Original Article

A Comparative Analysis on MRR of Plain Epoxy Composite with Reinforcement of 10 wt% of Pista Shell Particles Novel Composite using CNC Machining

B. Venkataraman[1], A.Bovas Herbert Bejaxhin[2*], R. Saravanan[3]

[1]Research scholar,Department of Mechanical Engineering,Saveetha School of Engineering,Saveetha Institute of Medical and Technical Sciences,Saveetha University, Chennai, Tamil Nadu, India, Pincode: 602105.

[2]Project Guide, Department of Mechanical Engineering,Saveetha School of Engineering,Saveetha Institute of Medical and Technical Sciences,Saveetha University, Chennai, Tamil Nadu, India, Pincode: 602105.

[3]Research Supervisor and Corresponding Author,Department of Mechanical Engineering,Saveetha School of Engineering,Saveetha Institute of Medical and Technical Sciences,Saveetha University, Chennai, Tamil Nadu, India, Pincode:602105

Abstract

Aim: The objective of this paper is to investigate the Material removal rate of 10% of pista shell powder reinforced epoxy composite compared to plain epoxy resin composite.

Materials and Methods: Experiment was carried out for two groups namely Group 1 (Plain Epoxy Resin composites) and Group 2 (10% of pista shell powder reinforced epoxy composite). The sample size calculation was done using a G power calculated and pre-test power is 80% mean value and standard deviation are 0.5 and 0.1 for without filler and 0.2 and 0.06 for filler respectively and 16 samples per group were taken for study. Pista shell powder contains heavy calcium carbonate. Statistical analysis was performed using the SPSS software tool.G power is taken as 80%.

Results: It was inferred from the results that the material removal rate of the plain epoxy resin composite was 0.510 mm^3/min and 10% of pista shell powder reinforced epoxy composite was 0.798 mm^3/min. The significance value obtained from statistical value analysis $p=0.00$; $p<0.05$ and hence no significant variation observed between the groups.

Conclusion: Within the limitations of the study,it is found that the Material removal rate of novel 10% of pista shell powder reinforced Novel polymer composite was better than the plain epoxy resin composite by approximately 30%.

Keywords: Pista shell reinforcement CNC machining, Epoxy hardener, Plain epoxy resin, Novel polymer composite, SPSS software, Material removal rate.

DOI: 10.47750/pnr.2022.13.S04.041

INTRODUCTION

This research is mainly about analyzing the machinability of 10% of pista shell powder reinforced epoxy composite and plain epoxy resin composite to Material Removal Rate (Dave, Patel, and Raval 2012a). It is done by CNC machining operation of 10% of pista shell powder reinforced epoxy composite compared to plain Epoxy hardener resin composite and comparing its results to find the improved material removal rate value (Yadav, Ram, and Negi 2019). CNC Drilling of 10% of pista shell powder reinforced Epoxy hardener composite is done to improve the hardness for better quality. Epoxy resin composite can be used to replace non-biodegradable novel polymers composite for roofing in automobiles. Pista shell powder contains cellulose (42%), lignin (13.5%), cellulose lignin (3.11%), ash (1.26%) and extractable (0.18%) (Dave, Patel, and Raval 2012b)(Thomas, Hosur, and Chirayil 2019),(Momber and Kovacevic 2012)(Dave, Patel, and Raval 2012b).

The total number of related articles published in the previous years in Google Scholar citations is 59 and in Science Direct is 112. Pista shell powder reinforced composite can be used for aerospace, automotive parts, roofing in automobiles, boat interiors, office products, toys and building construction materials, machinery etc, (Fu et al.

2008). When adding Pista shell reinforcement to a novel polymer composite, the material removal rate of the Epoxy hardener composite improves (Paulo Davim 2009). The CNC machining of pista shell powder filled composites shows better surface finish by approximately 30 %. More force is required for drilling pista shell powder filled with novel polymer composite when compared with pista shell powder unfilled polymer composite (Yao et al. 2014). Considered that the filler material has a major impact on the overall mechanical properties of novel polymer composites and can be used to improve mechanical properties (Momber and Kovacevic 2012). When Pista shell reinforcement is added to an unique polymer composite, The best study among the above Paper is the Epoxy hardener composite's material removal rate improves (Paulo Davim 2009).Our team has extensive knowledge and research experience that has translate into high quality publications(Bhansali et al. 2021; Jayanth et al. 2021; Sudhakar, Ravel, and Perumal 2021; Sathiyamoorthi et al. 2021; Deepanraj et al. 2021; Raju et al. 2021; Arun Prakash et al. 2020; Kamath et al. 2020; Shanmugam et al. 2021; Rajasekaran et al. 2020; Adhinarayanan et al. 2020; Rajesh et al. 2020; Aurtherson et al. 2021)

No research has been carried out using this novel filler in fiber composites. In this research These pista shell powder have high calcium carbon content which in turn increases the material removal rate of pista shell powder filled with Epoxy hardener composite. Addition of Pista shell reinforcement composite will also improve material removal rate due to stront chemical bonding. In this research comparison of two groups, pista shell powder filled epoxy composite and plain Epoxy hardener composite were investigated for their material rate and analyzed using the SPSS software tool (Emmanual and Karthikeyan 2018).

MATERIALS AND METHODS

The fabrication was done in a central workshop and machining was done in Saveetha Industries, Institute of Mechanical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai. Ethical approval for this project is not applicable since we are not working on human samples. Epoxy resin (LY556) was the matrix material used for fabrication of composite materials(Patnaik, Kozeschnik, and Kukshal 2021). It was purchased from a private vendor in Poonamallee, Chennai. Pista shell was prepared by making powder of natural pistachio shells. Two groups were selected for experimental investigation. Group 1 is Plain Epoxy Resin composites and Group 2 is 10% of Pista shell reinforcement epoxy composites. (Palaniappan et al. 2020) Sample size is 32 (16 for each group) was calculated using g-power calculated and pre-test power is 95% mean value and standard deviation are 0.5 and 0.1 for without filler and 0.2 and 0.06 for filler respectively. G-power is taken as 80% (Chaturvedi, Narang, and Sahu 2018).

In Group 1, the plain epoxy resin (LY556) and hardener (HY951) was mechanically stirred in a container for about 10 minutes in 10:1 ratio as shown in Fig. 1 and formed into plates on mica sheet (300 x 300 x 3 mm) and folding by using hand layup method. The curing time for composite is 24-36 hrs.

In Group 2, the fabrication of Pista shell reinforcement was done by mixing epoxy resin (LY556) and hardener (HY951) and stirring in a container for about 10 minutes in 10:1 ratio added with 10 wt% of pista shell powder and formed into plates on mica sheet (300x300x3mm) in Fig. 2 by using hand layup technique. The curing time for composite is about 24-36 hrs.

The CNC machining was carried out in a machine by varying of input parameters i.e. speed, feed rate and depth of cut on different levels, datas are collected of control group (Plain Epoxy Composites) for 16 samples and Epoxy 10% reinforced pista shell powder composites for 16 samples in Fig. 3. MRR values for Epoxy 10% reinforced pista shell powder composites varied from 0.548 mm^3/min to 0.798 mm^3/min and the values of Plain Epoxy Composites varied from 0.410 mm^3/min to 0.510 mm^3/min.

The data from the VMC machine which shows in the FANUC is drilling time. Volume of the cut is found using the formula $3.14 \times r^2 \times h$, where ‘r' is the radius of the hole and ‘h' is the height of the hole, which in this case is the thickness of the plate. Material removal rate (MRR) is found using the ratio of volume with respect to time, after drilling (Emmanual and Karthikeyan 2018).

STATISTICAL ANALYSIS

The SPSS software was used to compare the values of plain epoxy composites, the mean surface average was plotted in Y-axis and the epoxy 10% reinforced pista shell powder composite was in X-axis as shown in Fig. 5.

The composite had three independent variables namely depth of cut (mm), feed rate (mm/rev) and speed (m/min). The material removal rate was dependent variable (MRR) in mm^3/min, (i.e) any change in independent variable the values of material removal rate was affected. These statistics were used to identify the significant parameter and its analysis was done (Pant, Mishra, and Mishra 2020).

RESULTS

The CNC machining experiments are performed on experimental and control groups based on the independent input parameters as shown in Fig. 1 and Fig. 4 and their values as shown in Table 1 and the determined surface roughness value of the drilled hole are shown in Fig. 2 and Fig. 3 their values as shown in Table 2 and 3. The comparison graph is also plotted using the SPSS software tool and its significance is analyzed.

In Table.1, the specimens are machined under these input parameters with different levels. In Table 2, the MRR values of 16 samples drilled on plain epoxy composites are tabulated. The values of speed (m/min), depth of cut (mm) and feed rate (mm/rev) are given as the input parameters and the corresponding MRR values are obtained by simple calculation. The least value of MRR is 0.410 mm^3/min when machined with plain epoxy composites during the 1th trial at a speed of 500 m/min, 0.08mm depth of cut and 0.5mm/rev feed rate. In Table 3,The MRR values of 16 samples machined with the 10% reinforced pista shell powder composites. The values of speed (m/min), depth of cut (mm) and feed rate (mm/rev) are given as the input parameters while testing and the MRR values are calculated accordingly. The least value of MRR is 0.548 mm^3/min when machined with 10% reinforced Pista shell reinforcement composites during the 5th trial at a speed of 700m/min, 0.08mm depth of cut and 0.5mm/rev feed rate.

In Table 4,the t-test table shows the standard deviation value for both plain epoxy composites and 10% reinforced pista shell powder composites. In Table 5**,** an independent sample test is tabulated to find the significance of the samples machined with both the composites by finding the T-test for equality of means with its significance in 2 tailed processes. The significance value is found to be 0.00 which is higher than $p<0.05$ and hence there is no significance among the considered groups. From Fig. 4**,** the bar chart shows the comparison of the mean average value of the samples machined with both plain epoxy composites and 10% reinforced pista shell powder composites. As expected the value of the MRR is improved in the sample when drilled with the 10% reinforced pista shell powder composites than the plain epoxy composites as shown in Fig. 5.

DISCUSSION

By this study we compare two different types of composites in which we found that 10% reinforced pista shell powder composites give a maximum of MRR. Using filler filled composites, the maximum MRR is found to be 0.798 mm^3/min using 500 m/min of speed, 0.16mm of depth of cut and 1.3mm/rev of feed rate. Minimum MRR is registered as 0.548 mm^3/min. Using without filler composites, the maximum MRR was obtained as 0.510 with the influence of 700 m/min of speed, 0.08 mm of depth of cut and 0.5mm/rev of feed rate. Minimum MRR was registered as 0.410 mm^3/min. Test results show that 10% reinforced pista shell powder composites give maximum MRR when compared to plain epoxy composites.

The MRR of the composite was significantly improved with the usage of filler composites when it is compared to without filler composites with a significance value of 0.005 (Dave, Patel, and Raval 2012a). Also other parameters which were influencing MRR are depth of cut and feed rate which is similarly stated in (Masooth et al. 2020). If feed rate and depth of cut increases then MRR will also increase (Sathish and Karthick 2020). Based on this it can be stated that the material removal rate is improved by 30%. This is a newly reinforced composite (10% reinforced pista shell powder composites) required to get improved surface finish and lower depth of cut for this composite (Sultan et al. 2020). There is no opposite research analysis observed in MRR findings.

This study considered only 10% reinforced pista shell powder composites. In future, research work can be expanded to the volume fractions of 5wt%, 15wt%, 25 wt% and 30wt% to improve material removal properties of composites This is a novel reinforced composite (10 percent reinforced pista shell powder composites) that requires a better surface polish and a less cut depth This research compares two distinct types of composites and finds that 10% reinforced pista shell powder composites have the highest MRR.

CONCLUSION

Within the limitations of the study, the drilling studies on plain epoxy composite and 10% reinforced pista shell powder composite using HSS drill bit and the performance of these materials were evaluated based on the measured material removal rate. Outcome of these experiments show that 10% reinforced pista shell powder exhibits better material removal rate than plain epoxy composites. The results of conducted experiments show the depth of cut, speed and feed rate are the most significant factors of material removal rate.

DECLARATION

Conflict of interests

The authors declare that there is no conflict of interest.

Authors contribution

Author BVR was involved in data collection, data analysis, manuscript writing. Author TMD was involved in conceptualization, data validation, and critical review of manuscript.

Acknowledgement

The authors would like to express their gratitude towards Saveetha Industries, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding

We thank the following organizations for providing financial support that enabled us to complete the study

1. Neel Industry Pvt. Ltd, Kuthambakkam, Chennai, Tamil Nadu,India
2. Saveetha University
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering

REFERENCES

1. Adhinarayanan, Rajesh, AravindhRamakrishnan, Gopal Kaliyaperumal, Melvinvíctor De Poures, Rajesh Kumar Babu, and DamodharanDillikannan. 2020. "Comparative Analysis on the Effect of 1-Decanol and Di-N-Butyl Ether as Additive with diesel/LDPE Blends in Compression Ignition Engine." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, June, 1–18.
2. Arun Prakash, V. R., J. Francis Xavier, G. Ramesh, T. Maridurai, K. Siva Kumar, and R. Blessing Sam Raj. 2020. "Mechanical, Thermal and Fatigue Behaviour of Surface-Treated Novel Caryota Urens Fibre–reinforced Epoxy Composite." *Biomass Conversion and Biorefinery*, August. https://doi.org/10.1007/s13399-020-00938-0.
3. Aurtherson, P. Babu, Bhanu Teja Nalla, Karthikeyan Srinivasan, Kulmani Mehar, and Yuvarajan Devarajan. 2021. "Biofuel Production from Novel Prunus Domestica Kernel Oil: Process Optimization Technique." *Biomass Conversion and Biorefinery*, May. https://doi.org/10.1007/s13399-021-01551-5.
4. Bhansali, Karan J., Kamlesh R. Balinge, Subodh U. Raut, Shubham A. Deshmukh, M. Senthil Kumar, C. Ramesh Kumar, and Pundlik R. Bhagat. 2021. "Visible Light Assisted Sulfonic Acid-Functionalized Porphyrin Comprising Benzimidazolium Moiety for Photocatalytic Transesterification of Castor Oil." *Fuel* 304 (November): 121490.
5. Chaturvedi, Poornesh Kumar, Harendra Kumar Narang, and Atul Kumar Sahu. 2018. "Optimization of MRR and Surface Roughness of AlMg3 (AA5754) Alloy in CNC Lathe Machine by Using Taguchi Method." *Applied Mechanics and Materials*. https://doi.org/10.4028/www.scientific.net/amm.877.110.
6. Dave, H. K., L. S. Patel, and H. K. Raval. 2012a. "Effect of Machining Conditions on MRR and Surface Roughness during CNC Turning of Different Materials Using TiN Coated Cutting Tools – A Taguchi Approach." *International Journal of Industrial Engineering Computations*. https://doi.org/10.5267/j.ijiec.2012.04.005.
7. ———. 2012b. "Effect of Machining Conditions on MRR and Surface Roughness during CNC Turning of Different Materials Using TiN Coated Cutting Tools – A Taguchi Approach." *International Journal of Industrial Engineering Computations*. https://doi.org/10.5267/j.ijiec.2012.04.005.
8. Deepanraj, B., N. Senthilkumar, D. Mala, and A. Sathiamourthy. 2021. "Cashew Nut Shell Liquid as Alternate Fuel for CI Engine—optimization Approach for Performance Improvement." *Biomass Conversion and Biorefinery*, February. https://doi.org/10.1007/s13399-021-01312-4.
9. Emmanual, L., and T. Karthikeyan. 2018. "Investigation of Surface Roughness and Material Removal Rate on Machining of TIB2 Reinforced Aluminum 6063 Composites: A Taguchi's Approach." *Mechanics and Mechanical Engineering*. https://doi.org/10.2478/mme-

2018-0102.
10. Fu, Shao-Yun, Xi-Qiao Feng, Bernd Lauke, and Yiu-Wing Mai. 2008. "Effects of Particle Size, Particle/matrix Interface Adhesion and Particle Loading on Mechanical Properties of Particulate–polymer Composites." *Composites Part B: Engineering*. https://doi.org/10.1016/j.compositesb.2008.01.002.
11. Jayanth, BellappuVenkat, Melvin Victor Depoures, Gopal Kaliyaperumal, DamodharanDillikannan, DilipsinghJawahar, KumaranPalani, and Ganesha Prasad MeravanigeeShivappa. 2021. "A Comprehensive Study on the Effects of Multiple Injection Strategies and Exhaust Gas Recirculation on Diesel Engine Characteristics That Utilize Waste High Density Polyethylene Oil." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, June, 1–18.
12. Kamath, Manjunath, Subha Krishna Rao, Jaison, Sridhar, Kasthuri, Gopinath, Sivaperumal, and Shantanu Patil. 2020. "Melatonin Delivery from PCL Scaffold Enhances Glycosaminoglycans Deposition in Human Chondrocytes – Bioactive Scaffold Model for Cartilage Regeneration." *Process Biochemistry* 99 (December): 36–47.
13. Masooth, P. Haja Syeddu, P. Haja Syeddu Masooth, V. Jayakumar, and G. Bharathiraja. 2020. "Experimental Investigation on Surface Roughness in CNC End Milling Process by Uncoated and TiAlN Coated Carbide End Mill under Dry Conditions." *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2019.10.036.
14. Momber, Andreas W., and Radovan Kovacevic. 2012. *Principles of Abrasive Water Jet Machining*. Springer Science & Business Media.
15. Palaniappan, S. P., K. Muthukumar, R. V. Sabariraj, S. Dinesh Kumar, and T. Sathish. 2020. "CNC Turning Process Parameters Optimization on Aluminium 6082 Alloy by Using Taguchi and ANOVA." *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2019.10.053.
16. Pant, Prita, Sushil K. Mishra, and Purna Chandra Mishra. 2020. *Advances in Mechanical Processing and Design: Select Proceedings of ICAMPD 2019*. Springer Nature.
17. Patnaik, Amar, Ernst Kozeschnik, and VikasKukshal. 2021. *Advances in Materials Processing and Manufacturing Applications: Proceedings of iCADMA 2020*. Springer Nature.
18. Paulo Davim, J. 2009. *Drilling of Composite Materials*. Nova Science Pub Incorporated.
19. Rajasekaran, S., D. Damodharan, K. Gopal, B. Rajesh Kumar, and Melvin Victor De Poures. 2020. "Collective Influence of 1-Decanol Addition, Injection Pressure and EGR on Diesel Engine Characteristics Fueled with diesel/LDPE Oil Blends." *Fuel* 277 (October): 118166.
20. Rajesh, A., K. Gopal, De Poures Melvin Victor, B. Rajesh Kumar, A. P. Sathiyagnanam, and D. Damodharan. 2020. "Effect of Anisole Addition to Waste Cooking Oil Methyl Ester on Combustion, Emission and Performance Characteristics of a DI Diesel Engine without Any Modifications." *Fuel* 278 (October): 118315.
21. Raju, P., K. Raja, K. Lingadurai, T. Maridurai, and S. C. Prasanna. 2021. "Glass/Caryota Urens Hybridized Fibre-Reinforced nanoclay/SiC Toughened Epoxy Hybrid Composite: Mechanical, Drop Load Impact, Hydrophobicity and Fatigue Behaviour." *Biomass Conversion and Biorefinery*, March. https://doi.org/10.1007/s13399-021-01427-8.
22. Sathish, T., and S. Karthick. 2020. "Wear Behaviour Analysis on Aluminium Alloy 7050 with Reinforced SiC through Taguchi Approach." *Journal of Materials Research and Technology*. https://doi.org/10.1016/j.jmrt.2020.01.085.
23. Sathiyamoorthi, Ramalingam, Gomathinayakam Sankaranarayanan, Dinesh Babu Munuswamy, and Yuvarajan Devarajan. 2021. "Experimental Study of Spray Analysis for Palmarosa Biodiesel-diesel Blends in a Constant Volume Chamber." *Environmental Progress & Sustainable Energy* 40 (6). https://doi.org/10.1002/ep.13696.
24. Shanmugam, Rajasekaran, DamodharanDillikannan, Gopal Kaliyaperumal, Melvin Victor De Poures, and Rajesh Kumar Babu. 2021. "A Comprehensive Study on the Effects of 1-Decanol, Compression Ratio and Exhaust Gas Recirculation on Diesel Engine Characteristics Powered with Low Density Polyethylene Oil." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* 43 (23): 3064–81.
25. Sudhakar, M. P., Merlyn Ravel, and K. Perumal. 2021. "Pretreatment and Process Optimization of Bioethanol Production from Spent Biomass of GanodermaLucidum Using Saccharomyces Cerevisiae." *Fuel* 306 (December): 121680.
26. Sultan, Mohamed Thariq Hameed, Azwan Iskandar Azmi, MohdShukryAbd Majid, MohdRidzuanMohd Jamir, and Naheed Saba. 2020. *Machining and Machinability of Fiber Reinforced Polymer Composites*. Springer Nature.
27. Thomas, Sabu, Mahesh Hosur, and Cintil Jose Chirayil. 2019. *Unsaturated Polyester Resins: Fundamentals, Design, Fabrication, and Applications*. Elsevier.
28. Yadav, Om Prakash, Mangey Ram, and PawanNegi. 2019. *Basics of CNC Programming*. River Publishers.
29. Yao, Zhitong, Meisheng Xia, Liuqin Ge, Tao Chen, Haiyan Li, Ying Ye, and Hao Zheng. 2014. "Mechanical and Thermal Properties of Polypropylene (PP) Composites Filled with CaCO3 and Shell Waste Derived Bio-Fillers." *Fibers and Polymers*. https://doi.org/10.1007/s12221-014-1278-5.

TABLES AND FIGURES

Table 1. Input parameters (speed, feed rate, depth of cut)

Index	Factor description	Level 1	Level 2	Level 3	Level 4
A	Speed(m/min)	500	700	900	1100
B	Depth of Cut(mm)	0.08	0.12	0.16	0.2
C	Feed rate (mm/rev)	0.5	0.9	1.3	1.7

Table 2. Material removal rate of plain epoxy drilled with given speed, feed rate, depth of cut.

Trail	Factor A	Factor B	Factor C	Speed (m/min) A	Depth of Cut (mm) B	Feed rate (mm/rev) C	Material removal rate (mm^3/min)
1	1	1	1	500	0.08	0.5	0.410
2	1	2	2	500	0.12	0.9	0.430
3	1	3	3	500	0.16	1.3	0.420
4	1	4	4	500	0.2	1.7	0.440
5	2	1	2	700	0.08	0.5	0.430
6	2	2	1	700	0.12	0.9	0.510
7	2	3	4	700	0.16	1.3	0.430
8	2	4	3	700	0.2	1.7	0.410
9	3	1	3	900	0.08	0.5	0.420
10	3	2	4	900	0.12	0.9	0.410
11	3	3	1	900	0.16	1.3	0.430
12	3	4	2	900	0.2	1.7	0.450
13	4	1	4	1100	0.08	0.5	0.430
14	4	2	3	1100	0.12	0.9	0.410
15	4	3	2	1100	0.16	1.3	0.420
16	4	4	1	1100	0.2	1.7	0.440

Table 3. Material removal rate of plain epoxy with 10 wt% of pista shell powder drilled with given speed, feed rate, depth of cut.

Trail	Factor A	Factor B	Factor C	Speed (m/min) A	Depth of Cut (mm) B	Feed rate (mm/rev) C	Material removal rate(mm^3/min)
1	1	1	1	500	0.08	0.5	0.706
2	1	2	2	500	0.12	0.9	0.696
3	1	3	3	500	0.16	1.3	0.798
4	1	4	4	500	0.2	1.7	0.696
5	2	1	2	700	0.08	0.5	0.548
6	2	2	1	700	0.12	0.9	0.658
7	2	3	4	700	0.16	1.3	0.764
8	2	4	3	700	0.2	1.7	0.594
9	3	1	3	900	0.08	0.5	0.626
10	3	2	4	900	0.12	0.9	0.698
11	3	3	1	900	0.16	1.3	0.778
12	3	4	2	900	0.2	1.7	0.726
13	4	1	4	1100	0.08	0.5	0.688
14	4	2	3	1100	0.12	0.9	0.733

15	4	3	2	1100	0.16	1.3	0.677
16	4	4	1	1100	0.2	1.7	0.633

Table 4. T-Test mean value, standard deviation level and standard error level of given polymer values.

Group Statistics					
	COMPOSITE	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
MRR	**WITH FILLER**	16	.68869	.066491	.016623
	WITHOUT FILLER	16	.43063	.024350	.006087

Table 5. Independent sample T-test t is performed for the two groups for significance and standard error determination. P value is less than 0.05 and it is considered to be statistically significant.

Independent samples test										
		Levene' Test For equality of Variances		**T-test For Equality of Means**						
		F	**sig**	**t**	**df**	**Sig 2**	**Mean difference**	**Std error difference**	**95% confidence interval of the difference**	
									lower	**upper**
MRR	**Equal variances assumed**	9.0	0.00	14.57	30	.000	.258	.0177	.2219	.2942
	Equal Variances Not assumed			14.57	18.9	.000	.258	.0177	.2210	.2951

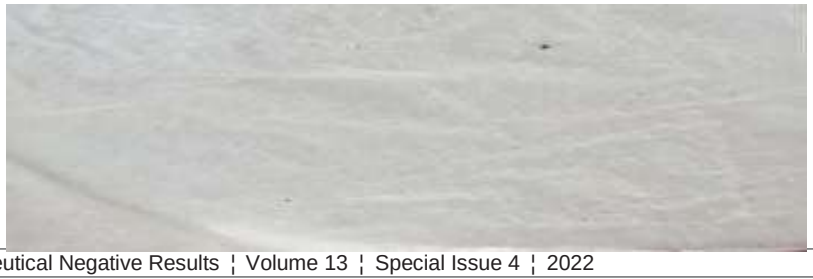

Fig. 1. Epoxy resin (LY556) and Hardener (HY951) mixture

Fig. 2. Epoxy + 10wt% pista shell powder reinforcement

Fig. 3. CNC machined Plain epoxy 16 samples drilled by 8mm drill bit.

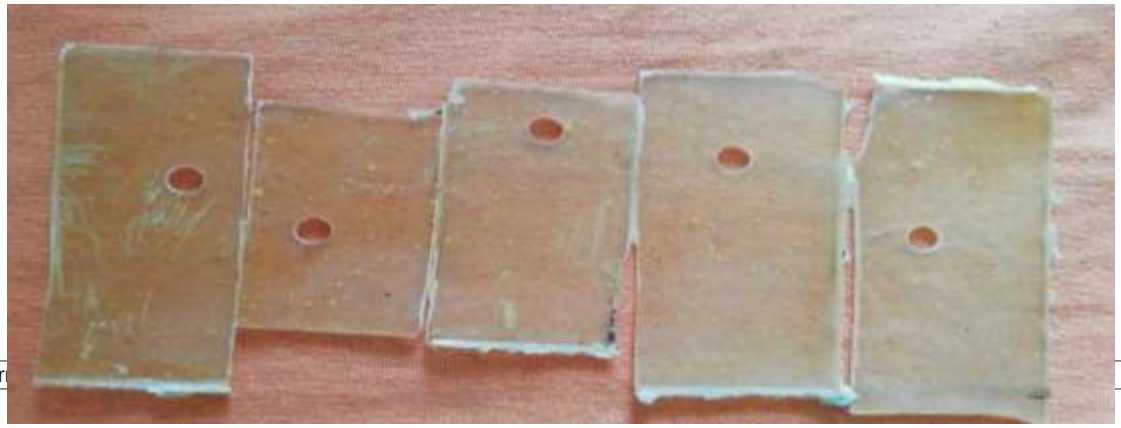

Fig. 4. CNC machined Plain epoxy + 10% pista shell powder 16 samples drilled by 8mm drill bit

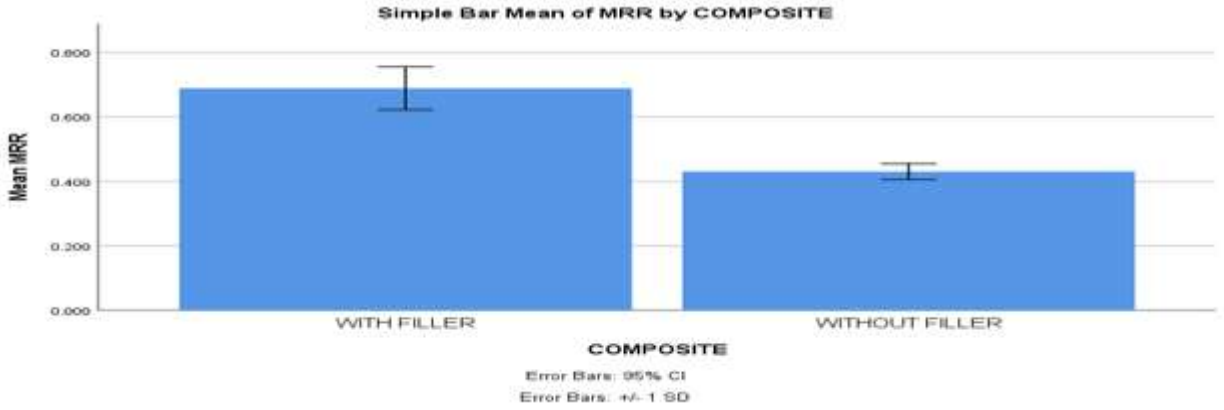

Fig. 5. Comparison of reinforced pista shell powder composites (With filler) or Plain Epoxy composites (Without filler) in terms of mean accuracy. The Mean accuracy of reinforced pista shell powder composites (With filler) better than Plain Epoxy composites (Without filler). The standard deviation of reinforced pista shell powder composite is slightly better than Plain Epoxy composites. X Axis: With VS without filler, Y Axis: Mean accuracy of detection ± 1SD.