Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

# ENHANCEMENT OF THE QUALITY FEATURES OF DRILLING OF C-C COMPOSITE BY THE OPTIMIZATION OF PROCESS PARAMETERS

**K.V.Krishna Sastry[1*], V.Seshagiri Rao[2],**
[1]Department of Mech. Engg, AVIT, Chennai, India,
[2]St. Joseph's college of Engineering, Chennai, India,
[*]**Corresponding author: Email: kvkrishnasastry@gmail.com**

**ABSTRACT**

This paper deals with drilling of Carbon-Carbon composite material and presents the influence of process parameters like Tool point angle,spindle speedand feed rate on the Performance characteristics like Thrust force and Torque of Carbon-carbon composite material by using HSS and TiN coated carbide drill bits. A plan of experiments based on Taguchi's technique has been used to acquire the data. An $L_{27}$ Orthogonal array is employed to establish the optimal cutting parameters for the desired performance parameters. The drilling experiments were conducted on a CNC Drilling Machine at Anna University campus, Chennai, India. A comparison of the drillingprocess performanceby using both HSS tool and TiN coated carbide tools was also done in this paper.

**Keywords:** Carbon-Carbon composites, Optimization, Machinability, Orthogonal Array, Drilling process.

## INTRODUCTION

The usage of Carbon-Carbon composite materials has been increased in the production of advanced structures like space shuttles, main battle field tanks, nuclear reactors and other bio related devices. This composite is nothing but a reinforcement of carbon fibres in to a carbon matrix. Though the material is very costly, the material is widely used in various fields due to its attractive combination of corrosion resistance, high strength and light weight. The properties of the material are varied due to its anisotropic behavior. Major applications of this material involve high performance braking systems, refractory materials using at high temperatures. Most notable applications are Heat shields for reentry vehicles, aircraft brakes, hot pressing dies, nozzles, and nose cones of intercontinental ballistic missiles and leading edges of the space shuttles.

Machinability isthe ease with which a material can be machined and this aspect has considerable importance for manufacturing engineering community to know the planning of production of work material in an efficient way. This machinability factor is influenced by number of parameters like work material properties, Tool geometry, Tool material, Cutting conditions, Machine capacity, etc., The study can be a basis for cutting tool performance evaluation and machining parameter optimization. These variables are the machining process input variables and independent of the machining process. The machining process output variables such as Tool life, Surface Finish, Dimensional accuracy& development of temperature, noise, vibration and chip characteristics.

Machining, especially Drilling is a complex process and it becomes complicated if the material is a composite one. The C-C composite is expensive and the cost increases if the drilling of this composite is not done properly. Hence it is decided to investigate the influence of cutting parameters like Tool Point Angle,Spindle Speed, andFeed Rate experimentally on the Thrust force and Torque, using the method of Design of Experiments.

### Experimental Procedure

The Photograph of Carbon-Carbon composite material used for experiment is shown in Figure 1.The Carbon-Carbon composite is fully made up of Carbon material and the composition of the material is shown in Table 1 and the EDAX Graph was also given in Figure 2.

**Fig 1. C-C composite material used for Experimental investigation**

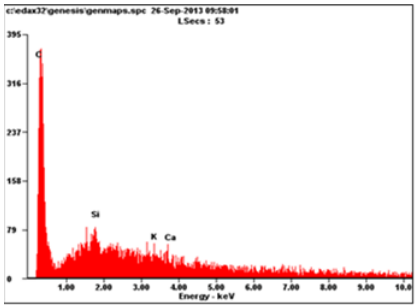


**Fig.2. EDAX Graph**

**Table1. Composition of C-C composite material by percentage of weight**

| Element | C | Si | K | Ca |
|---|---|---|---|---|
| Wt% | 96.58 | 1.34 | 1.1 | 0.98 |

The drilling experiment was conducted by using CNC drilling machine Vertical Machining Centre 100 at Anna university campus, Chennai. Drill bits with diameter 10mm of two different materials, i.e. HSS and TiN carbide

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

are used for drilling purpose. Thrust Force and Torque values are determined by using Kistler make dynamometer, which is attached to the Drilling Machine.The photograph of experimental setup used for the drilling purpose is shown in Figure 3.


**Fig.3. CNC vertical machining centre**

**Plan of Experiments**

The experiments were planned based on Taguchi's design of experiments, which helps in reducing the number of experiments. The experiments were conducted to a 3-level,$L_{27}$ Orthogonal array. The cutting parameters identified were point angle, spindle speed and feed rate. A constant depth of cut of 10 mm was used in the test. The control parameters and their levels are indicated in Table 2.

**Table 2. Control Factors and Levels for the Experimentation**

| Drilling Parameters | Point Angle | Spindle Speed | Feed Rate |
|---|---|---|---|
| Symbol | A | N | F |
| Unit | [$^0$] | [r.p.m] | [mm/min] |
| Level (1) | 100 | 1000 | 100 |
| Level (2) | 118 | 2000 | 300 |
| Level (3) | 135 | 3000 | 500 |

The $L_{27}$ Orthogonal array with the corresponding factors and levels are shown in Table 3.

**Table.3. $L_{27}$ Orthogonal Array**

| Expt.No. | Point Angle A($^0$) | Spindle Speed N(rpm) | Feed rate F(mm/min) |
|---|---|---|---|
| 1. | 100 | 1000 | 100 |
| 2. | 100 | 1000 | 300 |
| 3. | 100 | 1000 | 500 |
| 4. | 100 | 2000 | 100 |
| 5. | 100 | 2000 | 300 |
| 6. | 100 | 2000 | 500 |
| 7. | 100 | 3000 | 100 |
| 8. | 100 | 3000 | 300 |
| 9. | 100 | 3000 | 500 |
| 10. | 118 | 1000 | 100 |
| 11. | 118 | 1000 | 300 |
| 12. | 118 | 1000 | 500 |
| 13. | 118 | 2000 | 100 |
| 14. | 118 | 2000 | 300 |
| 15. | 118 | 2000 | 500 |
| 16. | 118 | 3000 | 100 |
| 17. | 118 | 3000 | 300 |
| 18. | 118 | 3000 | 500 |
| 19. | 135 | 1000 | 100 |
| 20. | 135 | 1000 | 300 |
| 21. | 135 | 1000 | 500 |
| 22. | 135 | 2000 | 100 |
| 23. | 135 | 2000 | 300 |
| 24. | 135 | 2000 | 500 |
| 25. | 135 | 3000 | 100 |
| 26. | 135 | 3000 | 300 |
| 27. | 135 | 3000 | 500 |

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

**Analysis of Data**

The drilling experiments were conducted with two drill bits of two different materials i.e. TiN coated carbide and High Speed Steel. The influence of process parameters on various performance characteristics are determined and given separately based on drilling tool material and later the values are compared.

**TiN coated Carbide Tool Drilling**: The influence of spindle speed, feed rate and point angle on Thrust force duringTitanium Nitride coated carbide tool drilling is shown in Figure. 4. It is very clear from the graph that High spindle speed (3000 rpm), low feed rate (100 mm/min) and high point angle ($135^0$) will give minimum thrust force.

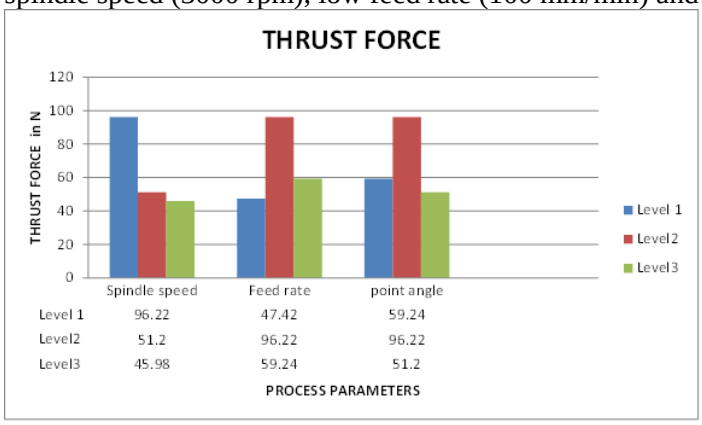


**Fig.4 Thrust force graph**

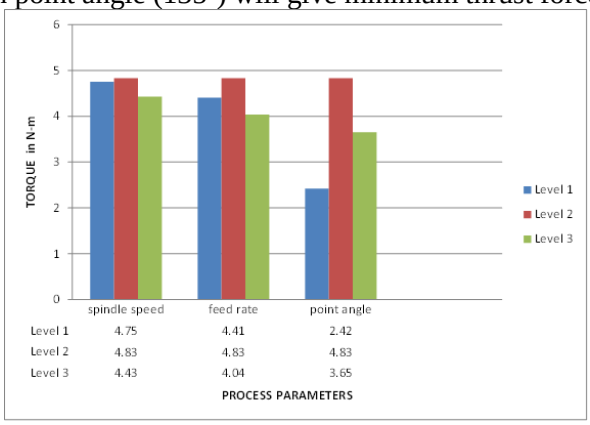


**Fig.5 Torque graph**

The influence of spindle speed, feed rate and point angle on Torque during TiN coated carbide tool drilling is shown in Figure. 5. The Torque graph shows that there is no major influence of spindle speed and feed rate on torque, but a low point angle ($100^0$) is giving minimum torque.

**HSS tool drilling:** The influence of spindle speed, feed rate and point angle on Thrust force during High speed steel tool drilling is shown in figure. 5. The Thrust Force graph shows a vital play of High spindle speed (3000rpm), low feed rate (100mm/min) and minimum point angle ($100^0$) in producing a minimum thrust force.

The influence of spindle speed, feed rate and point angle on Torque during High speed steel tool drilling is shown in Figure. 7. From this it is understood that the influence of process parameters on torque is very little.

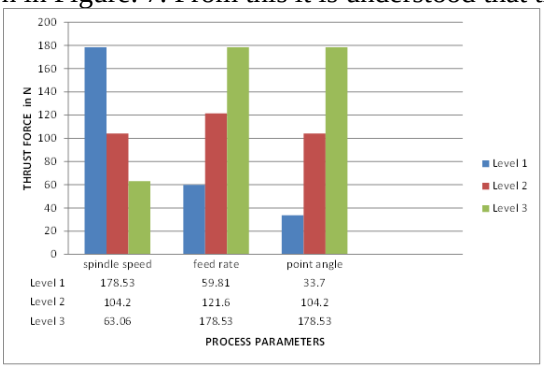


**Fig.6 Thrust force graph**

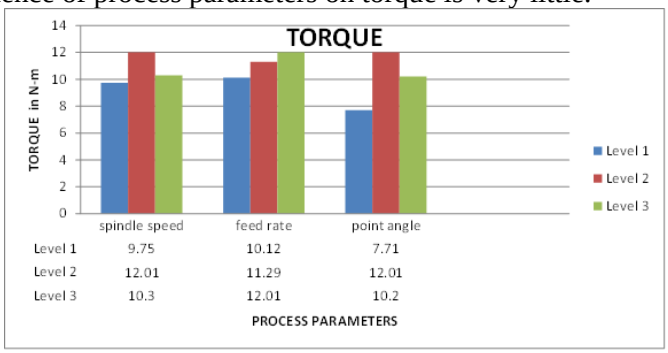


**Fig.7 Torque graph**

**Comparison of drilling process of TiN coated carbide tooland HSS tool**

The Thrust force of drilled work piece with different process parameters by using two different tool materials are shown in figure.8. The overall performance is better for TiN coated carbide tool drilling process. Minimum thrust force will give better hole quality.

The Torque of drilled work piece with different process parameters by using two different tool materials are shown in figure.10. This graph clearly indicates the torque values are low for TiN coated carbide drill. Lower values of torque will give better quality hole in drilling process.

**Conclusion**

The optimum conditions will be achieved mostly by TiN coated carbide for CFRC composite material drilling and High spindle speed, Lower feed rate and Lower point angle will give better drilling performance characteristics. Hence Titanium coated carbide tool is preferable to the High speed steel tool in drilling of Carbon-Carbon composite material.

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

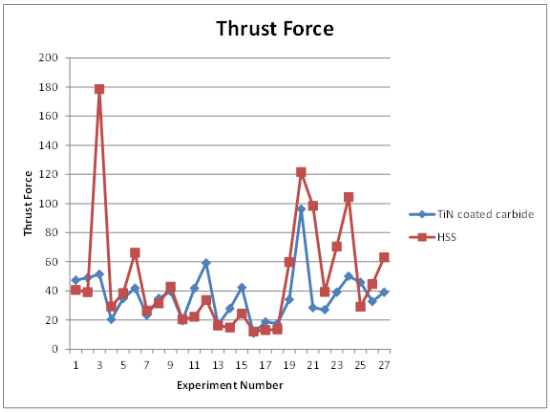


Fig.9 Thrust force graph

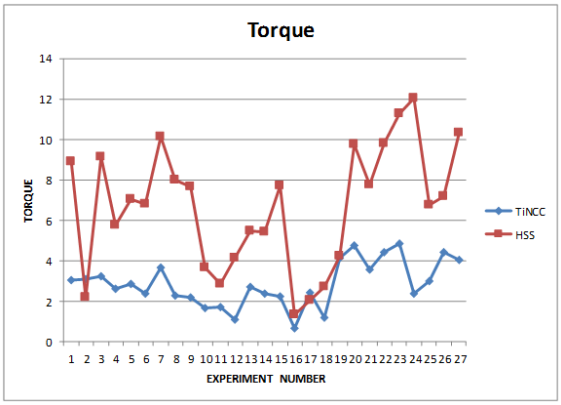


Fig.10 Torque graph

**Acknowledgment**

The authors would like to acknowledge the support of CVRDE,IIT Madras, Anna University, Sathyabama University and AVIT organizations of Chennai, Tamil Nadu, India.

**References**

K. V. Krishnasastry, S. Dhanalakshmi., V. Seshagirirao, K. Palanikumar, Characteristics of re-inforced Carbon-Carbon, In Frontiers in Automobile and Mechanical Engineering (FAME), IEEE, 2010, pp. 12-15.

K. V. Krishnasastry, V. Seshagirirao, "Optimization of Drilling Process Parameters for Minimizing Surface Roughness in Carbon-Carbon Composite Materials",Adv.Mat.Research, vol 1077 (2015), pp. 96-105.

K. V. Krishnasastry, S. Dhanalakshmi., V. Seshagirirao, K. Palanikumar, "CFRC- A new millennium composite material," Recent advances in mechanical engineering, Int. Conf. Chennai, 2011. Pp.32-36.

K. V. Krishnasastry, V. Seshagirirao, "Carbon fibre reinforced CARBON (CFRC)-A SPECIAL material," proc. int. conf. & exhibition on Pressure vessels and piping,IGCAR, Kalpakam, C-086, pp.120

P. J. Ross, "Taguchi Techniques for Quality Engineering," New York: McGraw-Hill, 2004, pp. 66-71.

K. V. Krishnasastry, V. Seshagirirao. (2013, September). Parametric Optimization of CFRC Composite Drilling with HSS Drillbyusing GRA. 2(9) Available. www.ijirset.com

K. V. Krishnasastry, V. Seshagirirao, M S Kumar ,A Velayudham,Palanikumar K, "Determination and Analysis of Optimal Drilling conditions of Carbon-Carbon composites using Deng's Grey Theory", Indian journal of engineering,vol.10(24),pp92-100.

K. V. Krishnasastry, V. Seshagirirao. (2013 September). Application of Grey Relational Analysis to Determine the Optimum Drilling Parameters of RCC.vol. (4)www.ijreat.org.

K.V.Krishna Sastry et.al, "Multi Response Optimization of Carbon-Carbon (C/C) Drilling Parameters by Using Grey Theory Technique", Adv.Mat.Research, vol. 936 (2014),pp.1801-1808.