles of E-glass woven fabric fiber are taken by one over the other and epoxy resin has been used as an adhesive. The size of the mould taken is (250x110x30) mm. The list of ingredients of composite laminate is shown in the Table 1. Initially the glass fiber is to be cut in required shape of the size 250 mm × 110 mm of required orientation (Figure 2). A thin plastic sheet is also used at the top and bottom of the mould in order to get good surface finish for the laminate. The mould has to be cleaned well. After that Poly Vinyl Acetate (PVA) is applied in order to avoid sticking of the laminate to the mould after curing of the laminate. Sufficient amount of resin which is prepared beforehand by using 40% hardner (HY951) of the resin is to be mixed with the resin and stirred well. This mixture is poured over the ply. The resin is poured in to the mould uniformly and it is rolled in order to get the required bonding by using a rolling device. Enough care should be taken to avoid the air bubbles formed while rolling. The compression is applied on the fiber- resin mixture by tightening the two mould plates uniformly.

**Table 1: List of ingredients to prepare a composite laminate**

<b>Type of resin</b>	<b>Epoxy</b>
Type of fiber	E-Glass(200,400,600 Woven Fabric)
Hardner used	HY 951
No. of Plies per laminate	10
Nature of Laminate	Symmetric Type
Method of Preparation	Compression Moulding Method



**Figure 1: Compression Molding**

### TESTING OF COMPOSITES

#### Analysis of the Mechanical Properties

The tensile, flexural, compressive and impact strength of the specimens were analyzed as per ASTM standard for testing of materials (ASTM:D638), (ASTM:D790), (ASTM:D695) and (ASTM:D256), using computerized Universal Testing Machine (UTM) at a cross-head speed of 50 mm/min. Figures 3, 4 and 5 indicate the ASTM specimens of composite testing.



**Figure 2: Tensile Test Specimens**



**Figure 3: Flexural Test Specimens.**



**Figure 4: Impact Test Specimens**

### RESULTS AND DISCUSSIONS

### Tensile Properties

The three different composite specimens like E-glass-200-400-600 woven mat were tested in the universal testing machine to find the tensile properties. A sample graph showing stress and strain of 200-400-600 woven mat is shown in Figure 6. The mechanical properties of the fabricated composite (E-glass-200-400-600 woven fabric mat) are summarized in the Table 2. It is seen that the tensile strength of the 400 and 600 mat is high. when compared to the 200 woven fabric mat. The tensile modulus are calculated from the linear portion of the graph. All the composites are manufactured at the highest volume fraction of 0.60.

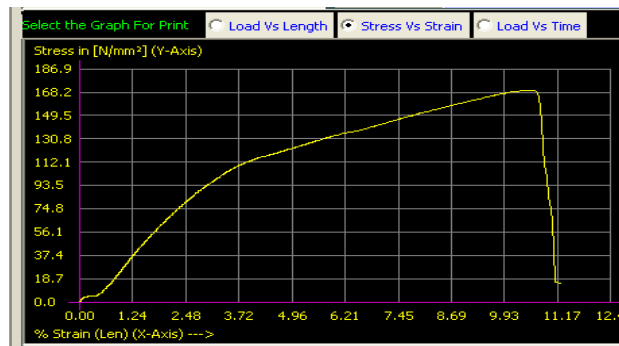


Figure 5: Stress- Strain Curve For Woven Fabric Mat

Table 2: Results Of Tensile Test Of Different Composite

Sample	BreakLoad (kN)	Maximum Displacement (mm)	Elongation (%)	Tensile Strength (MPa)	Tensile Modulus (MPa)
200 Woven Fabric	16.45	3.6	11.34	46.81	47
400 Woven Fabric	24.82	5.32	14.37	95.15	87
600 Woven Fabric	23.13	4.78	13.98	231.73	225

The comparison between different composites for break load, maximum displacement and percentage of elongation are shown in Figure7. It is found that the break load of the 400 mat is high. The maximum displacement is also high for the 400 mat. Eventhough the displacement is high the tensile strength and modulus of the composite is less than that of 200 and 400 mat which means that the 600 woven mat withstands more strain than the 200 and 400 mat before failure. Thus it can be concluded that the E-glass woven fabric composite is more ductile than the glass fibre composite. From the results of the tensile test, it can be concluded that the 600 woven fabric mat composite is well performing when compared with other types of mat. This has also been experimentally proved by increasing strain rate[23].

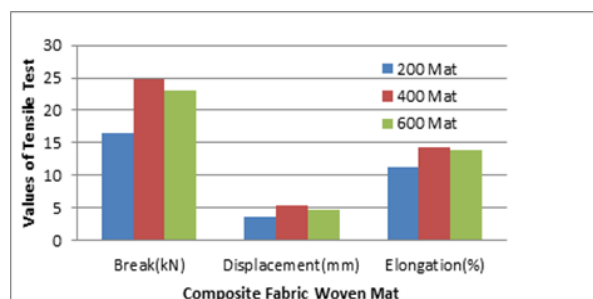


Figure 6: Comparison Between Different Composite: Break Load,Displacement And % Of Elongation

### Flexural Properties

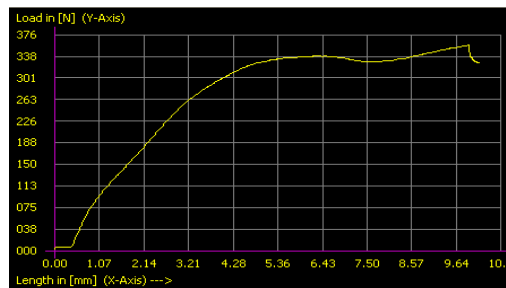
A typical load–displacement curve for composite is shown in the Figure 8. It is seen that the curves increase linearly with respect to displacement up to the maximum flexural load of 1.48 (kN) and then decreases

since breakage takes place. The maximum flexural strength is observed in 400 mat fibre. The flexural resistance of other composites are shown in Table 3. With 400 woven the fabric mat has the highest flexural resistance due to the presence of uniformly distributed E-glass woven fabric fiber and its high stiffness. Moreover, the adhesion between the fibre and the epoxy matrix is better than the other two composites. The results are in alignment with the findings of Satnam Singh et al [9] where increasing volume fraction of composites prove improved mechanical properties.

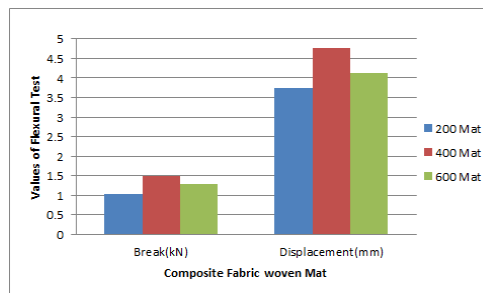
**Table 3: Results of Flexural Test of Different Composite**

Sample	Flexural Break Load (kN)	Maximum Displacement (mm)	Flexural Strength (MPa)	Flexural Modulus (MPa)
200 Woven Fabric	1.03	3.74	12.70	247
400 Woven Fabric	1.48	4.76	44.90	278
600 Woven Fabric	1.28	4.12	34.80	217

The flexural modulus of the composite is shows 400 mat has the highest flexural modulus when compared with the other two composites. The comparison between different composites break load and displacement are shown in Figure9. The maximum displacement is marginally higher for the 400 mat, when compared to the other two types of mat. After the maximum flexural load point, the graph decreases and shows random behaviour since the fibres tend to pullout from the composite at the breaking point.



*Figure 7: Load Vs Displacement (Fabric woven mat) for Flexural Test*



*Figure 8: Comparison Between Different Composite: Break Load, Displacement*

### Compression Properties

A typical load–displacement curve for three different types of composites, is shown in the Fig 10.

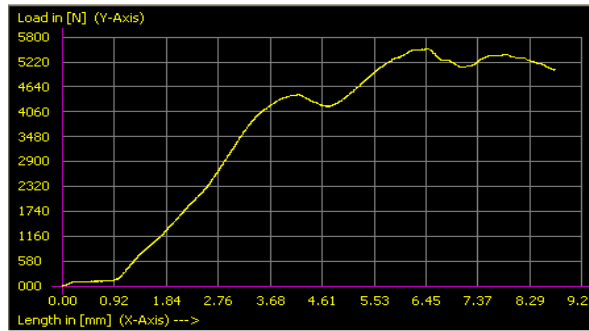


Figure 9: Load Vs Displacement (Fabric Woven Mat) For Compressive Test

The compression test results are summarized in the Table 4. The comparison between different composites break load and displacement are shown in Figure 11. It can be seen that as the load increases, the displacement increases linearly presenting elastic nature. Then there is a gradual decrease in the graph as the displacement increases. It can be seen that the curve follows almost smooth and are regular linear pattern. The yield load is calculated from curve.

Table 4. Results Of Compressive Test Of Different Composite

Sample	Break Load (kN)	Maximum Displacement (mm)	Compressive Strength (MPa)
200Woven Fabric	1.5	2.37	11.3
400Woven Fabric	2.49	3.05	17.63
600Woven Fabric	2.03	2.89	76.14

The maximum break load is obtained for the 400 mat composite which is equal to 2.49 kN. The maximum displacement is also high for the 400 mat but the maximum compressive strength is found in the 600 woven fabric mat

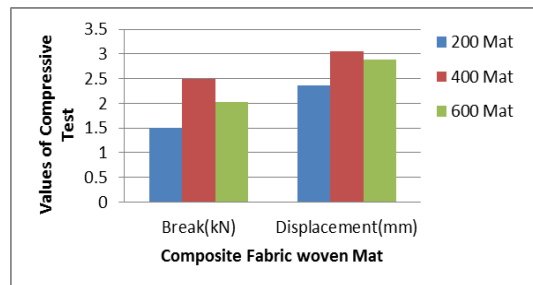


Figure 10: Comparison Between Different Composite: Break Load, Displacement

### Impact Properties

The impact test is conducted for analyzing the impact capability of three different composites. The loss in energy has been found by using charpy impact test machine (100 tonne capacity).

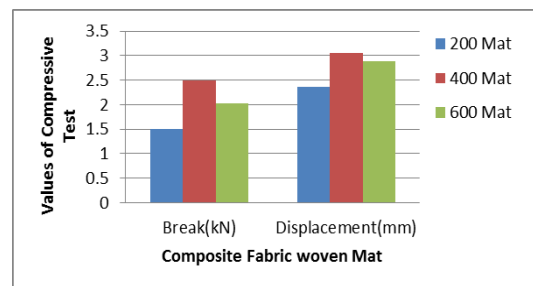


Figure 11: Comparison Between Different Composite: Break Load, Displacement

The energy absorbed by the each specimen is summarized in the Table 5. The comparison of the impact test results of different composites are shown in Figure 12. It can be seen that the 600 mat has very high impact strength when compared to other mat composites. The energy absorbed by the 600 mat fibre is 18.21 J. The reason for such high strength is due to the presence of single type fibre in the matrix in alternating directions. Thus when the crack propagates it travel through the matrix and the fibres of the composite. Impact results are in alignment with the findings of Mallick and Cartie [24,25] have found that stacking arrangement of the fibers is more important than composition in defining impact toughness and resin toughness relatively than fiber strength and stiffness is the main parameter influencing the impact resistant properties of the composites.

**Table 5: Results Of Impact Test For Different Composite**

Sample	Energy Absorbed(Joules)
200 Woven Fabric	4.51
400 Woven Fabric	7.08
600 Woven Fabric	18.21

**Morphological Analysis**

Morphological analysis was done using Scanning Electron Microscope (SEM). The samples were taken from each test, dried and coated with 15–20 nm thick layer of gold with an ion-sputter coater device. Subsequently the specimens have inspected by a scanning electron microscope. The interfacial adhesion between matrix and the fibre is clearly seen from scanning electron micrographs. The scanning electron micrograph of the 200-400-600 fabric woven mat is shown in Figure 13. Even though the manufacturing of the composite has been done with care, it is seen that there is intra fibre delamination primarily present in the woven fabric which reduces the strength of the composite. Figure 14 shows the adhesion of fibre and resin in 0.6 volume fraction of E-glass woven fabric mat composite which is subjected to tensile testing.

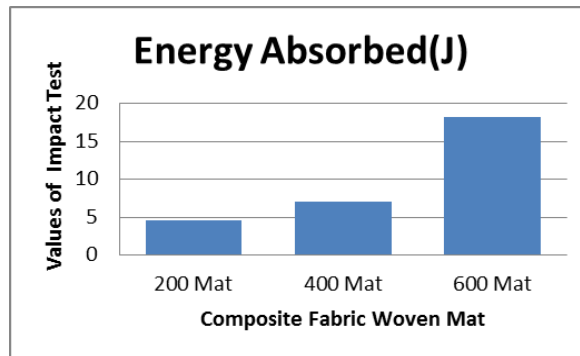


Figure 12: Comparison of Impact Test Result of Different Composite

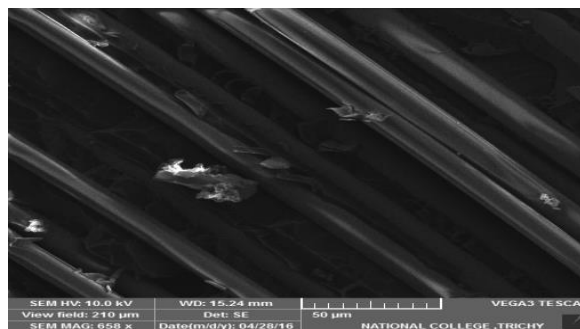
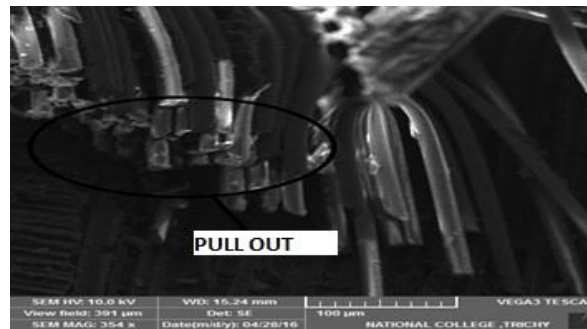


Figure 13: SEM Image of E-Glass Fiber

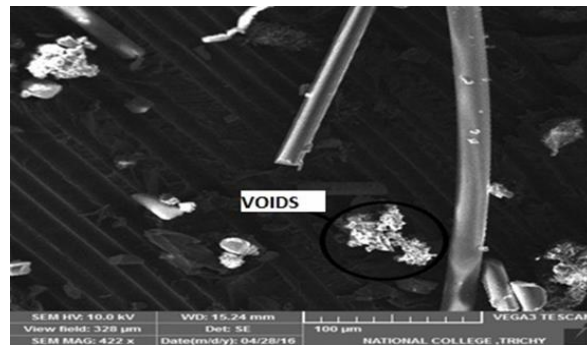
In general, the adhesion is good although there are a few defects like air bubbles and pull out. The smooth surface is the resin and the irregular surface is fibre. Due to the high strength of E-glass composite, they have undergone individual breakage, giving it very high strength. The effective stress transfer in the tensile

direction between the fibers and matrix is supported by the high stress values obtained in the test. Figure 15 shows the SEM micrograph of flexural fractured specimen. Inter-phase delamination is found at the cross-section of applied load. Presence of voids in the specimen is found to be minimal due to uniform load applied on it



*Figure 14: Pull Out of Fiber*

The crack propagates through the glass fibers rather than the other fiber and causes failure. Flexural strength values also indicate that there is very little stress transfer from the matrix to the fiber and hence very low values.



*Figure 15: Voids of Fiber*

## CONCLUSION

In this research work, different E-Glass woven fabric composites are fabricated with fibres mat 200, 400 and 600. All the composites have the highest volume fraction of 0.60. Their mechanical properties like tensile strength, compressive, flexural strength and impact strength have been investigated and from the results obtained, the following conclusions are drawn.

- The tensile strength of 600 mat is the highest among all the composites which has the value of 23.13 kN.
- The percentage of elongation of 200 fabric woven mat in tensile testing is found to be less than that of the other types of mat composite. Therefore, the 600 woven mat withstands more strain before failure in tensile testing than the 200 and 400 woven fabric mat fibre composite.
- The flexural strength of the composite is in decreasing order from 400 mat, 600 mat and 200 mat. 400 mat has the highest flexural strength as its strength increases with increase in interfacial adhesion. Flexural modulus is also found to be highest for the 400 fabric woven mat.
- Compressive test results shows that 600 mat is highest among all the three manufactured composites.
- Impact strength of 600 woven mat composite is 18.21 J which is quite high when compared with the 400 mat and 200 mat whose impact values are 7.08 J and 4.51 J respectively.

The effect of the different tests are studied and the microstructures of composites have been investigated using SEM and it is found that the orientation angles of fibres play an important role in the mechanical behaviour of natural fibre composite. SEM micrographs of the tensile, flexural, impact and impact tested specimens help to predict fibre failure, presence of voids and fibre pullout during loading condition. It also gives an idea about the crack propagation in the composite. From the above results, the E-glass woven fabric

composite is found to be the best option for general applications. E-glass composite can be used for applications which call for high impact strength. Moreover they have high mechanical properties as discussed above and hence can be used for a variety of applications which includes housing, automobile and packaging industry, etc. This work can be further extended to real time replacement of automotive components including leaf spring, car panel, helmet etc, The mechanical characteristics of the composites can be analyzed under different working conditions to suggest for better design and green environment.

## REFERENCES

- [1] A. Tasdemircia, A.K. Karaa, G. Turana, Tunusoglua, M. Gudena, I. W. Hall, *Experimental and Numerical Investigation of High Strain Rate Mechanical Behavior of a [0/45/90/- 45] Quadriaxial EGlass/Polyester Composite*, *Procedia Engineering* 10 (2011) 3068–3073.
- [2] Giovanni Belingardi, Davide S. Paolino, Ermias G. Koricho, *Investigation of influence of tab types on tensile strength of E-glass/epoxy fiber reinforced composite materials*, *Procedia Engineering* 10 (2011) 3279–3284.
- [3] S. Sivasaravanan, V.K. Bupesh Rajab, Manikandan, *Impact Characterization of Epoxy LY556/E-Glass Fibre/ Nano Clay Hybrid Nano Composite Materials*, *Procedia Engineering* 97 (2014) 968 – 974.
- [4] Naresh Kumar Miryala, Divit Gupta, "Data Security Challenges and Industry Trends" *IJARCCCE International Journal of Advanced Research in Computer and Communication Engineering*, vol. 11, no.11, pp. 300-309, 2022, Crossref <https://doi.org/10.17148/IJARCCCE.2022.111160>
- [5] Ashween. Ganesh, *Critical Evaluation of Low Ergonomics Risk Awareness among Early Product Development Stage of the Medical Device Industry*, pp. 15, 2022. | Google Scholar
- [6] Kushal Walia, 2024. "Accelerating AI and Machine Learning in the Cloud: The Role of Semiconductor Technologies" *ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 2: 34-41. | Google Scholar
- [7] Julian, Anitha, Mary, Gerardine Immaculate, Selvi, S., Rele, Mayur & Vaithianathan, Muthukumaran (2024) Blockchain based solutions for privacy-preserving authentication and authorization in networks, *Journal of Discrete Mathematical Sciences and Cryptography*, 27:2-B, 797–808, DOI: 10.47974/JDMSC-1956
- [8] Sridhar Selvaraj, 2024. "Futuristic SAP Fiori Dominance" *ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 1: 32-37. | Google Scholar
- [9] Bhattacharya, S. (2024). Securing the Gatekeeper: Addressing Vulnerabilities in OAuth Implementations for Enhanced Web Security. *International Journal of Global Innovations and Solutions (IJGIS)*. <https://doi.org/10.21428/e90189c8.af381673>
- [10] Chanthati, S. R. (2024). Website Visitor Analysis & Branding Quality Measurement Using Artificial Intelligence. Sasibhushan Rao Chanthati. <https://journals.e-palli.com/home/index.php/ajet>. <https://doi.org/10.54536/ajet.v3i3.3212>
- [11] Venkata Sathya Kumar Koppiseti, "Automation of Vendor Invoice Process with OpenText Vendor Invoice Management," *International Journal of Computer Trends and Technology*, vol. 71, no. 8, pp. 71-75, 2023. Crossref, <https://doi.org/10.14445/22312803/IJCTT-V71I8P111>
- [12] Sumanth Tatineni, Anirudh Mustyala, 2024. "Enhancing Financial Security: Data Science's Role in Risk Management and Fraud Detection" *ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 2: 94-105.
- [13] Arnab Dey, 2021. "Implementing Latest Technologies from Scratch: A Strategic Approach for Application Longevity" *European Journal of Advances in Engineering and Technology*, 2021, 8 (8): 22-26. | PDF
- [14] Dhamotharan Seenivasan, Muthukumaran Vaithianathan, 2023. "Real-Time Adaptation: Change Data Capture in Modern Computer Architecture" *ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 1, Issue 2: 49-61
- [15] "Optimizing Wiring Harness Minimization through Integration of Internet of Vehicles (IOV) and Internet of Things (IoT) with ESP-32 Module: A Schematic Circuit Approach", *International Journal of Science & Engineering Development Research* ([www.ijrti.org](http://www.ijrti.org)), ISSN:2455-2631, Vol.8, Issue 9, page no.95 - 103, September-2023, Available : <http://www.ijrti.org/papers/IJRTI2309015.pdf>
- [16] Vijay Panwar, "AI-Powered Data Cleansing: Innovative Approaches for Ensuring Database Integrity and Accuracy," *International Journal of Computer Trends and Technology*, vol. 72, no. 4, pp. 116-122, 2024. Crossref, <https://doi.org/10.14445/22312803/IJCTT-V72I4P115>
- [17] Dixit, A., Sabnis, A. and Shetty, A., 2022. Antimicrobial edible films and coatings based on N, O-carboxymethyl chitosan incorporated with ferula asafoetida (Hing) and adhatoda vasica (Adulsa) extract. *Advances in Materials and Processing Technologies*, 8(3), pp.2699-2715.
- [18] Amit Mangal, 2024. *Role of Enterprise Resource Planning Software (ERP) In Driving Circular Economy Practices in the United States*, *ESP Journal of Engineering & Technology Advancements* 4(3): 1-8. [Link]
- [19] Chanthati, Sasibhushan Rao. (2021). Second Version on A Centralized Approach to Reducing Burnouts in the IT industry Using Work Pattern Monitoring Using Artificial Intelligence using MongoDB Atlas and Python. 10.13140/RG.2.2.12232.74249.

- [20] Pandiya , D. K. . (2022). Performance Analysis of Microservices Architecture in Cloud Environments . *International Journal on Recent and Innovation Trends in Computing and Communication*, 10(12), 264–274. Retrieved from <https://ijritcc.org/index.php/ijritcc/article/view/10745>
- [21] Gaayathri, R. S., Rajest, S. S., Nomula, V. K., & Regin, R. (2023). Bud-D: enabling bidirectional communication with ChatGPT by adding listening and speaking capabilities. *FMDB Transactions on Sustainable Computer Letters*, 1(1), 49–63.
- [22] M. A Kermo, B.T. Astrom, *Modelling component cost in compression moulding of thermoplastic composite and sandwich components*, *Composites: Part A* 31 (2000) 319–333.
- [23] A.C.N. Singletona, C.A. Baillieb, P.W.R. Beaumonta, T. Peijsc, *On the mechanical properties, deformation and fracture of a natural fibre/recycle polymer composite*, *Composites: Part B* 34 (2003) 519–526.
- [24] C. Elanchezian, B. Vijaya Ramnath, Kaosik R., Nellaiappan T. K., Santhosh Kumar K., Kavirajan P. and Sughan M. U., *Evaluation Of Mechanical Properties Of Kenaf Based Hybrid Composite For Automotive Components Replacement*, *ARPN Journal of Engineering and Applied Sciences*, vol. 10, No. 13, July 2015.
- [25] A. Kumar, S. M. Ahmed and V. K. Duleb, "English text compression for small messages," *ICIMU 2011 : Proceedings of the 5th international Conference on Information Technology & Multimedia*, Kuala Lumpur, Malaysia, 2011, pp. 1-5, doi: 10.1109/ICIMU.2011.6122737.
- [26] Shubham Gupta and Ariful Rahaman, *Effect of Carbon Nanotube on Thermo- Mechanical Properties of Glass Fiber/Epoxy Laminated*, *International Journal of Scientific and Research Publications*, Volume 5, Issue 2, February (2015).
- [27] Narendra Kumar Attili, Ch Siva Rama Krishna, *Experimental Investigation and Analysis of Mechanical Properties of Chopped Strand Mat-E Glass Fiber Polyester Resin & Silica Powder Composite*, *Journal of Machinery Manufacturing and Automation*, Vol. 4 Iss. 1, PP. 1-9, (2015).
- [28] Pavithran C, Mukherjee PC, Brahma Kumar M. *Impact properties of sisal-glass hybrid laminates*, *Journal of Material Science* 1991;26:452–9.
- [29] Kuraku, Sivaraju and Kalla, Dinesh and Smith, Nathan and Samaah, Fnu, *Safeguarding FinTech: Elevating Employee Cybersecurity Awareness In Financial Sector (December 29, 2023)*. *International Journal of Applied Information Systems (IJAIS)*, Volume 12– No.42, December 2023, Available at SSRN: <https://ssrn.com/abstract=4678581>
- [30] Raif Sakin, Irfan Ay, Ramazan Yaman, *An investigation of bending fatigue behavior for glass-fiber Reinforced polyester composite materials*, *Materials and Design* (2006), doi:10.1016/j.matdes.2006.11.006.
- [31] Chanthati, S. R. (2024). Product Colour Variation Management with Artificial Intelligence. *Sasibhushan Rao Chanthati. American Journal of Education and Technology*, 3(3), 46–52. <https://doi.org/10.54536/ajet.v3i3.3213>
- [32] Esmael Adem, Er. Mukesh Didwania, Gurala Muralidhar reddy, Ermias, Koricho, *Eperimental analysis of E-glass/Epoxy & E-glass/polyester Composites for Auto Body Panel*, *American International Journal of Research in Science, Technology, Engineering & Mathematics*, 10(4)-(2005), pp-377-383.
- [33] Mallick PK, Broutman LJ. *Static and impact properties of laminated hybrid composites*, *Journal of Testing and Evaluation*, (1977)5:190–200.
- [34] Cartie DDR, Irving PE. *Effect of resin and fibre properties on impact and compression after impact performance of CFRP. Composite A* (2002);33:483–9.
- [35] Next-Generation Decision Support: Harnessing AI and ML within BRMS Frameworks (N. R. Palakurti , Trans.). (2023). *International Journal of Creative Research in Computer Technology and Design*, 5(5), 1-10. <https://jrctd.in/index.php/IJRCTD/article/view/42>
- [36] Pratiksha Agarwal, Arun Gupta, "Harnessing the Power of Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) Systems for Sustainable Business Practices," *International Journal of Computer Trends and Technology*, vol. 72, no. 4, pp. 102-110, 2024. Crossref, <https://doi.org/10.14445/22312803/IJCTT-V72I4P113>
- [37] "Optimizing Wiring Harness Minimization through Integration of Internet of Vehicles (IOV) and Internet of Things (IoT) with ESP-32 Module: A Schematic Circuit Approach", *International Journal of Science & Engineering Development Research* ([www.ijrti.org](http://www.ijrti.org)), ISSN:2455-2631, Vol.8, Issue 9, page no.95 - 103, September-2023, Available : <http://www.ijrti.org/papers/IJRTI2309015.pdf>
- [38] Praveen Borra, Comparison and Analysis of Leading Cloud Service Providers (AWS, Azure and GCP), *International Journal of Advanced Research in Engineering and Technology (IJARET)*, 15(3), 2024, pp. 266- 278.
- [39] Kalla, Dinesh and Smith, Nathan and Samaah, Fnu and Polimetla, Kiran, *Hybrid Scalable Researcher Recommendation System Using Azure Data Lake Analytics (February 2024)*. *Journal of Data Analysis and Information Processing*, 2024, 12, 76-88 , Available at SSRN: <https://ssrn.com/abstract=4722802>
- [40] Palakurti, N. R. (2023). Governance Strategies for Ensuring Consistency and Compliance in Business Rules Management. *Transactions on Latest Trends in Artificial Intelligence*, 4(4).
- [41] S. Masarath, V. N. Waghmare, S. Kumar, R. S. M. Joshitta, D. D. Rao and Harinakshi, "Storage Matched Systems for Single-click Photo Recognitions using CNN", 2023 *International Conference on Communication Security and Artificial Intelligence (ICCSAI)*, pp. 1-7.
- [42] S. E. Vadakkethil Somanathan Pillai and K. Polimetla, "Integrating Network Security into Software Defined Networking (SDN) Architectures," 2024 *International Conference on Integrated Circuits and Communication Systems (ICICACS)*, Raichur, India, 2024, pp. 1-6, doi: 10.1109/ICICACS60521.2024.10498703.

- [43] S. E. Vadakkethil Somanathan Pillai and K. Polimetla, "Mitigating DDoS Attacks using SDN-based Network Security Measures," 2024 International Conference on Integrated Circuits and Communication Systems (ICICACS), Raichur, India, 2024, pp. 1-7, doi: 10.1109/ICICACS60521.2024.10498932.
- [44] Sachan, V., Malik, S., Gautam, R., & Kumar, P. (Eds.). (2024). *Advances in AI for Biomedical Instrumentation, Electronics and Computing: Proceedings of the 5th International Conference on Advances in AI for Biomedical Instrumentation, Electronics and Computing (ICABEC - 2023)*, 22-23 December 2023, India (1st ed.). CRC Press. <https://doi.org/10.1201/9781032644752>
- [45] S. E. V. S. Pillai and K. Polimetla, "Enhancing Network Privacy through Secure Multi-Party Computation in Cloud Environments," 2024 International Conference on Integrated Circuits and Communication Systems (ICICACS), Raichur, India, 2024, pp. 1-6, doi: 10.1109/ICICACS60521.2024.10498662.
- [46] Vamsi Katragadda "Ethical AI in Customer Interactions: Implementing Safeguards and Governance Frameworks" *Iconic Research And Engineering Journals Volume 7 Issue 12 2024 Page 394-397.*
- [47] Naga Ramesh Palakurti, 2023. "Evolving Drug Discovery: Artificial Intelligence and Machine Learning's Impact in Pharmaceutical Research" *ESP Journal of Engineering & Technology Advancements* 3(3): 136-147. [Link]
- [48] Chanthati, Sasibhushan Rao. (2021). How the Power of Machine - Machine Learning, Data Science and NLP Can Be Used to Prevent Spoofing and Reduce Financial Risks. 10.13140/RG.2.2.18761.76640.
- [49] Naga Ramesh Palakurti, 2022. "AI Applications in Food Safety and Quality Control" *ESP Journal of Engineering & Technology Advancements* 2(3): 48-61. [Link]
- [50] Chanthati, S. R. (2024). An automated process in building organic branding opportunity, budget Intensity, recommendation in seasons with Google trends data. Sasibhushan Rao Chanthati. <https://doi.org/10.30574/wjaets.2024.12.2.0326>
- [51] Kumar Shukla, Shashikant Tank, 2024. "CYBERSECURITY MEASURES FOR SAFEGUARDING INFRASTRUCTURE FROM RANSOMWARE AND EMERGING THREATS", *International Journal of Emerging Technologies and Innovative Research* (www.jetir.org), ISSN: 2349-5162, Vol.11, Issue 5, page no.i229-i235, May-2024, Available: <http://www.jetir.org/papers/JETIR2405830.pdf>
- [52] Sukhdev S. Kapur, Ashok Ganesan, Jacopo Pianigiani, Michal Styszynski, Atul S Moghe, Joseph Williams, Sahana Sekhar Palagrahara Chandrashekar, Tong Jiang, Rishabh Ramakant Tulsian, Manish Krishnan, Soumil Ramesh Kulkarni, Vinod NairJeba Paulaiyan, 2021. *Automation of Maintenance Mode Operations for Network Devices*, US10938660B1. [Link]
- [53] Kumar Shukla, Nimeshkumar Patel, Hirenkumar Mistry, 2024. "Transforming Incident Responses, Automating Security Measures, and Revolutionizing Defence Strategies through AI-Powered Cyber security", *International Journal of Emerging Technologies and Innovative Research* (www.jetir.org), ISSN: 2349-5162, Vol.11, Issue 3, page no.h38-h45, March-2024, Available: <http://www.jetir.org/papers/JETIR2403708.pdf>
- [54] Lekkala, Chandrakanth, AI-Driven Dynamic Resource Allocation in Cloud Computing: Predictive Models and Real-Time Optimization (February 06, 2024). *J Artif Intell Mach Learn & Data Sci | Vol: 2 & Iss: 2*, Available at SSRN: <https://ssrn.com/abstract=4908420> or <http://dx.doi.org/10.2139/ssrn.4908420>
- [55] Patel, N. (2024, March). SECURE ACCESS SERVICE EDGE(SASE): "EVALUATING THE IMPACT OF CONVERGED NETWORK SECURITYARCHITECTURES IN CLOUD COMPUTING." *Journal of Emerging Technologies and Innovative Research*. <https://www.jetir.org/papers/JETIR2403481.pdf>
- [56] Ayyalasomayajula, Madan Mohan Tito, Sathishkumar Chintala, and Sandeep Reddy Narani. "Optimizing Textile Manufacturing With Neural Network Decision Support: An Ornstein-Uhlenbeck Reinforcement Learning Approach." *Journal of Namibian Studies: History Politics Culture* 35 (2023): 335-358.
- [57] Vishwanath Gojanur , Aparna Bhat, "Wireless Personal Health Monitoring System", *IJETCAS:International Journal of Emerging Technologies in Computational and Applied Sciences*,eISSN: 2279-0055,pISSN: 2279-0047, 2014. [Link]
- [58] Ayyalasomayajula, Madan Mohan Tito, et al. "Proactive Scaling Strategies for Cost-Efficient Hyperparameter Optimization in Cloud-Based Machine Learning Models: A Comprehensive Review." *ESP Journal of Engineering & Technology Advancements (ESP JETA)* 1.2 (2021): 42-56.
- [59] Mistry, H., Shukla, K., & Patel, N. (2024). Transforming Incident Responses, Automating Security Measures, and Revolutionizing Defence Strategies throughAI-Powered Cybersecurity. *Journal of Emerging Technologies and Innovative Research*, 11(3), 25. <https://www.jetir.org/>
- [60] Ayyalasomayajula, M., & Chintala, S. (2020). Fast Parallelizable Cassava Plant Disease Detection using Ensemble Learning with Fine Tuned AmoebaNet and ResNeXt-101. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, 11(3), 3013-3023.
- [61] Aparna Bhat, "Comparison of Clustering Algorithms and Clustering Protocols in Heterogeneous Wireless Sensor Networks: A Survey," 2014 *INTERNATIONAL JOURNAL OF SCIENTIFIC PROGRESS AND RESEARCH (IJSPR)*-ISSN : 2349-4689 Volume 04- NO.1, 2014. [Link]
- [62] Ayyalasomayajula, Madan Mohan Tito, et al. "Implementing Convolutional Neural Networks for Automated Disease Diagnosis in Telemedicine." 2024 *Third International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE)*. IEEE, 2024.

- [63] Shashikant Tank Kumar Mahendrabhai Shukla, Nimeshkumar Patel, Veeral Patel, 2024." AI BASED CYBER SECURITY DATA ANALYTIC DEVICE", 414425-001, [Link]
- [64] Ayyalasomayajula, Madan Mohan Tito, Akshay Agarwal, and Shah Nawaz Khan. "Reddit social media text analysis for depression prediction: using logistic regression with enhanced term frequency-inverse document frequency features." *International Journal of Electrical and Computer Engineering (IJECE)* 14.5 (2024): 5998-6005.
- [65] Aparna Bhat, Rajeshwari Hegde, "Comprehensive Study of Renewable Energy Resources and Present Scenario in India," 2015 IEEE International Conference on Engineering and Technology (ICETECH), Coimbatore, TN, India, 2015. [Link]
- [66] Ayyalasomayajula, Madan Mohan Tito. "Innovative Water Quality Prediction For Efficient Management Using Ensemble Learning." *Educational Administration: Theory and Practice* 29.4 (2023): 2374-2381.
- [67] Sarangkumar Radadia Kumar Mahendrabhai Shukla, Nimeshkumar Patel, Hiren Kumar Mistry, Keyur Dodiya 2024." CYBER SECURITY DETECTING AND ALERTING DEVICE", 412409-001, [Link]
- [68] Ayyalasomayajula, Madan Mohan Tito, Srikrishna Ayyalasomayajula, and Sailaja Ayyalasomayajula. "Efficient Dental X-Ray Bone Loss Classification: Ensemble Learning With Fine-Tuned VIT-G/14 And Coatnet-7 For Detecting Localized Vs. Generalized Depleted Alveolar Bone." *Educational Administration: Theory and Practice* 28.02 (2022).
- [69] Aparna K Bhat, Rajeshwari Hegde, 2014. "Comprehensive Analysis Of Acoustic Echo Cancellation Algorithms On DSP Processor", *International Journal of Advance Computational Engineering and Networking (IJACEN)*, volume 2, Issue 9, pp.6-11. [Link]
- [70] Ayyalasomayajula, M. M. T., Chintala, S., & Sailaja, A. (2019). A Cost-Effective Analysis of Machine Learning Workloads in Public Clouds: Is AutoML Always Worth Using? *International Journal of Computer Science Trends and Technology (IJCTST)*, 7(5), 107-115.
- [71] Nimeshkumar Patel, 2022." QUANTUM CRYPTOGRAPHY IN HEALTHCARE INFORMATION SYSTEMS: ENHANCING SECURITY IN MEDICAL DATA STORAGE AND COMMUNICATION", *Journal of Emerging Technologies and Innovative Research*, volume 9, issue 8, pp.193-202. [Link]
- [72] Bhat, A., & Gojanur, V. (2015). Evolution Of 4g: A Study. *International Journal of Innovative Research in Computer Science & Engineering (IJRCSE)*. Booth, K. (2020, December 4). How 5G is breaking new ground in the construction industry. *BDC Magazine*. <https://bdcmagazine.com/2020/12/how-5g-is-breaking-new-ground-in-the-constructionindustry/>. [Link]
- [73] Nimeshkumar Patel, 2021." SUSTAINABLE SMART CITIES: LEVERAGING IOT AND DATA ANALYTICS FOR ENERGY EFFICIENCY AND URBAN DEVELOPMENT", *Journal of Emerging Technologies and Innovative Research*, volume 8, Issue 3, pp.313-319. [Link]
- [74] Bhat, A., Gojanur, V., & Hegde, R. (2014). 5G evolution and need: A study. In *International conference on electrical, electronics, signals, communication and optimization (EESCO) – 2015*. [Link]
- [75] Chintala, S., & Ayyalasomayajula, M. M. T. (2019). OPTIMIZING PREDICTIVE ACCURACY WITH GRADIENT BOOSTED TREES IN FINANCIAL FORECASTING. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, 10(3), 1710-1721. <https://doi.org/10.61841/turcomat.v10i3.14707>
- [76] A. Bhat, V. Gojanur, and R. Hegde. 2015. 4G protocol and architecture for BYOD over Cloud Computing. In *Communications and Signal Processing (ICCSP)*, 2015 International Conference on. 0308-0313. Google Scholar. [Link]
- [77] Akbar Doctor, 2023." Biomedical Signal and Image Processing with Artificial Intelligence Chapter Manufacturing of Medical Devices Using Artificial Intelligence-Based Troubleshooters", Springer Nature Switzerland AG, Volume 1, PP-195-206. [LINK]
- [78] DOCTOR A., VONDENBUSCH B., KOZAK J., Bone segmentation applying rigid bone position and triple shadow check method based on RF data, *Acta of Bioengineering and Biomechanics*, 2011, Vol. 13, 3-11. [LINK]
- [79] Rajarao Tadimety Akbar Doctor, 2016." A METHOD AND SYSTEM FOR FLICKER TESTING OF LOADS CONTROLLED BY BUILDING MANAGEMENT DEVICES", patent Office IN, Patent number-201641009974, Application number, 201641009974, [LINK]
- [80] Rajarao Tadimety Akbar Doctor, Sambiah Gunkala, 2016." A Method and System For Automated Light Intensity Testing Of Building Management, patent Office IN, Patent number 201641001890, Application number 201641001890, [LINK].
- [81] Rajarao Tadimety Akbar Doctor, 2015." A Method And System For Analysing Electronic Circuit Schematic" Patent office IN, Patent number 6529/CHE/2014, Application number 201641001890, [LINK].
- [82] Shrikaa Jadiga, "Big Data Engineering Using Hadoop and Cloud (GCP/AZURE) Technologies," *International Journal of Computer Trends and Technology*, vol. 72, no. 8, pp.60-69, 2024., [Link]
- [83] Shrikaa Jadiga, A. S. (2024). AI Applications for Improving Transportation and Logistics Operations. *International Journal of Intelligent Systems and Applications in Engineering*, 12(3), 2607-2617 [Link]
- [84] Amrisha Solanki, Kshitiz Jain, Shrikaa Jadiga, "Building a Data-Driven Culture: Empowering Organizations with Business Intelligence," *International Journal of Computer Trends and Technology*, 2024; 72, 2: 46-55. [Link]

- [85] Darji P., Patel J., Patel B., Chudasama A., Fnu P.I.J., Nalla S. A comprehensive review on anticancer natural drugs. *World J. Pharm. Pharm. Sci.* 2024; 13:717-734. [Link]
- [86] Ankitkumar Tejani, 2021. "Assessing the Efficiency of Heat Pumps in Cold Climates: A Study Focused on Performance Metrics", *ESP Journal of Engineering & Technology Advancements* 1(1): 47-56. [Link]
- [87] Ankitkumar Tejani, 2021. "Integrating Energy-Efficient HVAC Systems into Historical Buildings: Challenges and Solutions for Balancing Preservation and Modernization", *ESP Journal of Engineering & Technology Advancements* 1(1): 83-97. [Link]
- [88] Vedamurthy Gejjegondanahalli Yogeshappa, 2024. "AI - Driven Innovations in Patient Safety: A Comprehensive Review of Quality Care", *International Journal of Science and Research (IJSR)*, Volume 13 Issue 9, September 2024, pp. 815-826, [Link]
- [89] Vikramraj Kumar Thiyagarajan, 2024. "Predictive Modeling for Revenue Forecasting in Oracle EPBCS: A Machine Learning Perspective", *International Journal of Innovative Research of science, Engineering and technology (IJIRSET)*, Volume 13, Issue 4, [Link]
- [90] Sunil Kumar Suvvari (2022). Managing Project Scope Creep: Strategies for Containing Changes. *Innovative Research Thoughts*, 8(4), 360-371. <https://doi.org/10.36676/irt.v8.i4.1475>
- [91] Sunil Kumar Suvvari (2022). Project Portfolio Management: Best Practices for Strategic Alignment. *Innovative Research Thoughts*, 8(4), 372-385. <https://doi.org/10.36676/irt.v8.i4.1476>
- [92] Sunil Kumar Suvvari (n.d.). *Project manager, University of Central Missouri, 116 W South St, Warrensburg, Missouri, USA, 64093*. <https://doi.org/10.56726/IRJMETS18095>