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Fabrication And Study Of Drilling Parameters On Banana-Pineapple Hybrid Natural Fibre Reinforced Composites

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Abstract: *In the rapid developing world, environmental pollution and the prevention of non-renewable and non-biodegradable resources has become a concern which attracted researchers to develop new eco-friendly materials based on sustainability principles. Thenaturalfibers provide indisputable advantages over artificial reinforcement materials such as low cost, low density, non-toxicity, comparable strength and minimum waste disposal problems. In the present work, banana pine-apple fiber reinforced epoxy composites are prepared using hand layup technique. The composite samples with different fiber weight fractions of banana/ pineapple 15/0, 10/5, 7.5/7.5, 5/15, 0/15 are considered for fabrication. The material removal rate, torque, thrust force, delamination effectswere investigatedduring drilling operationwithdifferent diameters(6mm, 8mm, 10mm) at different speed and feed.*

Keywords: *Banana-Pineapple, Fibre reinforced composites, CNC drilling machine, Drilling parameters, Epoxy resin, Thrust force, Weight ratios, Material removal rate, De-lamination, Torque..*

I. Introduction

Resin systems such as epoxies and polyesters have limited use for the manufacture of structures.Since their mechanical properties are not good enoughwhen compared to most of the metals.Materials such as glass, aramid and boron have extremely high tensile and compressive strength but in solid form these properties are not readily apparent. The most common hybrid composites are carbon-aramid reinforced epoxy (which combines strength and impact resistance) and glass-carbon reinforced epoxy (which gives a strong material at a reasonable price). Hybridization with some amounts of synthetic fibres makes these natural fibre composites more suitable for technical applications such as automotive interior parts. Natural fibres article is to provide a comprehensive review of the foremost appropriate as well as widely used natural fibre reinforced polymer composites (NFPCs) and their applications. The properties of NFPCs vary with fibre type and fibre source as well as fibre structure. Many researchers found the effects of various chemical treatments on the mechanical and thermal properties of natural fibres reinforcements thermosetting and thermoplastics composites were studied. Impact of chemical treatment on the water absorption, tribology, viscoelastic behaviour, relaxation behaviour, energy absorption flames re-tendency, and biodegradability properties of NFPCs were also highlighted. The applications of NFPCs in automobile and construction industry and other applications are demonstrated. It is concluded that chemical treatment of the natural fibre improved adhesion between the fibre surface and the polymer matrix which ultimately enhanced physical, mechanical and thermochemical properties of the NFPCs.There are considerable enhancement and suggestions for the natural fibres that can be implemented in order to enhance their mechanical properties resulting in high strength and structure.Thechemical treatment with 2% NaOH leadsto clean fibres by removing the amorphous compounds and to increase of crystallinity index of the fibre bundles. The effects of alkali NaOH treatment for various concentrations (0.5%, 1%, 2%, 5%, 10%, 15%, and 20%) on the mechanical properties of banana/epoxy composite were investigated. The results reported were compared to other treated and untreated fibre composites, 2% NaOH treated fibre reinforced composites have better properties. Alkali treatment showed a rise in the composites tensile strength in comparison to untreated composites and with 4% NaOH treated fibres, optimum tensile strength was seen for resulted composites.M. Ramesh et al [1] has investigated the Processing and Mechanical Property Evaluation of Banana Fibre Reinforced Polymer Composites.The properties like tensile strength, flexural strength, impact strength were increased by increasing the reinforcement. The SEM analysis shows the cracks formed at various locations of the fabricated composites during the loading. M Ramesh et al [2] has studied the Influence of tool materials on thrust force and delamination in drilling sisal-glass fibre reinforced polymer composites, The thrust force increased with the feed rate, the Max delamination is with HSS tool bit and the main input parameters for drilling are feed rate and the type of drill tool. R vinayagamurthy et al [3] has given the analysis of Surface and sub-surface hybrid polymer composites during machining operations.The delamination entry and exit are highly influenced by feed rate, surface roughness influenced by speed followed by feed rate and surface roughness decreases with increase in feed rate and tool angle.M. Sakthivel [4] has reported the Drilling Analysis on Basalt/Sisal Reinforced Polymer Composites Using ANOVA and Regression Model The optimum process parameters are chosen for drilling in BSRPC with Drill bit diameter at 3mm, speed at 300 rpm and feed rate at 0.1mm/rev for monitoring thrust force and delamination whose results obtained provides impetus concomitant.K. A. Jagtap [5] has reported the Effect of Drilling Parameters for the Assessment of Roughness of Drilled Holes in Glass Fibre Reinforced Plastic (GFRP)As far as the effect of input factors are considered, the factor spindle speed is having dominating effect on final surface quality of drilled hole in GFRP substrate, while the feed rate shows the secondary effect on roughness of drilled holes.

II. Materials and Methodology

2.1 Materials: For the fabrication of the composites, Polymer Epoxy Resin (Epoxy LY 556) was selected as matrix. Epoxy LY 556 resin, chemically belonging to the 'epoxide' and its common name is Bisphenol ADiglycidylEther and was reinforces with two types of natural reinforcements by varying different weight fractions. The banana and Pineapple fibres are taken as reinforcements and finally (HY951) was used as the hardenerduring the fabrication of all the composites. The properties of banana fibre were given in Table 1. A wooden mould of 200X200X5 mm was prepared by using teak wood to obtain required cavities of the composites.


Fig**: 1 (a) Pineapple and banana fibers** **Fig 1 (b) After drying and combing**


Fig: 1(c) Resin and hardener Fig: 1(d)Mould of composite plate

Table1. Properties of Banana Fibers:

Tenacity g/denier	Fineness	Moisture Regain	Elongation	Alco-ben Extractives%	Total Cellulose	Alpha Cellulose	Residual Gum	Lignin%
29.98	17.15	13.00%	6.54	1.70	81.80%	61.50%	41.90%	15.00

2.2. Methodology: The composites were fabricated by using hand layup technique Fig 2. For this, chemical treatment named as combing process of the reinforcements in diluted Nacl solution was carried out to remove moisture content, impurities and to increase the flexural strength. For the fabrication of these composites, initially epoxy resin (Araldite LY 556) and corresponding hardener (HY951) are well mixed with glass rod in the weight ratio of 10:1. The temperature of this well mixed composition was increased during the mixing process; hence it was cooled in air before the fabrication process. Hardeners include anhydrides (acids), amines, polyamides, dicyandiamide etc. For the fabrication of the composites, the required compositions of fibers, matrix and hardener were weighed and are separated. For easy removal of the final composite, a polythene paper was placed inside the mould and was brushed with wax. The well mixed hardener epoxy was layered on the polythene sheet then number of plies for each fiberwas taken as two i.e. total number of plies used in hybrid composite are four, an alternate fibers were arranged in every composite and the layers were separated by the mixture of resin hardener. The proper hand rolling process was done at every stage of the pliesto remove air gaps in the cavities. A 20 kg weight was applied on the composite for about 72 hours to allow sufficient time for curing and subsequent hardening.Finally, the Natural fiber composite samples with different fiber weight fractions of banana/ pineapple 15/0, 10/5, 7.5/7.5, 5/15, 0/15 were fabricated by using hand layup technique.

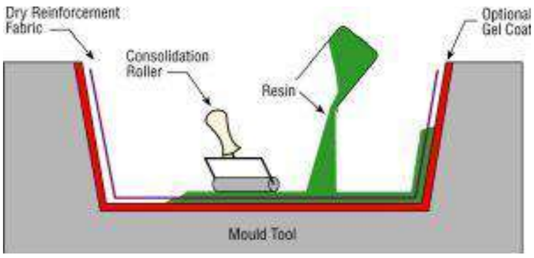


Fig.2(a)Hand Lay-up technique

Fig.2(b)Test Specimen after curing

Table 2 Composition and designation of composites

S. No	Weight % of Reinforcement		(%) of Epoxy Matrix	% of Total reinforcement
	Banana	Pineapple		
1	15	0	85	15
2	10	5	85	15
3	7.5	7.5	85	15
4	5	10	85	15
5	0	15	85	15

III. Results And Discussion

3.1 Experimental setup

A number of drilling experiments were carried out on a CNC machining centre (Maxmill) using HSS twist drills for the machining of NFRP composites. Conventional high-speed steel twist drills were used as much as cemented tungsten carbide drills. Tool geometry is a relevant aspect to be considered in drilling of fibber-reinforced composites, particularly when the quality of the machined hole is critical. The properties were found on the fabricated compositesby drilling three types of holes6mm, 8mm and 10mm diametersunder the CNC drilling machine.

Final test specimen for the different compositions is obtained after drilling. Further the study of delamination is made under the profile projector by measuring the diameter of the laminated hole. The drilling parameters are to be obtained by taking the formulas from data books and the results are to be presented in results and discussion.

3.2Cutting forces in drilling

This can be conveniently resolved into three components, a tangential component PZ, a radial component PY and an axial component PX. PX is the thrust force in drilling.The following equations are taken from Machine Design Data and Metal cutting theory books.

Material removal rate = 3.14/4 *d^2*f*N (cm^3/min)

Thrust force (PX) = 0.195HBS^0.8 d^0.8+0.0022HB d^2 (N)

Torque (PZ) =C d^2 S^0.8 HB^0.7 (N-cm)

Where: HB= Brinel 's hardness number , S = feed (m/rev),

d = diameter of drill bit (m), C = constant = 2x10^6

Fig. 3 Final Test specimen after drilling

3.3 Test Results:

3.3.1 for pure banana plate

Table.3 WhenDiameter 6mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm^3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.038	1.001	3.658	191.171	27.02
600	0.4	1.046	1.098	7.433	338.213	42
600	0.6	1.156	1.16	13.617	571.298	60.89
800	0.2	1.026	1.036	4.523	320.77	36.48
800	0.4	1.043	1.048	9.047	667.126	59.991
800	0.6	1.018	1.018	13.579	784.016	71.25
1000	0.2	1.145	1.018	5.654	522.542	49.388
1000	0.4	1.0165	1.008	11.309	100.398	75.308
1000	0.6	1.135	1.03	16.964	137.586	95.438

Table.4 Diameter 8 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm^3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.008	1.101	6.031	186.899	26.68
600	0.4	1.102	1.085	12.063	338.213	42.006
600	0.6	1.016	1.137	18.095	441.819	53.841
800	0.2	1.095	1.112	8.042	377.968	40.308
800	0.4	1.021	1.025	16.084	572.42	55.22
800	0.6	1.008	1.028	24.127	772.487	70.721
1000	0.2	1.007	1.007	10.053	501.42	48.104
1000	0.4	1.015	1.012	21.106	883.493	70.113
1000	0.6	1.005	1.02	30.159	1238.92	90.25

Table.5Diameter 10 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm^3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.03	1.084	9.424	232.466	30.197
600	0.4	1.082	1.09	18.849	319.103	40.793
600	0.6	1.077	1.098	28.275	550.095	59.78
800	0.2	1.009	1.094	12.566	319.975	36.433
800	0.4	1.015	1.062	25.132	565.435	54.86
800	0.6	1.022	1.038	37.699	766.754	70.45
1000	0.2	1.074	1.025	15.707	568.14	52.124
1000	0.4	1.086	1.085	31.415	1011.418	75.72
1000	0.6	1.091	1.034	47.123	1411.86	96.77

3.3.2 Banana/Pine (10/5) apple plate:

Table.6 Diameter 6mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm^3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.146	1.006	4.561	246.423	32.73
600	0.4	1.156	1.003	9.078	436.564	50.351
600	0.6	1.2	1.04	14.698	651.737	68.423
800	0.2	1.126	1.021	5.742	392.233	43.14
800	0.4	1.14	1.093	11.758	630.465	61.111
800	0.6	1.163	1	18.367	897.311	80.288
1000	0.2	1.023	1.05	5.921	525.82	51.803
1000	0.4	1.023	1.098	11.843	930.14	75.718
1000	0.6	1.008	1.16	17.248	1340.428	98.9

Table.7Diameter 8mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm^3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.085	1.08	7.1	237.902	32.084
600	0.4	1.042	1.098	13.11	424.074	49.603
600	0.6	1.057	1.115	20.236	610.82	66.28
800	0.2	1.09	1.09	9.55	395.857	43.383
800	0.4	1.11	1.107	19.862	716.362	65.494
800	0.6	1.12	1.117	30.265	1006.51	85.144
1000	0.2	1.012	1.01	10.305	526.867	51.868
1000	0.4	1.023	1.018	21.072	931.977	75.862
1000	0.6	1.018	1.015	31.3	1306.934	97.581

Table.8 Diameter 10 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm^3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.005	1.023	9.519	196.264	28.774
600	0.4	1.013	1.042	19.392	341.716	49.443
600	0.6	1.034	1.068	30.229	458.894	57.729
800	0.2	1.006	1.03	12.717	341.566	39.669
800	0.4	1.014	1.048	25.841	607.991	59.931
800	0.6	1.021	1.056	39.299	832.755	77.309
1000	0.2	1.012	1.045	16.087	533.17	52.263
1000	0.4	1.021	1.082	32.749	944.889	76.394
1000	0.6	1.036	1.094	50.577	1345.618	99.103

3.3.3 Banana/Pineapple(15/15) plate:

Table.9 Diameter 6 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm^3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.003	1.011	3.414	208.334	32.43
600	0.4	1.07	1.015	7.769	412.536	53.567
600	0.6	1.12	1.04	12.768	625.177	73.591
800	0.2	1.05	1.001	4.987	421.536	48.866
800	0.4	1	1.02	9.047	677.94	69.413
800	0.6	1.011	1	13.89	958.322	90.952
1000	0.2	1.008	1.008	5.73	592.243	60.444
1000	0.4	1.028	1.106	11.766	1029.124	87.338
1000	0.6	1.026	1.036	17.881	1585.012	118.187

Table.10 Diameter 8 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm^3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.07	1.007	6.905	228.165	34.123
600	0.4	1.028	1.015	12.767	360.325	50.035
600	0.6	1.04	1.017	19.572	510.084	66.723
800	0.2	1.015	1	8.285	379.035	45.841
800	0.4	1.018	1.013	16.693	664.824	68.69
800	0.6	1.04	1.02	35.348	930.878	89.626
1000	0.2	1.095	1.002	12.052	684.254	66.342
1000	0.4	1.052	1.01	22.272	1027.095	87.24
1000	0.6	1.006	1.017	30.537	1506.03	115.005

Table.11 Diameter 10 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Materail Removal Rate (cm^3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.015	1.062	9.709	210.46	32.61
600	0.4	1.014	1.107	19.381	374.88	51.039
600	0.6	1.07	1.009	32.371	525.32	67.669
800	0.2	1.091	1.022	14.957	441.398	50.267
800	0.4	1.014	1.034	25.79	709.604	71.138
800	0.6	1.07	1.052	41.01	897.13	87.973
1000	0.2	1.096	1.041	14.868	690.54	66.739
1000	0.4	1.095	1.031	37.668	1200.108	95.339
1000	0.6	1.098	1.019	56.812	1669.051	121.513

3.3.4Banana/Pineapple (10/20) plate

Table.12 Diameter 6mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.003	1.006	3.415	197.199	29.983
600	0.4	1.013	1.015	6.968	350.221	46.872
600	0.6	1.006	1.023	10.314	478.06	61.397
800	0.2	1.03	1.026	4.799	350.867	41.818
800	0.4	1.005	1.035	9.138	612.418	62.59
800	0.6	1.01	1	13.844	864.015	82.046
1000	0.2	1.03	1.026	4.799	350.867	41.818
1000	0.4	1.005	1.035	9.138	612.418	62.59
1000	0.6	1.01	1	13.844	864.015	82.046

Table.13 Diameter 8 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.003	1.013	6.077	207.82	30.874
600	0.4	1.005	1.01	12.184	344.485	46.49
600	0.6	1.015	1.021	18.642	481.231	61.591
800	0.2	1.08	1.008	9.38	406.194	45.694
800	0.4	1.015	1.017	16.571	624.66	63.255
800	0.6	1.022	1.03	25.225	876.83	82.657
1000	0.2	1.087	1.005	11.889	550.641	52.251
1000	0.4	1.096	1.012	24.162	970.28	80.566
1000	0.6	1.115	1.002	37.494	1347.364	103.191

Table.14 Diameter 10 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.023	1.022	9.863	198.511	30.094
600	0.4	1.064	1.032	21.339	347.21	46.722
600	0.6	1.083	1.044	33.162	490.808	62.173
800	0.2	1.006	1.084	12.717	411.861	60.096
800	0.4	1.012	1.062	25.737	728.677	87.218
800	0.6	1.014	1.09	38.762	1042.65	110.8
1000	0.2	1.074	1.086	17.984	627.65	46.083
1000	0.4	1.085	1.092	36.983	1115.31	68.738
1000	0.6	1.084	1094	55.373	1539.812	90.072

3.3.5Pure pineapple plate:

Table.15 Diameter 6 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.018	1.03	3.519	191.384	27.994
600	0.4	1.04	1.01	7.339	347.549	44.191
600	0.6	1.023	1.09	10.659	465.433	57.276
800	0.2	1.01	1.011	4.584	334.693	38.691
800	0.4	1.012	1.01	9.567	585.622	57.939
800	0.6	1.003	1	14.82	796.071	74.507
1000	0.2	1.042	1.034	5.806	556.62	53.076
1000	0.4	1.046	1.076	11.843	976.587	76.814
1000	0.6	1.034	1.096	22.696	1319.96	96.75

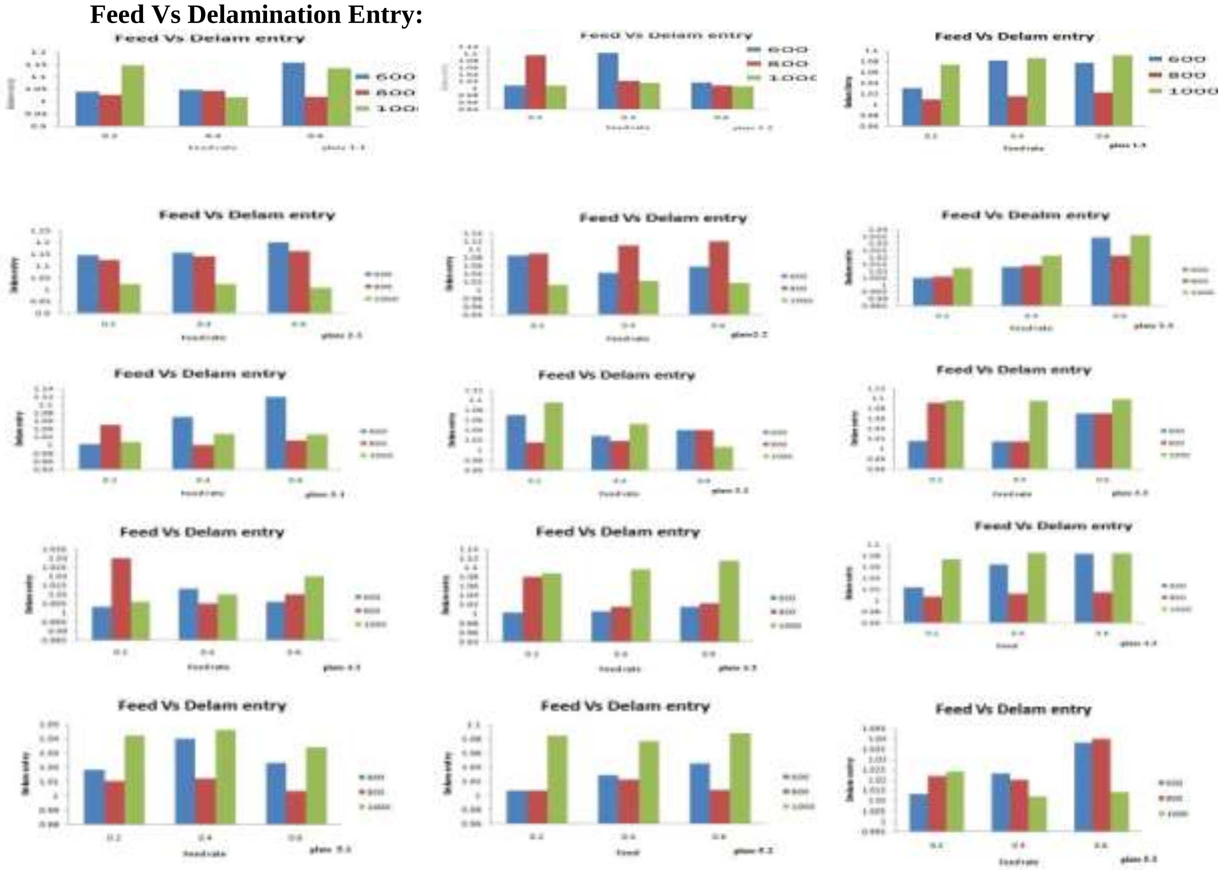
Table.16 Diameter 8 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.006	1.133	6.153	187.024	27.637
600	0.4	1.028	1.12	12.367	337.596	43.691
600	0.6	1.045	1.16	18.231	485.35	58.437
800	0.2	1.006	1.035	8.305	338.847	38.979
800	0.4	1.022	1.23	16.489	585.622	57.931
800	0.6	1.007	1.017	24.49	802.03	74.787
1000	0.2	1.084	1.046	5.806	599.066	55.658
1000	0.4	1.076	1.086	11.843	1033.409	79.336
1000	0.6	1.088	1.098	22.696	1461.431	102.161

Table.17 Diameter 10 mm

Speed (rpm)	Feed rate (mm/rev)	Delamination Entry	Delamination Exit	Material Removal Rate (cm3/min)	Torque (N-cm)	Thrust Force (N)
600	0.2	1.084	1.046	5.806	599.066	55.658
600	0.4	1.076	1.086	11.843	1033.409	79.336
600	0.6	1.088	1.098	22.696	1461.431	102.161
800	0.2	1.013	1.026	10.233	189.509	27.841
800	0.4	1.023	1	20.623	336.499	43.477
800	0.6	1.038	1.133	30.229	594.62	64.476
1000	0.2	1.022	1.052	14.684	343.028	39.268
1000	0.4	1.02	1.03	29.098	606.041	59.012
1000	0.6	1.04	1.012	44.624	854.608	77.224

Feed Vs Delamination Entry:



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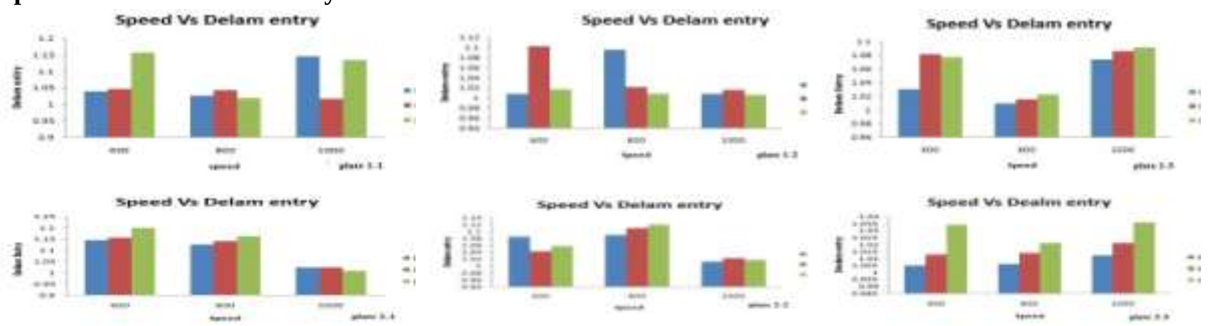

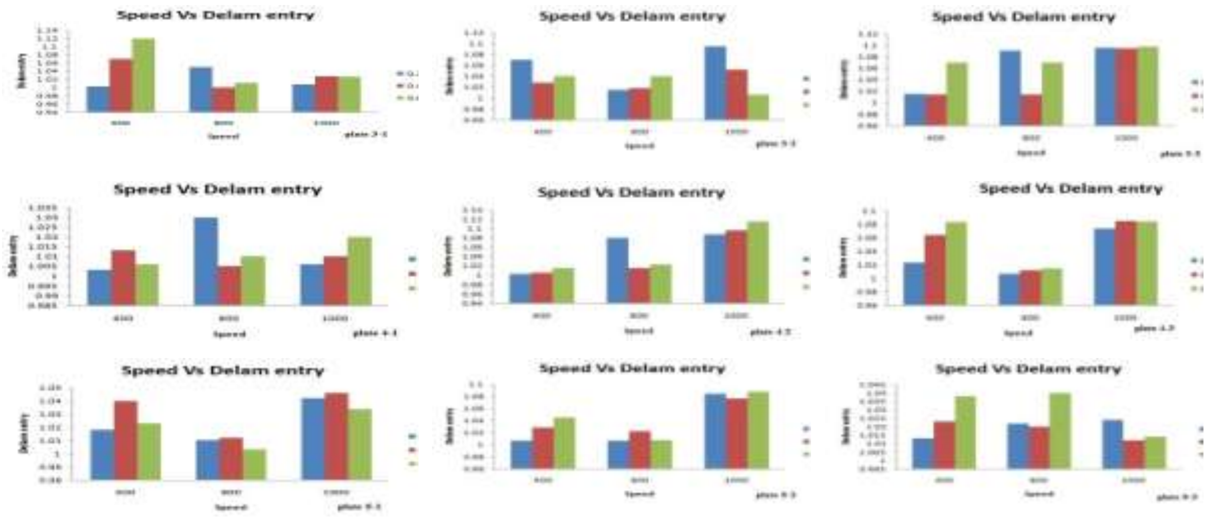

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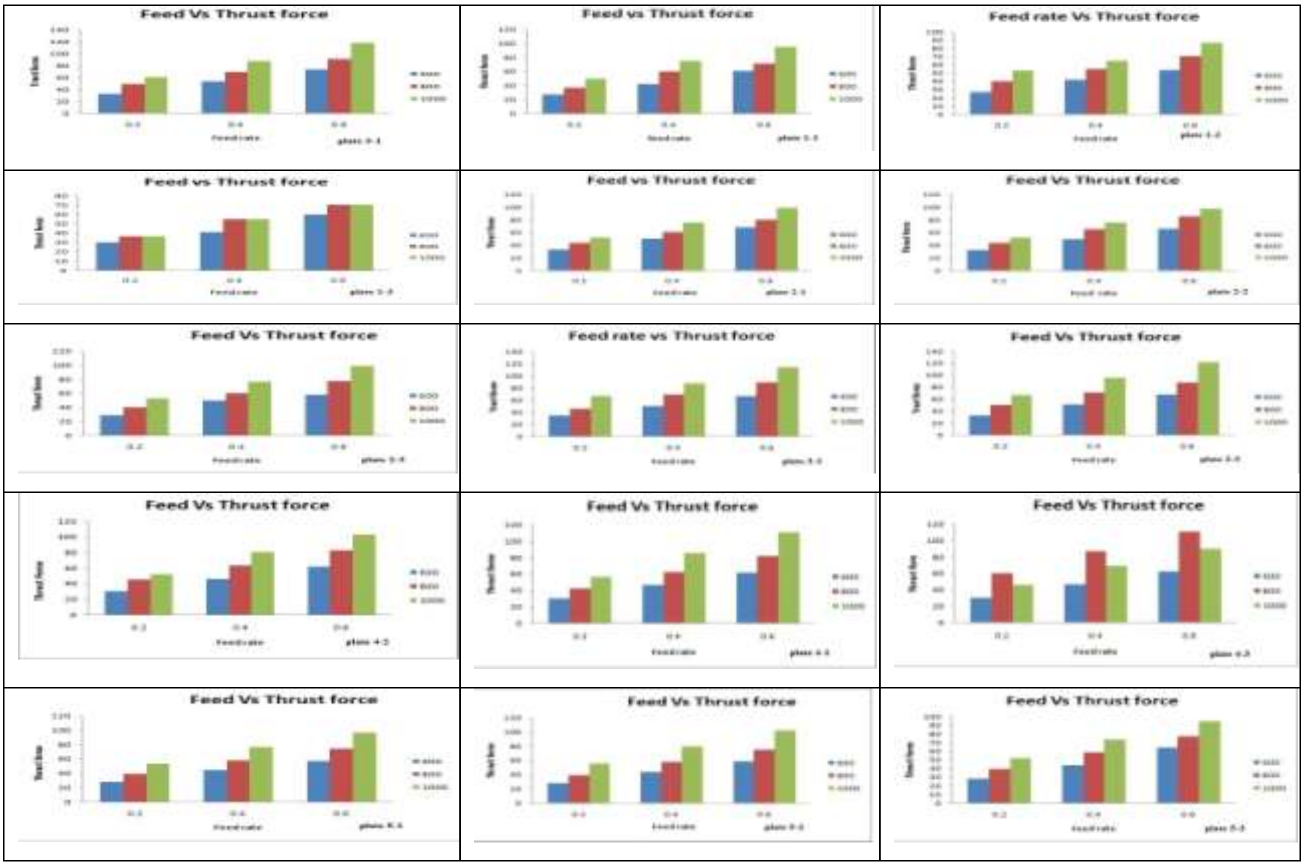

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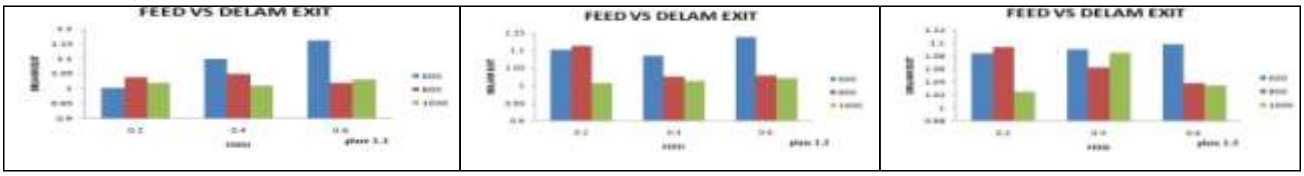
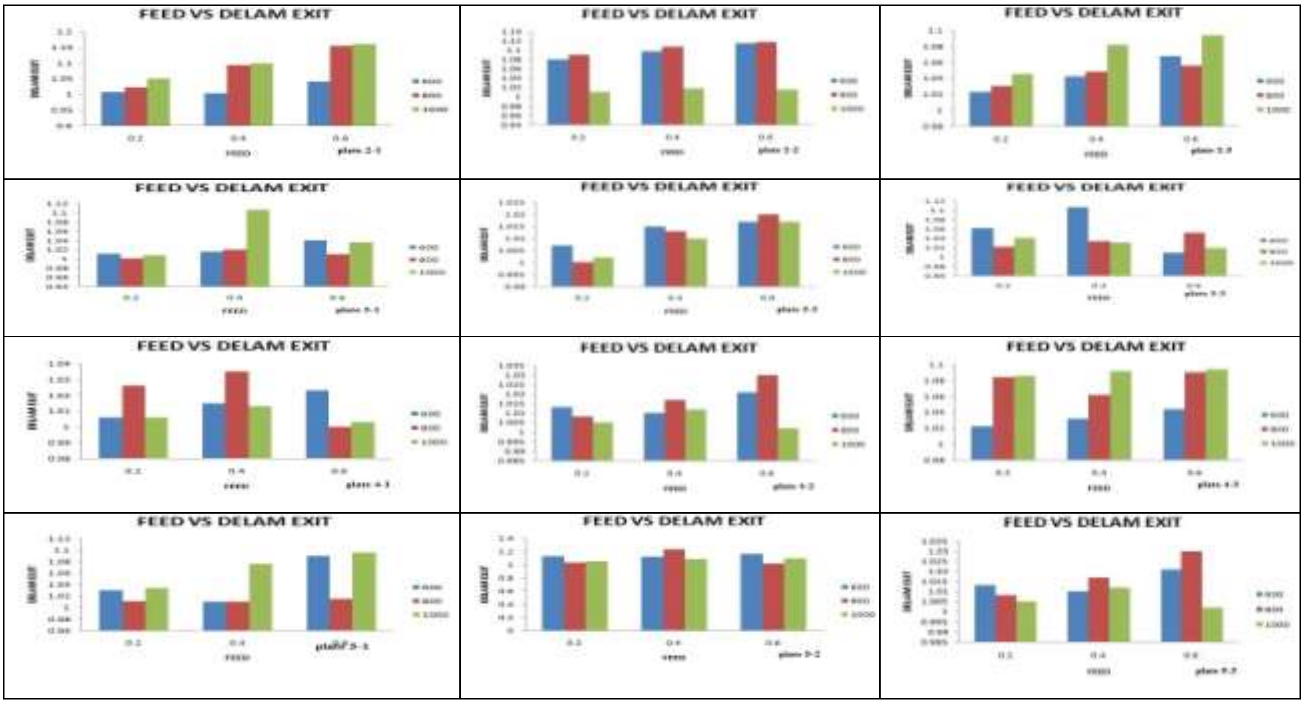
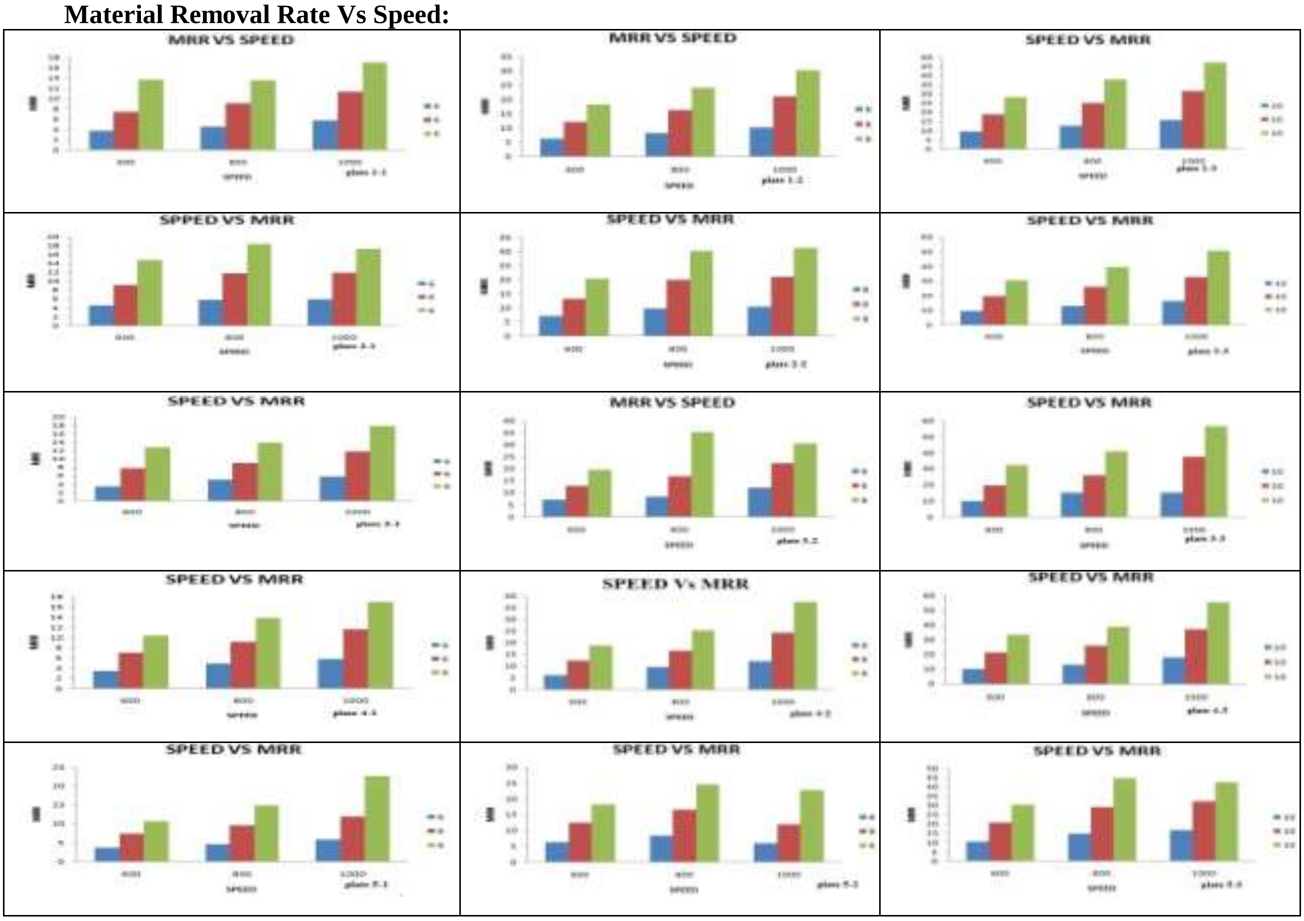
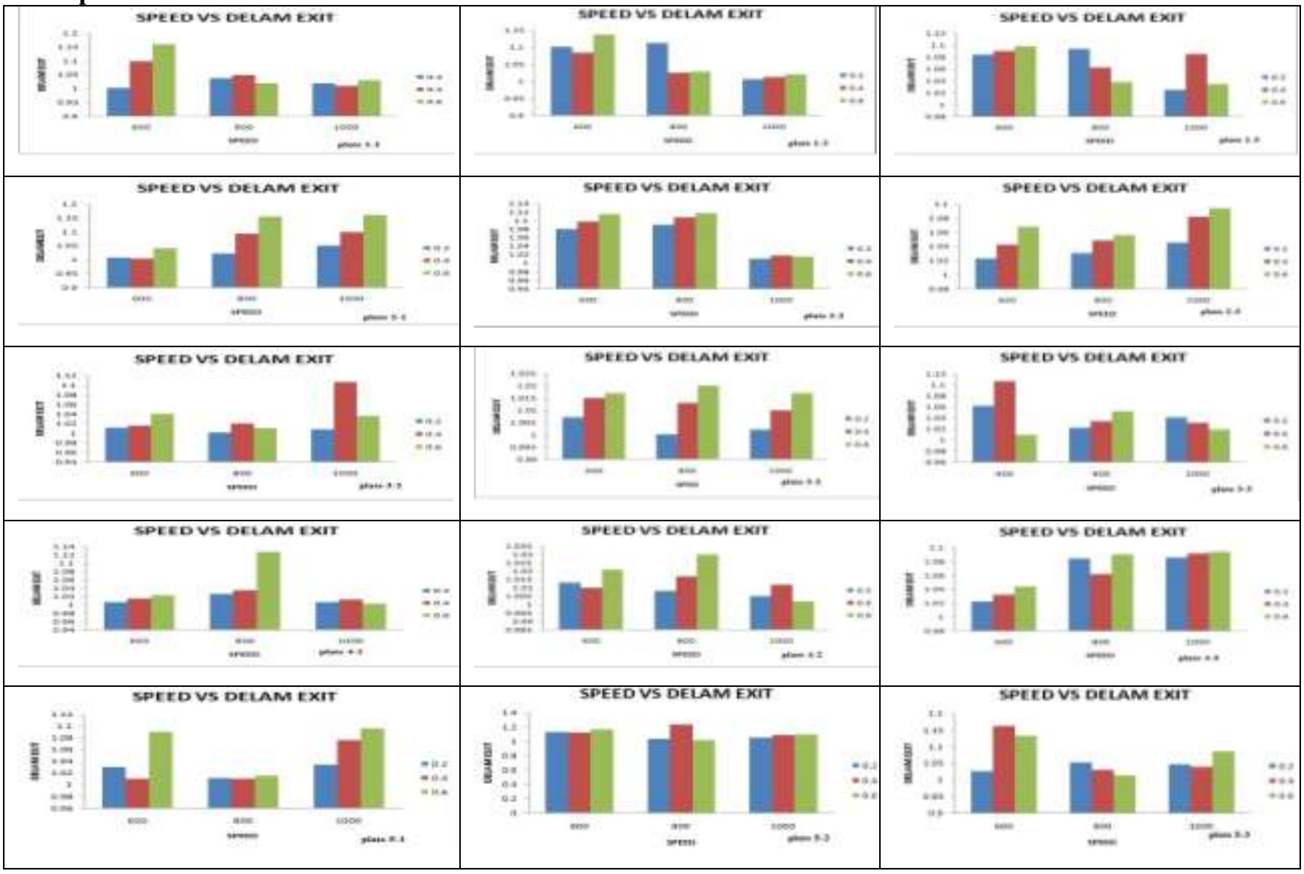




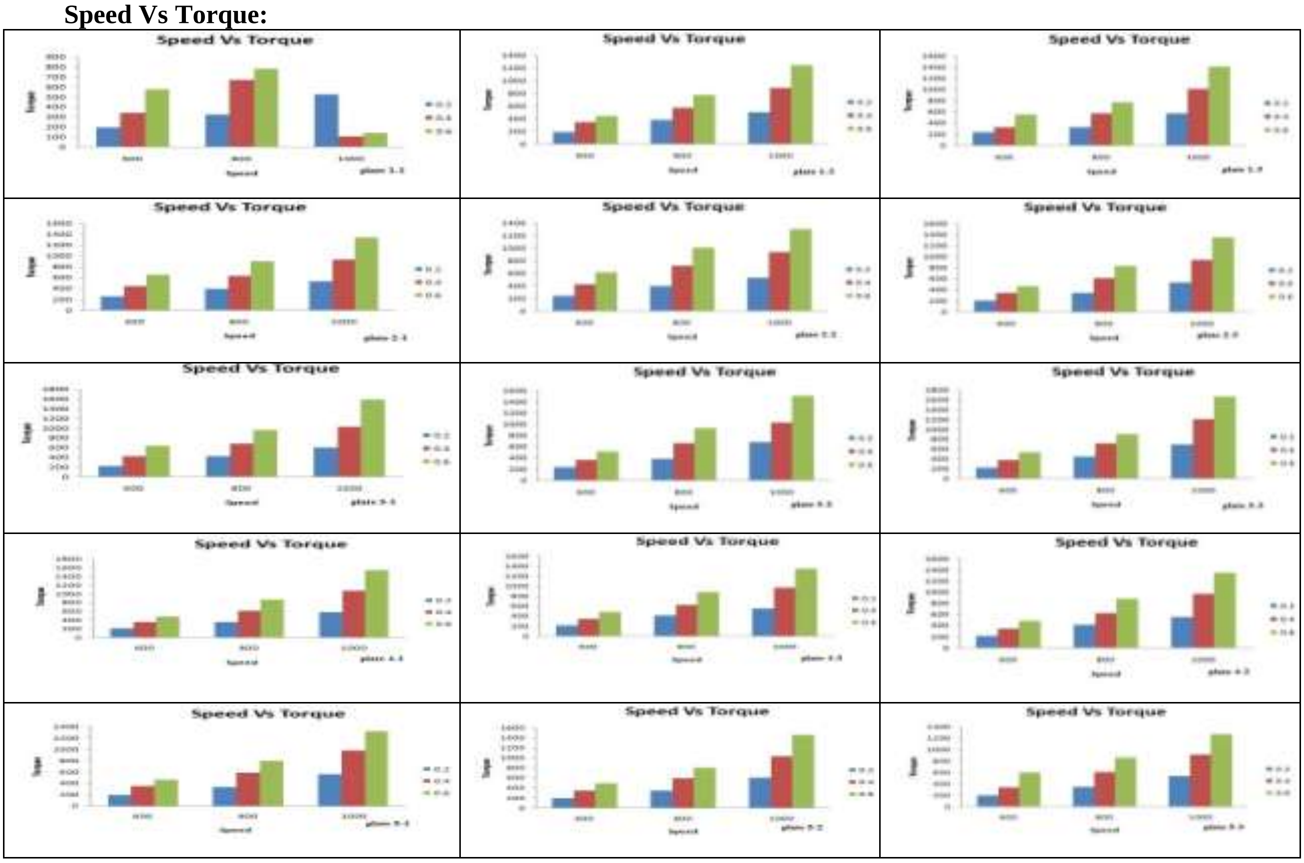
Material Removal Rate Vs Speed:



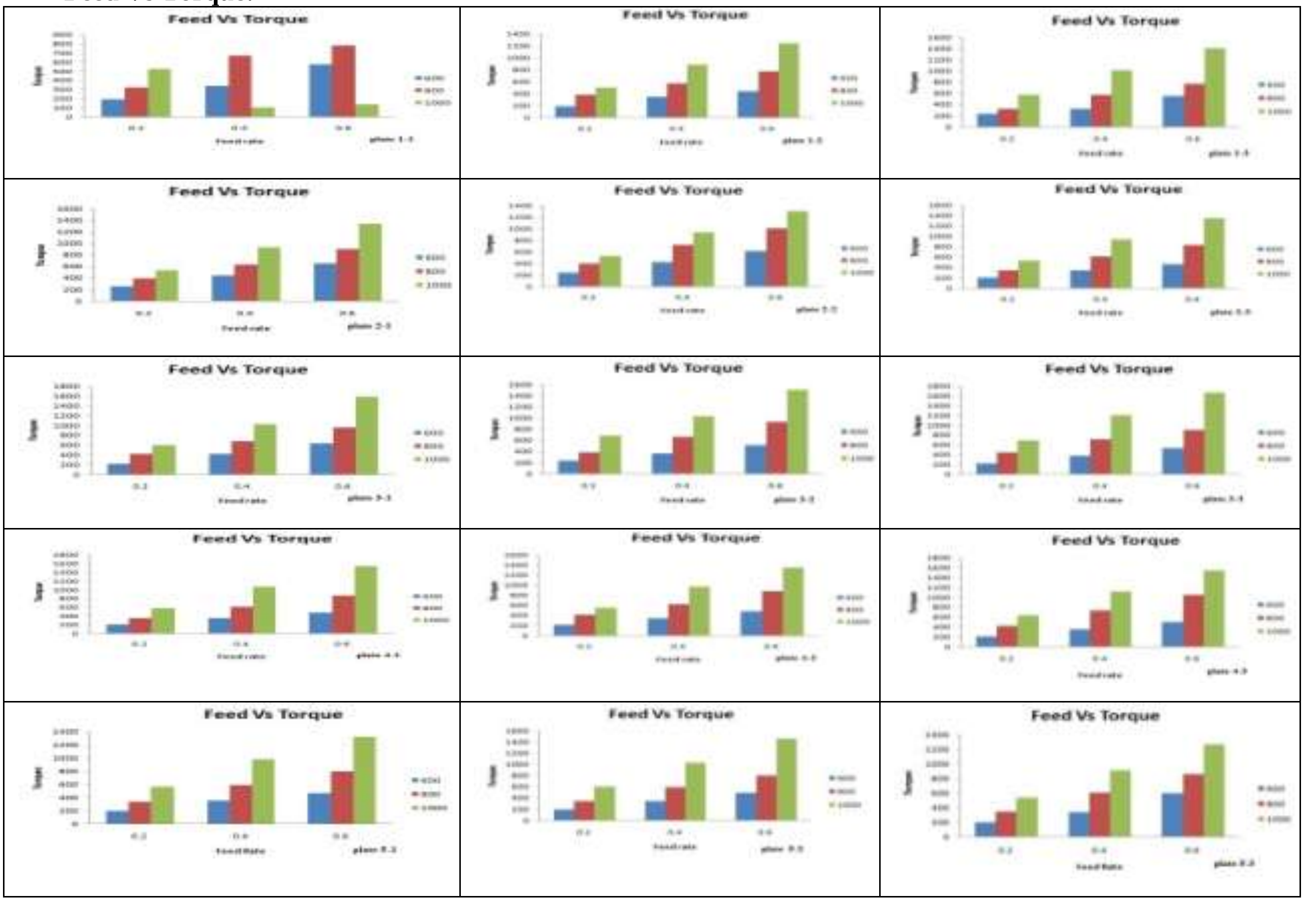
Speed Vs Delamination Exit:



Speed Vs Torque:



Feed Vs Torque:



IV. Conclusions:

In general, the thrust and torque parameters are mainly dependent on the manufacturing conditions feed, cutting speed, tool geometry, machine tool and cutting tool rigidity. A larger thrust force occurs for larger diameter drills and higher feed rates. In other words, feed rate and drill diameter are recognized as the most significant factors affecting the thrust force. Worn-out drill may be one of the major reasons for the drastic increase in the thrust force as well as for the appearance of larger thrust forces. Although tools are worn out quickly and the thrust force increases drastically as cutting speed increases, an acceptable whole entry and exit is maintained. Ingeneral, the thrust force increases with the increase in the feed, this study provides quantitative measurements of such relationships for the present composite materials. In general, increase in cutting speed decreases thrust force. The results indicate that the torque increases as the feed increases. The results indicate that the torque increases with the increase in the fibre volume fraction. Increasing fibre volume fraction increases the static strength, and thus, the resistance of the composite to mechanical drilling increases. This leads to the increase in the required thrust force and torque. The result also indicates that the torque decreases when increasing the cutting speed.

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