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Investigations on Drilling Characterization of Coconut Shell Particle Reinforced Epoxy (CSPE) Composites

Manjunatha Chary G H[1], K Sabeel Ahmed[2]

[1]*Assistant Professor, Dept. of Mechanical Engineering, J N N College of Engineering, Karnataka, India*
[2]*Professor, Dept. of Mechanical Engineering, J N N College of Engineering, Karnataka, India*

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Abstract - In this novel work, experiments were carried out to investigate the drilling characterization of coconut shell particle reinforced epoxy (CSPE) composites. Test samples were fabricated by open mold technique with particle volume fraction of 40% in epoxy resin using 0.25 mm size of particles. The quality of hole and effect of speed and feed on thrust force and torque was investigated by conducting drilling operations using Batlibai radial drilling machine. Two types of drill bits viz., twist drill (118^0) and Multi face drill bits both of 10 mm diameter were used to perform the drilling operations at feed rates of 0.13 mm/rev, 0.18 mm/rev, and 0.25 mm/rev and speeds of 500 rpm, 800 rpm, and 1000 rpm. Results reveal that, best quality of holes was produced at feed rate of 0.13 mm/rev and speed of 500 rpm using twist drill bit.

***Key Words*: Coconut Shell Particle, Drilling Characterization, Particle volume fraction, CSPE Composite.**

1. INTRODUCTION

In the recent years, natural fillers are used as reinforcements to develop the novel composite for use in automobile, aircraft and household applications **[1,2]** due to their several advantages like ease of fabrication, lower density, low cost, degradability, non corrosiveness and high specific strength etc. A Natural filler composite finds an alternative material to wood and overcomes the problem of scarcity of wood resources. Enormous amount of work was carried out to produce polymer matrix composites using natural reinforcement material in the particulate form. Natural particles like rice husk, wheat husk, ground nut shell particles, different types of wood particles, argan nut shell particles, pista shell particles and coco pod particles, coconut shell particles, etc., have been used for several applications as an alternative to conventional materials. Several articles were published by researchers on mechanical and other strength properties of natural filler reinforced polymer composites **[3,4]**. For effective utilization of natural filler composite during the joining and assembly of components, its machining characteristics need to be thoroughly investigated. Drilling is one of the most important machining operations required during assembly of components. Drilling of polymer based composites causes extensive damages like matrix cracking, spalling, particles pull out etc., at the entry and exit of holes that leads to the reduction of strength and service performance of the composite. The severity of damage depends on machining parameters like speed, feed and also on type and geometry of tools used. The effect of thrust force and torque produced during drilling, on the quality of holes was investigated by several researchers. **Tsao [5]** experimentally investigated the thrust force induced in different step core drills (Twist drill, Saw drill and Candle stick drill) with the drill parameters like feed rate, spindle speed etc., during the drilling of oven WFC200 fabric carbon fiber (55 vol %) reinforced epoxy with 16-ply (0^0, 90^0) composite laminates of 4 mm thickness. Tests were carried out at spindle speeds of 800, 1000 and 1200 rpm and feed rates of 8, 12 and 16 mm/min. Test results showed that thrust force in all types of step-core drills increase with decrease in diameter and increase in feed rate. The combination of low feed rate of 8 mm/min and high spindle speed of 1200 rpm for all types of step-core drills could be the best experimental conditions. Step-core-saw drill offers the highest drilling thrust force compared to other drills. **Gaitonde et al [6]** investigated the machinability characteristics, viz., the thrust force, surface roughness of hole and specific cutting coefficient during the hole drilling process of E- Glass fiber (50% and 60% vol. fraction) reinforced LAPOX L-12 epoxy (40%) composites with and without the addition of SiCp filler (10%). Results of the investigation reveal that SiCp-filled glass/epoxy composite exhibited better machinability characteristics when compared to unfilled glass/epoxy composite. **Mariatti et al [7]** conducted tests to study the effect of orbital and conventional hole drilling techniques on tensile properties of continuous fiber impregnated thermoplastic (COFIT) plain weave composites. Composites were developed using continuous unidirectional E-glass fibers reinforced with Acrylonitrile Butadiene Styrene (ABS) matrix material. Results indicated that tensile property of composite with orbital hole drilling exhibited better damage resistance than conventional hole drilling. **Pramendra et al [8]** evaluated experimentally the drilling behavior of sisal fiber mat (20wt. %) reinforced polypropylene composites. The drill bits such as twist drill and trepanning drill of outer diameter of 14 mm and core diameter of 10 mm with a tool tip of 2 mm thickness were used in this analysis. Results of the experiment reported that drill bit geometry has significant influence on drilling force and the cutting speed has least influence during the drilling of composites. Also, thrust force exerted with trepanning drill is relatively low when compared to twist drill during the drilling operation. **Julian**

et al [9] investigated the effect of constituents of composite and cutting speed on the cutting forces induced during drilling of carbon fiber reinforced polymer matrix composites. Three types of composites were fabricated combining two types of woven carbon fiber fabrics (CF0300 and CF2216) and two types of thermoset resins (MTM28B and MTM44-1). The results indicated that matrix materials showed significant influence on maximum thrust force and torque developed while the carbon fiber fabrics revealed insignificant effect on maximum thrust force. Cutting speed exhibited a strong influence on torque developed. In this work, drilling characterization of CSPE composites was also carried out to study the effect of speed and feed on thrust force and torque. Test samples were prepared to experimentally evaluate the effect of particle size and particle volume fraction of CSPE composites.

2. MATERIALS

The materials used for fabrication of composites consists of fully matured coconut shell particles of 0.25 mm size as reinforcement material. The epoxy resin LY556 and hardener HY951 in the ratio of 10:1 was used as matrix. 5% of melamine was also added into the matrix to increase the rate of curing, bonding strength, and to improve the surface finish of the developed composites. The resin, hardener, and melamine were procured from M/s insulation house, Bengaluru, India.

3. FABRICATION OF COMPOSITE

Composites boards were prepared with coconut shell particles of 0.25 mm size in volume fraction of 40% using open mold process. Drilling characterization was studied only on CSPE composite samples (0.25 mm particle size with 40% particle volume fraction), as this composition showed better properties than all other compositions considered **[10]**. Samples were prepared from the composite boards to dimensions of 85 mm × 75 mm ×10 mm to drill two holes for each feed rate at constant speed.

4. DRILLING OPERATION

The drilling operation was carried out for feed rates of 0.13 mm/rev, 0.18 mm/rev, and 0.25 mm/rev at three different speeds of 500 rpm, 800 rpm, and 1000 rpm. The thrust force and torque developed during drilling was recorded using two channel drill tool dynamometer. The peak values of thrust force and torque were tabulated. Two identical holes were drilled at each feed rate and spindle speeds and average values are recorded. Figure 1 shows the process of drilling.

Fig -1: Process of Drilling

5. RESULTS AND DISCUSSION

5.1 Drilling Characterization

5.1.1 Thrust force and Torque measurement

In general, the thrust and torque parameters mainly depend on the manufacturing conditions employed, such as feed, cutting speed, tool geometry and cutting tool rigidity. During the process of drilling, it is observed that, the thrust force contour comprises of four different stages. There is a large thrust force at the entry of the drill into the work piece. The increase in the thrust force represents the elastic loading of work piece due to negative rake angle of chisel edge with zero center speed, henceforth, the chisel edge will extrude into the material instead of cutting the work piece **[5]**. Second stage begins when the chisel edge pierce the work piece. At this moment, due to maximum thrust force and reduction in the stiffness of the work piece, the tool tip penetrates into the work piece upto about 55% of thickness. Further, in the third stage, the cutting of approximately 55% of the thickness along with the induced temperature results in the drop of thrust force up to about 60% of the maximum value. In the fourth stage, the opening of bottom face of the work piece by the tool tip lead to gradual decrease in the thrust force over the drill point length. It is observed that feed rate is the most important factor affecting the thrust force. Also, the thrust developed during drilling causes many problems as explained by Mohan **[11]** and Velayudham **[12]**. Some problems that may arise during drilling of particulate composites are matrix cracking, particles pull out thermal degradation and spalling. Hence, the thrust force and torque developed in drilling operation can be considered as key parameters.

5.1.2 Analysis of Feed v/s Thrust force for different drill bits

It is observed from Figures 2 and 3 that, as the speed and feed is increased, the thrust force will also increase. For all the values of feed and speed, the thrust force in multi face drill bit is larger than the twist drill bit. Also, the difference in the values of thrust force is little bit higher in multi face drill bit when feed and speed are increased. The worn-out dril1 may be the reason for the increase of the thrust force and the same may be the reason for higher value of thrust force in multi face dril1 bit **[13]**.

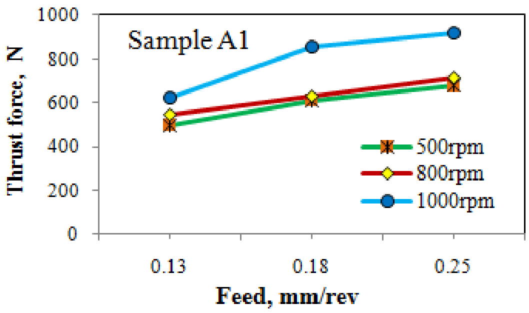

Fig – 2: Thrust force v/s Feed for Twist drill bit

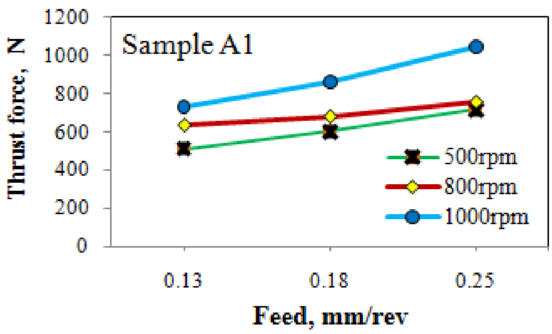

Fig – 3: Thrust force v/s Feed for Multi face drill bit

5.1.3 Analysis of Feed v/s Torque for different drill bits

Figures 4 and 5 revealed the effects of drilling parameters on torque. From the observation of results, as the feed and speed is increased, there is a slight increase in the values of torque. It is also observed that, the increasing trend of torque was much smaller when compared to increasing trend in the values of thrust force when both feed and speed were increased. For all the values of feed and speed, the torque in twist drill bit is slightly higher than the torque induced in multi face drill bit. The reason may be because multi face drill bit consists of two faces that require less torque to drill the hole when compared to twist drill bit.

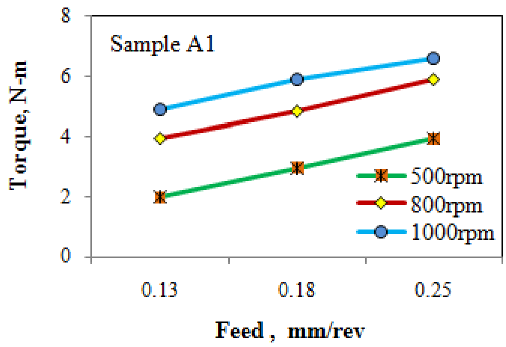

Fig – 4: Torque v/s Feed for Twist drill bit

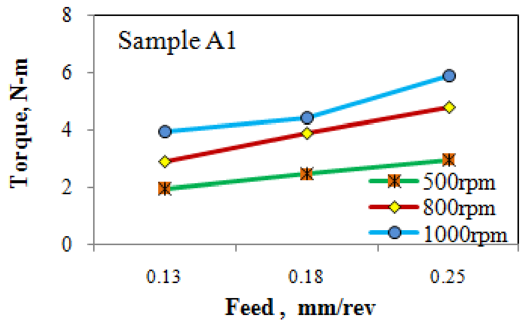

Fig – 5: Torque v/s Feed for Multi face drill bit

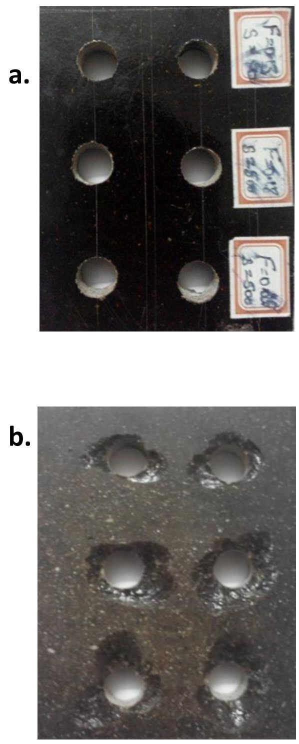

Fig -6: Hole quality for different feeds at (a) entry face and (b) exit face at 500 rpm using Twist drill bit

c.

d.

Fig – 7: Hole quality for different feeds at (c) entry face and (d) exit face at 500 rpm using Multi face drill bit

The quality of holes was observed at different values of feed and speed. Due to the influence of drilling parameters and design of composite, slight damages at the exit face of the hole occurs. At higher feed and speed values, the increased area damage was observed at the exit face. The increase in the feed rate and speed increases the heat generation, resulting in higher matrix cracking and spalling at the exit face of the hole. The increase in the feed rate and speed also increases the chatter and produces the incomplete drilling at faster traverse that leads to higher damage at the exit face. However, no damages occurred at the entry face of the holes for all values of feed and speed. Better hole quality at the exit face can be obtained by reducing the feed rate even less than 0.13 mm/rev. It can be seen that for feed rate of 0.13 mm/rev has good quality holes with slight damages at the exit face. Better holes can be produced using twist drill bit than multi face drill bit. Figure 6 and 7 depicted the hole quality for different feeds at entry and exit face at 500 rpm using Twist and Multi face drill bits.

6. CONCLUSION

CSPE composites were developed and the drilling characterization of developed composites was investigated experimentally. From the experimental results, the values of thrust force are found to be higher in multi face drill bit than twist drill. However, torque was found lesser in multi face drill bit than twist drill. Lower feed and speed can produce good quality holes at both entry and exit part.

REFERENCES

[1] Maya and Sabu Review, "biofibres and biocomposites," Carbohydr. Polym. Vol. 71, 2008, pp. 343–364.

[2] Faruk Bledzki AK and Finkb HP, "Bio-composites reinforced with natural fibers," Prog. Polym. Sci. Vol. 37(11), 2012, pp. 1552–1596.

[3] G U Raju and S Kumarappa, "Experimental study on mechanical properties of groundnut shell particle-reinforced epoxy composites," J Reinf Plast Compos, Vol. 30, 2011, pp. 1029–1037.

[4] J Sarki, S B Hassan, V S Aigbodion and J E Oghenevweta, "Potential of using coconut shell particle fillers in eco-composite materials," J Alloys Compd, Vol. 509, 2011, pp. 2381–2385.

[5] Tsao CC, "Experimental study of drilling composite materials with step-core drill," Mater Des, Vol. 29, 2008, pp. 1740–1744.

[6] V N Gaitonde, S R Karnik, S Basavarajappa and Abay Venkatesh, "Experimental Investigations on Some Aspects of Machinability in Drilling of Glass Epoxy Polymer Composites," J. Thermoplast. Compos. Mater, Vol. 25, 2012, pp. 363-387.

[7] M Mariatti, M Nasir and H Ismail, "Effect of Hole Drilling Techniques on Tensile Properties of Continuous Fiber Impregnated Thermoplastic (COFIT) Plain Weave Composites," J. Reinf. Plast. Compos, Vol. 23, 2004, pp. 1173 – 1185.

[8] Pramendra Kumar Bajpai and Inderdeep Singh, "Drilling behavior of sisal fiber-reinforced polypropylene composite laminates," J. Reinf. Plast. Compos, Vol. 32, 2013, pp. 1569–1576.

[9] Julian Luis Merino-Perez, Raphael Royer, Eleanor Merson, Aiden Lockwood, Sabino Ayvar-Soberanis and Matthew B Marshall, " Influence of work piece constituents and cutting speed on the cutting forces developed in the conventional drilling of CFRP composites," Compos. Struct, Vol. 140, 2016, pp. 621–629.

[10] Manjunatha Chary G H and K Sabeel Ahmed. "Experimental characterization of coconut shell particle reinforced epoxy composites," J. Mater. Env. Sci, Vol. 8, 2017, pp. 1661-1667. ISSN: 2028-2508.

[11] Mohan N S, Ramachandra A and Kulkarni S M, "Influence of process parameters on cutting force and torque during drilling of glass–fiber polyester reinforced

composites," Compos. Struct, Vol. 71, 2005, pp. 407–413.

[12] Velayudham and Krishnamurthy, "Effect of point geometry and their influence on thrust and delamination in drilling of polymeric composites," J. Mater. Process Technol, Vol. 185, 2007, pp. 204–209.

[13] S.C. Lin and I. K. Chen, "Drilling carbon fiber-reinforced composite material at high speed," Wear, Vol. 194, 1996, pp. 156-162.

BIOGRAPHIES

Author 1 is an Assistant Professor in J N N College of Engg., Shivamogga, Karnataka, India from past 15 years. He pursued Ph.D from VTU, Belagavi, Karnataka. His research area is Polymer Composites.

Author 2 is presently Professor in J N N College of Engg., Shivamogga, Karnataka, India having an experience of 36 years. He pursued Ph.D from Anna University, Chennai. He has published several research