ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

# Parametric Optimization of CFRC Composite Drillingwith HSS Drillbyusing GRA

K.V.KRISHNASASTRY[1], V.SESHAGIRIRAO[2]

Research Scholar, Sathyabama University &Professor, Department of Mechanical Engineering, AVIT, Chennai, India[1]

Professor, Department of Mechanical Engineering, St.Joseph's College of Engineering, Chennai, India[2]

**Abstract:**The Carbon Fiber Reinforced Carbon (CFRC) Composite material is gaining prominent position among the materials of modern period. The light weight and high strength composite is finding its way in various applications of Bio, Medical, Space and Defence fields. The growing use of this composite in aerospace and defence industries has prompted studies in developing technology for machining of these composites, especiallydrilling in recent years. This paper emphasizes the application of Grey Relational Analysis to determine the suitable values of drilling parameters of CFRC. The Grey theory provides solution to the uncertain, multi input and discrete data problems. AHigh Speed Steel tool is used for drilling the material on a CNC machine. The purpose of this paper is to find the significant parameters affecting the drilling of this unique material with the experimental results by using Grey Relational Analysis method.

**Keywords:**Carbon-Carbon composites, RCC, CFRC, GRA, Orthogonal Array, Design of experiments.

## I. INTRODUCTION

Drilling is one of the major complicated machining processes and is also a frequently used process of machining in the latest developed industrial applications. This drilling process further becomes more complicated, when the work piece is a composite material. Numerous studies have been under taken on the details of drilling processes of various composite materials.The Drilling of composites is different from the approach that adopted for conventional materials. Drilling is an operation that produces holes of desired diameter in the given material. But much attention was not given on the drilling process of the most advanced and promising engineering material called 'carbonfiber reinforced carbon (CFRC)' composite.

## II. CFRC COMPOSITE MATERIAL

Carbon fibre reinforced Carbon composite (CFRC) materials, the ruler of modern era, is occupying significant position among the various advanced materials, particularly in composite materials. These innovative materials are logical candidates for the construction of advanced structures. The properties of these materials are tailarable according to the requirements. CFRC is a light weight and high strength composite material capable of withstanding temperatures in many environments. In the general field of materials, CFRC composite materials,which consist of carbon fibres having various textile structures and a carbonaceous matrix based on coke, polymeric resins, pitch or pyrolitic carbon occupy a special place.CFRC matrix composites or the so called carbon-carbon or carbon/carboncomposites, whichcan be treated as an important subclass of ceramic matrix composites have lower density values, much lower than the metals and ceramics and hence make lower component weight [1]. This is an important consideration for selection of aerospace, defence and bio materials. It is so light and equally strong when compared to monolithic materials. For example,CVRDE has developed high performance carbon-carbon brake discs for the main brake assembly of MBT Arjun. The weight of brakes was compared with that of steel material, which is used generally to fabricate the brake discs and found a saving of weight by 75%. [2]

The high thermal stability of the solid carbon is the basis for the high temperature applications of these carbon/carbon composite materials. Carbon or Graphite melts only under conditions of high pressure and temperature, i.e. in the order of 100 bars and 4000K.Most notable applications are heat shields for reentry vehicles, hot pressing dies, nozzles. Nose cones of ICBMs

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

*(An ISO 3297: 2007 Certified Organization)*

Vol. 2, Issue 9, September 2013

(Intercontinental Ballistic Missiles).These materials are also used as refractory materials for various industrial furnaces. Printed circuit heat exchangers are currently manufactured from theses carbon-carbon composites [3].

## III. MACHINING OF CARBON-CARBON COMPOSITES

Very little has been found in the literature concerning machining of CFRC Composites. Since these composites are difficult to machine, a detailed study of their machinability features is essential. J.R.Ferreira et.al have carried out in rocket nozzle throats to study the performance of different tool materials. They also have carried out to observe the influence of cutting speed and feed rate on cemented carbide tool wear [4]. George et.al determined the setting of process parameters on EDM machine, while machining carbon-carbon composites using a Taguchi technique based on RSM and ANOVA [5]. To the author's knowledge, this little work is also on turning process and no literature is available on drilling process. Hence an experimental investigation is taken on drilling of this special material.

## IV. GREY THEORY

The Grey theory, which was established by Mr. Deng, can provide a solution of a system in which the model is unsure or the information is incomplete and also provides an efficient solution to the uncertainty, multi-input and discrete data problems.Generally, in this theory, Black represents having no information about the system and White represents having complete information about the system concerned.

## V. EXPERIMENTAL METHODOLOGY

Based on Taguchi quality design concept [6], a L27 mixed orthogonal array table was chosen for the experiments as shown in Fig.1. Drill bit point Angle, Spindle speed and feedrate were chosen as the three controlling factors and each parameter was designed to have three levels, denoted by 1, 2, and 3 as shown in Table 1. The drilling process performance is evaluated by the responseparameters like Thrust Force in Newtons, Torque in N-m and Surface Roughness in microns.

| Experiment | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 4 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 |
| 5 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 |
| 6 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 |
| 7 | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 2 |
| 8 | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 3 |
| 9 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| 10 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 11 | 2 | 1 | 2 | 3 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 |
| 12 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 |
| 13 | 2 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 3 | 1 | 3 | 1 | 2 |
| 14 | 2 | 2 | 3 | 1 | 2 | 3 | 1 | 3 | 1 | 2 | 1 | 2 | 3 |
| 15 | 2 | 2 | 3 | 1 | 3 | 1 | 2 | 1 | 2 | 3 | 2 | 3 | 1 |
| 16 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 3 | 1 |
| 17 | 2 | 3 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 3 | 3 | 1 | 2 |
| 18 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 3 |
| 19 | 3 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 |
| 20 | 3 | 1 | 3 | 2 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 |
| 21 | 3 | 1 | 3 | 2 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 |
| 22 | 3 | 2 | 1 | 3 | 1 | 3 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| 23 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 3 | 2 | 1 | 1 | 3 | 2 |
| 24 | 3 | 2 | 1 | 3 | 3 | 2 | 1 | 1 | 3 | 2 | 2 | 1 | 3 |
| 25 | 3 | 3 | 2 | 1 | 1 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 3 |
| 26 | 3 | 3 | 2 | 1 | 2 | 1 | 3 | 1 | 3 | 2 | 3 | 2 | 1 |
| 27 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | 2 | 1 | 3 | 1 | 3 | 2 |

**Fig.1, a model of** Orthogonal **Array ($L_{27}$)**

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 2, Issue 9, September 2013**

| Drilling Parameters | Symbol | Unit | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| Point Angle | θ | degree | 135 | 100 | 118 |
| Spindle Speed | N | r.p.m | 1000 | 2000 | 3000 |
| Feed Rate | f | mm/rev | 100 | 300 | 500 |

**Table. 1, Control Factors and levels for the experimentation**

## VI. EXPERIMENTAL SETUP

The Drilling experiments were carried out on a computer numerical control Vertical Machining centre (VMC100), which is manufacturedARIX CNC MACHINE Co.Ltd., Taiwan. A Kistler piezoelectric dynamometer is attached to this machine to measure the response parameters Thrust Force and Torque. The experimental setup is shown in Fig.2.

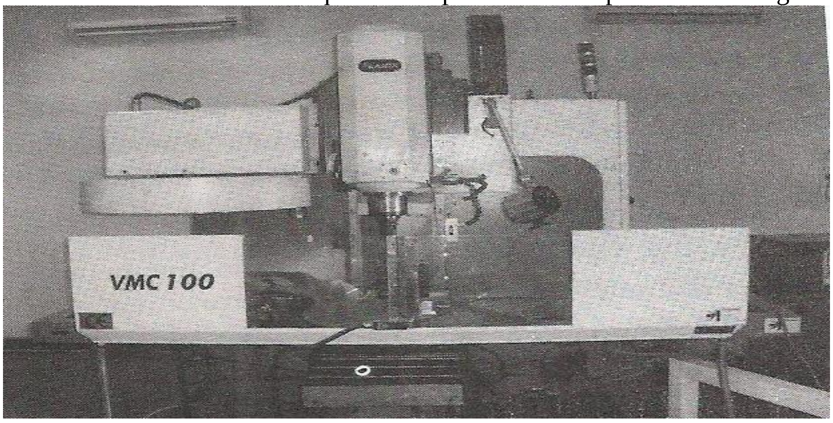


**Fig.2 CNC VERTICAL MACHINING CENTRE**

The other process parameter Surface Roughness is measured by using surface roughness tester at Micro Labs, Chennai. This setup is shown in Fig.3.

**Fig.2 SURFACE ROUGHNESS TESTER**

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 2, Issue 9, September 2013**

The experimental values of Thrust Force, Torque and Surface Roughness are given in Table 2.

| | | | |
|---|---|---|---|
| 1 | 47.42 | 3.02 | 2.21 |
| 2 | 49.05 | 3.1 | 3.27 |
| 3 | 51.52 | 3.22 | 4.28 |
| 4 | 20.42 | 2.6 | 4.07 |
| 5 | 34.82 | 2.86 | 5.24 |
| 6 | 41.88 | 2.37 | 4.60 |
| 7 | 23.22 | 3.65 | 3.15 |
| 8 | 34.81 | 2.27 | 3.30 |
| 9 | 39.7 | 2.2 | 3.89 |
| 10 | 19.61 | 1.68 | 6.41 |
| 11 | 41.81 | 1.71 | 2.36 |
| 12 | 59.24 | 1.1 | 5.18 |
| 13 | 16.89 | 2.7 | 6.59 |
| 14 | 27.95 | 2.37 | 4.27 |
| 15 | 42.35 | 2.25 | 4.02 |
| 16 | 11.04 | 0.68 | 2.31 |
| 17 | 18.73 | 2.42 | 5.12 |
| 18 | 17.47 | 1.17 | 4.39 |
| 19 | 34.17 | 4.14 | 1.56 |
| 20 | 96.22 | 4.75 | 6.01 |
| 21 | 128.46 | 3.56 | 4.65 |
| 22 | 27.16 | 4.41 | 4.90 |
| 23 | 39.19 | 4.83 | 2.56 |
| 24 | 50.12 | 2.38 | 6.70 |
| 25 | 45.98 | 2.99 | 3.28 |
| 26 | 32.79 | 4.43 | 2.62 |
| 27 | 39.19 | 4.04 | 3.13 |

**Table. 2, Experimental values of T.F, Torque and Surface Roughness**

## VII. GREY RELATIONAL ANALYSIS

In this GRA analysis, the experimental results are first normalized in the range between zero and one, which is also known as grey relational generation and then the grey relational coefficient is calculated from the normalized experimental data to express the relationship between the desired and actual experimental data. Then, thegrey relational grade was computed by averaging the grey relational coefficients corresponding to each performance characteristic (3 responses). The overall evaluation of the multiple process responses is based on the grey relational grade.As a result, optimization of the complicated multiple process

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

responses can be converted into optimization of a single grey relational grade. In other words, the grey relational grade can be treated as the overall evaluation of experimental data for the multi response process. Optimization of a factor is the level with the highest grey relational grade [7].

## VIII. DATA PREPROCESSING

Data Pre-Processing is of transferring the original sequence to a comparable sequence. Normally, the normalized value of the data is called as comparable sequence. This is normally required, since the range and unit in one data sequence may differ from others. It is also necessary when the sequence scatterrange is too large, or when the directions of the target in the sequences are different.

If the target value of original sequence is infinite, the normalized value is taken for "larger-the-better" characteristic and it is expressed as,

$$x_i^*(k)=\frac{x_i^0(k)-\min x_i^0(k)}{\max x_i^0(k)-\min x_i^0(k)} \quad (1)$$

The normalized value of "lower-the-better characteristic is expressed as,

$$x_i^*(k)=\frac{\max x_i^0(k)- \ x_i^0(k)}{\max x_i^0(k)-\min x_i^0(k)} \quad (2)$$

If the characteristicis "nominal-the-best", then the normalized value is expressed as

$$x_i^*(k)=1-\frac{|x_i^0(k)-x^0|}{\max x_i^0(k)-x^0} \quad (3)$$

Where i=1… m; k=1… n. m is the number of experimental data items and n is the number of parameters.$x_i^0(k)$is the original sequence, $x_i^*(k)$ is the sequence after the normalization, $max\ x_i^0(k)$is the largest value andmin $x_i^0\ (k)$is the smallest value of$x_i^0(k)$ and $x^0$ is the desired target value.

The data preprocessing results for response parameters i.e. Thrust Force, Torque and Surface roughness of process by using the HSS drill is presented inTable 3.

## IX. CALCULATION OF GREY RELATIONAL COEFFICIENT AND GREY RELATIONAL GRADE

After data preprocessing has been carried out, a GRC (grey relational coefficient) is calculated. The GRC expresses the relationship between the ideal and the actual normalized experimental results. The formula for calculation of Grey Relational Coefficient, $\xi_{ij}$is,

$$\xi_{ij} = \{\Delta_{min}+ \zeta\Delta_{max}\} / \{|x_i^0-x_{ij}|+\zeta\Delta_{max}\} \quad - (4)$$

Where $x_i^o$ is the ideal normalized results for the i[th] performance characteristic and $\zeta$ is the distinguishing coefficient, which is defined in the range $0 \leq \zeta \geq 1$. Butforpractical purposes, $\zeta$ is taken as 0.5.

The GRC values of various response parameters are entered in Table 4.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

| Expt.No. | Thrust Force F ( N) | Torque M ( N-m) | Surface Roughness $R_a$(µ m) |
|---|---|---|---|
| 1 | 0.6902 | 0.4361 | 0.8730 |
| 2 | 0.6763 | 0.4169 | 0.6669 |
| 3 | 0.6553 | 0.3880 | 0.4705 |
| 4 | 0.9201 | 0.5373 | 0.5120 |
| 5 | 0.7975 | 0.4747 | 0.2839 |
| 6 | 0.7374 | 0.5928 | 0.4076 |
| 7 | 0.8963 | 0.2843 | 0.6909 |
| 8 | 0.7976 | 0.6169 | 0.6604 |
| 9 | 0.7559 | 0.6337 | 0.5457 |
| 10 | 0.9270 | 0.7590 | 0.0564 |
| 11 | 0.7379 | 0.7518 | 0.8438 |
| 12 | 0.5895 | 0.8988 | 0.2949 |
| 13 | 0.9502 | 0.5133 | 0.0207 |
| 14 | 0.8560 | 0.5928 | 0.4718 |
| 15 | 0.7334 | 0.6217 | 0.5204 |
| 16 | 1.0000 | 1.0000 | 0.8529 |
| 17 | 0.9345 | 0.5807 | 0.3078 |
| 18 | 0.9452 | 0.8819 | 0.4491 |
| 19 | 0.8030 | 0.1663 | 1.0000 |
| 20 | 0.2746 | 0.0193 | 0.1342 |
| 21 | 0.0000 | 0.3060 | 0.3992 |
| 22 | 0.8627 | 0.1012 | 0.3506 |
| 23 | 0.7603 | 0.0000 | 0.8049 |
| 24 | 0.6672 | 0.5904 | 0.0000 |
| 25 | 0.7024 | 0.4434 | 0.6643 |
| 26 | 0.8148 | 0.0964 | 0.7926 |
| 27 | 0.7603 | 0.1904 | 0.6941 |

**Table. 4, Normalized values (Data Preprocessing of experimental results)**

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

| Expt.No. | Thrust Force F ( N) | Torque M ( N-m) | Surface Roughness $R_a$(μ m) |
|---|---|---|---|
| 1 | 0.6174 | 0.4700 | 0.7974 |
| 2 | 0.6070 | 0.4616 | 0.9379 |
| 3 | 0.5919 | 0.4496 | 0.4857 |
| 4 | 0.8622 | 0.5194 | 0.5061 |
| 5 | 0.7117 | 0.4877 | 0.4111 |
| 6 | 0.6556 | 0.5511 | 0.4577 |
| 7 | 0.8282 | 0.4113 | 0.6179 |
| 8 | 0.7118 | 0.5662 | 0.5955 |
| 9 | 0.6720 | 0.5772 | 0.5239 |
| 10 | 0.8726 | 0.6748 | 0.3464 |
| 11 | 0.6561 | 0.6683 | 0.7620 |
| 12 | 0.5492 | 0.8317 | 0.4149 |
| 13 | 0.9094 | 0.5067 | 0.3380 |
| 14 | 0.7764 | 0.5511 | 0.4863 |
| 15 | 0.6522 | 0.5693 | 0.5104 |
| 16 | 1.0000 | 1.0000 | 0.7727 |
| 17 | 0.8842 | 0.5439 | 0.4194 |
| 18 | 0.9013 | 0.8090 | 0.4758 |
| 19 | 0.7174 | 0.3749 | 1.0000 |
| 20 | 0.4080 | 0.3377 | 0.3661 |
| 21 | 0.3333 | 0.4188 | 0.4542 |
| 22 | 0.7846 | 0.3575 | 0.4350 |
| 23 | 0.6759 | 0.3333 | 0.7193 |
| 24 | 0.6004 | 0.5497 | 0.3333 |
| 25 | 0.6269 | 0.4732 | 0.5983 |
| 26 | 0.7297 | 0.3562 | 0.7068 |
| 27 | 0.6253 | 0.3818 | 0.6204 |

**Table. 4, Grade Relational Coefficients**

After the calculation of GRC values, the data can be reduced to a single value known as Grey Relational Grade (GRG). The GRG is calculated by the following formula by giving equal importance to the influence of various response parameters.

$$\textbf{GRG } (\alpha_j) = \frac{1}{N}\sum_{I=1}^{N} \xi_{ij} \quad - \qquad (5)$$

This is nothing but average value of GRC's of various response parameters i.e. Thrust Force, Torque and Surface Roughness. The GRG values for all the 27 trials are given Table 5.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

The highest grey relational grade calculated from the above expression will give the optimal combination of various process parameters.i.e 16th experiment.

## X. ANALYSIS OF RESULTS USING RESPONSE TABLE AND RESPONSE GRAPHS

Since the experimental design is orthogonal, it is then possible to separate out the effect of each drilling parameter on the grey relational grade at different levels. The mean grey relational grade for each level of all input parameters can be computed and the overall mean also calculated and entered in the Table 6.

| Expt...No. | Grey Relational Grade |
|---|---|
| 1 | 0.6283 |
| 2 | 0.6688 |
| 3 | 0.5091 |
| 4 | 0.6292 |
| 5 | 0.5368 |
| 6 | 0.5548 |
| 7 | 0.6191 |
| 8 | 0.6245 |
| 9 | 0.5910 |
| 10 | 0.6313 |
| 11 | 0.6955 |
| 12 | 0.5986 |
| 13 | 0.5847 |
| 14 | 0.6046 |
| 15 | 0.5773 |
| 16 | **0.9242** |
| 17 | 0.6158 |
| 18 | 0.7287 |
| 19 | 0.6974 |
| 20 | 0.3706 |
| 21 | 0.4021 |
| 22 | 0.5257 |
| 23 | 0.5762 |
| 24 | 0.4945 |
| 25 | 0.5661 |
| 26 | 0.5976 |
| 27 | 0.5425 |

**Table. 5, Grey Relational Grades**

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 2, Issue 9, September 2013**

| DRILLING PARAMETER | SYMBOL | GREY RELATIONAL GRADE | | |
|---|---|---|---|---|
| | | Level 1 | Level 2 | Level 3 |
| Point Angle | A | 0.5957 | **0.6623** | 0.5303 |
| Spindle Speed | N | 0.5780 | 0.5649 | **0.6455** |
| Feed Rate | F | **0.6451** | 0.5878 | 0.5554 |
| Overall mean of Grey Relational Grade = | 0.596111 | | | |

**Table. 6, Response table for the grey relational grade (High speed steel tool)**

The influence of each drilling parameter can be clearly presented by means of the response graph shown in Fig. 4.

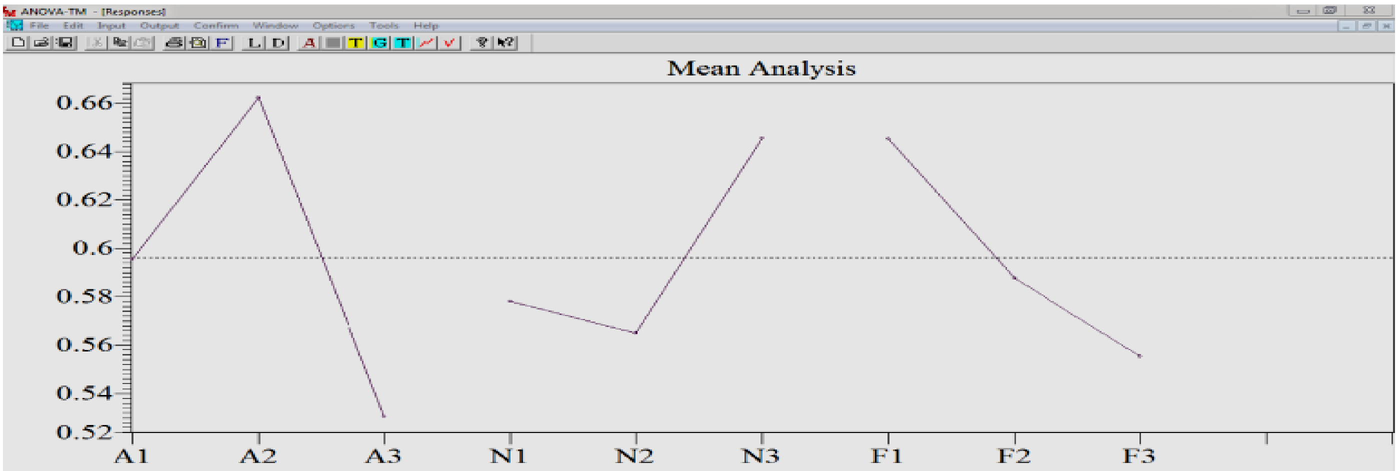


**Fig.4, RESPONSE GRAPH FOR GRG VALUES**

It is evident from the response table and response graph that the optimal combination of the parameters are point angle at level 2, spindle speed at level 3 and feed rate at level 1 to produce the best output.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

## XI. PREDICTION AND VALIDATION TEST

After the optimal level has been selected, the last step is to predict and verify the improvement in the performance characteristics for the CFRC plate by drilling process with respect to the chosen initial parameter setting.
This validation test is crucial and final part of the parametric design. The expected mean grey relational grade at the optimal settings is calculated by using the following model.

$$\tilde{\alpha} = \alpha_m + \sum_{i=1}^{n} [\bar{\alpha}_i - \alpha_m] \quad - \quad (6)$$

where α is the total mean of grey relational grade, $\bar{\alpha}$ is the mean grey relational grade corresponding to the $i^{th}$ significant factor on the $j^{th}$ level and n is the no. of significant factors that affect the multiple response parameters.
The predicted value of GRG,

$$\tilde{\alpha} = 0.596111 + (0.6623-0.596111) + (0.6455-0.596111) + (0.6451-0.596111) = 0.760678$$

Table 7, shows the comparison of the predicted and the actual drilling performance of the tin coated solid carbide drill for multiple performance characteristic using their optimal cutting parameters.

| Setting Level | Initial Drilling Parameters | Optimal Drilling Parameters | |
|---|---|---|---|
| | | Prediction | Experiment |
| Response | $A_3N_1F_2$ | $A_2N_3F_1$ | $A_2N_2F_1$ |
| Thrust Force(N) | 96.22 | - | 11.04 |
| Torque(N-m) | 4.75 | - | 0.68 |
| $R_a$(µm) | 6.01 | - | 2.31 |
| G R Grade | **0.3706** | **0.7607** | **0.9242** |

**Table.7, RESULTS OF VALIDATION EXPERIMENT**

The confirmation experiment results at the optimal level show that Thrust Force is decreased from 96.22 N to 11.04 N, Torque is also decreased from 4.75 N-m to 0.68N-m and Surface finish has improved from 6.01 µm to 2.31 µm due to the improvement of grade by 0.5423.It is clearly evident from the results that the multiple performance characteristics in the CFRC composite drilling process are greatly improved through this approach.

## XII. CONCLUSION

1. Experiments are conducted on a CNC Drilling machine to optimize the process parameters.
2. From the values observed from the GRA table, it is clearly understood that a point angle of $100^0$, a feed rate of 100mm/rev and a spindle speed of 3000 rpm of $16^{th}$ experiment is the optimal combination to have good drilling results.
3. The predicted results were checked with experimental results and a good agreement was found.

## ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of CVRDE, Sathyabama University,Anna Universityand Micro Labs organizations of Chennai.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 2, Issue 9, September 2013**

## REFERENCES

[1] Krishan.K.Chawla. "Composite materials Science and Engineering"ed.2, Springer (India) pvt.ltd.New Delhi, 2008.

[2] Krishnasastry et.al, "Characteristics of Reinforced carbon-carbon" proc. int. conf. on frontiers in automobile and mechanical engineering, sathyabamauniv, Chennai, pp.12-15, 2010.

[3] Krishnasastry et.al, "CFRC- A new millennium composite material" proc. int. conf. on recent advances in mechanical engineering, drmgruniv, Chennai, pp.32-36, 2011.

[4]J.R.Ferriera et.al "Characteristics of carbon-carbon composite turning", jour. of mat.Proce.Tech.Vol.109, pp65-71, 2001.

[5]George P M Raghunath. B. Manocha LM and Warrier AM, "EDM machining of carbon-carbon composite – a Taguchi approach", J. Mater. Process. Technol. Vol. 145.

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

[7]S. Balasubramanian, S. Ganapathy, Grey Relational Analysis to determine optimum process parameters for Wire Electro Discharge Machining (WEDM)., International journal of engineering Science and Technology, Vol. 3, No1, 2011, pp. 95-101.

## BIOGRAPHY

Prof. K.V.KrishnaSastry has obtained his B.Tech Degree from Govt Engg College, Anatapur and obtained his M.Tech from Manipal Institute of Technology.He also obtained PGDHRM from IGNOU. Presently, he is pursuing Ph.D. from Sathyabama University in production engineering Division. He has more than 30 years teaching experience in various institutions. He also worked in reputed organizations like Velammal Engineering College,MNM Jain Engineering College etc,..At present,he is working as Head of the Department in Mechanical Engineering division of AVIT, Chennai. He is also a member of many professional societies.His research area of interest is composite materials.