International Journal of Research in Advent Technology, Vol.6, No.6, June 2018
E-ISSN: 2321-9637
Available online at www.ijrat.org

Investigating Mix Proportions of Polyester Polymer concrete for Drillability by Taguchi Method

Gurpreet Singh[1], Harmesh Kumar[2], Sehijpal Singh[3]
Research Scholar[1], Professor[2], Professor[3],
IKG-PTU Kapurthala (Guru Nanak Dev Engg College Ludhiana) India [1]
Mechanical Engineering Department, UIET, Chandigarh, India[2]
Mechanical Engineering, Guru Nanak Dev Engineering College, Ludhiana, India[3]
Email:gurpreet.er@gmail.com[1], shaarut@yahoo.com[2], sehijpalsingh@yahoo.in[3]

Abstract In this study the various mix proportions of Polyester polymer Concrete has been analyzed by Taguchi's Experimental methodology for drillability. Drilling has been done at 100 rpm and Feed rate being 0.10 mm/rev & 0.20 mm/rev on radial drilling machine. The hole deviation data is obtained for different compositions of polymer concrete. The investigation is carried out from the view of the relation between machined hole quality both at inlet and exit. The best possible levels for mix proportions are determined for minimization of hole deviation.

Keywords: red mud, drilling, taguchi, polyester, concrete, mix proportions.

1. INTRODUCTION

Polyester resin is one of the most common materials used in polymer concrete formulations because it has excellent mechanical and chemical properties [1-2]. In addition, it costs less than epoxy resins and is readily available on the market. Polyester can be cured at room temperature using 4% metyl-ethyl-keton-peroxide (MEKP) as hardener and 1.25% cobalt oxalate as accelerator [3]. Calcium Carbonate, as filler is also added to the sand and resin mixture.

As the main aim of the study is to study the effect of polymer concrete composition on machining using percentage of polyester resin as one variable and aggregate (Table 1) having different sand grain size as second variable and calcium carbonate (filler) as the third variable, 9 different combinations were designed using taguchi method of design of experiments [4] values presented in Table2.

Based on these combinations (Table 2), 9 samples of polyester polymer concretes of different composition were prepared by fine mixing in a beaker. Then this mixture is poured in the mould made of square pipe 40*40*60(mm) size approximately [5]. This mould was pressed by joining pipes and tightening with a plastic cane. Then they were cured at room temperature for 24 hours. Afterwards, post curing was done in oven at the temperature of 80ºC for 8 hours and then allowed to cool at room temperature [6].

Table 1 Optimized foundry composition of fine aggregate

CFA / Type	300-600 µ	600-1200µ
1	35%	65%
2	50%	50%
3	65%	35%

Table 2 Taguchi method combinations

Composition / Run. No.	Resin (18-28%)	RED MUD (15-25%)	Calcium Carbonate (0.5-1.5%)	CFA
1	18	15	0.5	1
2	23	20	1	2
3	28	25	1.5	3
4	23	25	0.5	2
5	28	15	1	3
6	18	20	1.5	1
7	28	20	0.5	3
8	18	25	1	1
9	23	15	1.5	2

2. EXPERIMENTAL PROGRAM

The objective of the experiment is to select the best combination of control parameters so that the product or process will be most robust [7]. The Taguchi method utilizes orthogonal arrays from design of experiments theory to study a large number of variables with a small number of experiments. Using orthogonal arrays significantly reduces the number of experimental configurations to be studied [8]. Furthermore, the conclusions drawn from small scale experiments are valid over the entire experimental region spanned by the control factors and their settings. In this study, the following parameters are considered in the mix proportions:

1. Percentage of Resin (% R)
2. Percentage of Red Mud (% RM)
3. Percentage of Calcium Carbonate (% CC)
4. Types of Composition of Fine Aggregate (CFA)

Taguchi process is robust technique and the system design with the traditional R&D technique. The performance statistics for ''the smaller the better" situations are evaluated for maximization of drilled hole deviation of polyester polymer concrete. Smaller is better: choose when goal is to maximize the response. The S/N ratio is calculated as for smaller the better.

$$S/N = -10 * \log_{10}\left(\frac{1}{n}\sum_{i=n}^{n} Y_i^2\right)$$

3. EXPERIMENTAL RESULTS

Drilling of the composite specimens has been done using two different parametric as given below: I. 1000 rpm and Feed rate 0.10.mm/rev II. 1000 rpm and Feed rate 0.20.mm/rev. and the observations have been recorded and presented in the Table 3 and Table 5. Drilling methodology have been used according to the study referred [9].

3.1 S/N Analysis for Hole Deviation at 1000 rpm and Feed rate 0.10.mm/rev

Table 3 S/N values for Hole Deviation at 1000 rpm Feed rate: 0.10 mm/rev

Inlet Deviation R1	Inlet Deviation R2	Inlet Deviation R3	AV VALVE	SSQ	S/N
0.15	0.1	0.15	0.133333	0.018333	17.36
0.18	0.13	0.16	0.156667	0.024967	16.02
0.09	0.13	0.1	0.106667	0.011667	19.33
0.14	0.16	0.18	0.16	0.025867	15.87
0.22	0.26	0.22	0.233333	0.0548	12.61
0.29	0.25	0.24	0.26	0.068067	11.67
0.28	0.23	0.26	0.256667	0.0663	11.78
0.24	0.28	0.25	0.256667	0.066167	11.79

0.14	0.19	0.14	0.156667	0.0251	16.

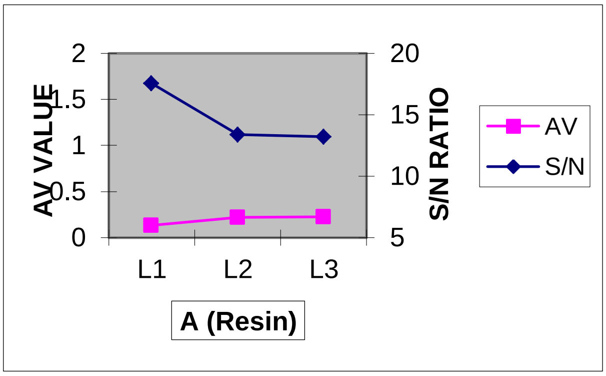

Figure1. Plot of Resin vs. average values of S/N ratio

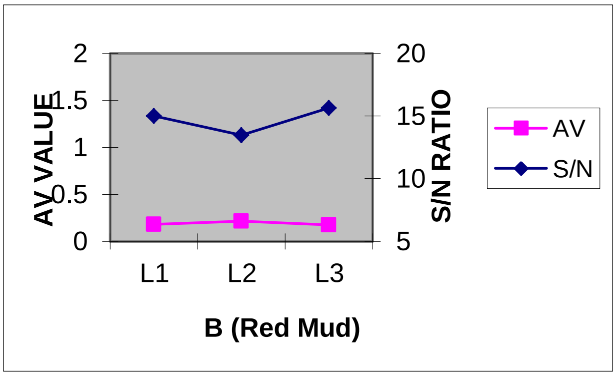

Figure 2. Plot of Red Mud vs. average values of S/N ratio

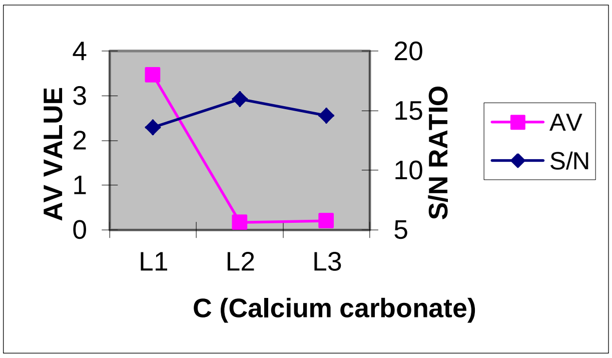

Figure 3. Plot of Calcium Carbonate vs. average values of S/N ratio

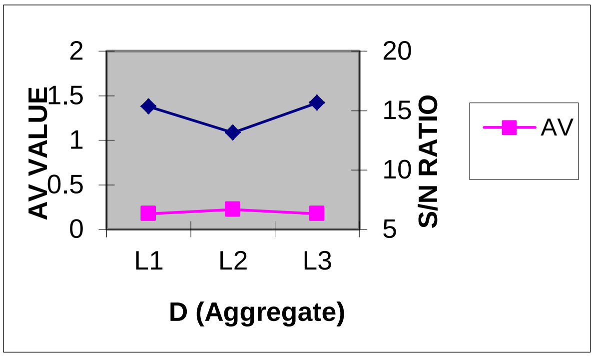

Figure 4. Plot of Aggregate vs. average values of S/N ratio

Table 4 Interaction between the factors

LEVEL	A(% of RESIN)	B(% of RM)	C(% of CC)	D(TYPE of CFA)
L1	17.57	15.01	13.61	15.33
L2	13.38	13.47	15.96	13.16
L3	13.193	15.66	14.58	15.67
Δ(MAX – MIN)	4.38	2.19	2.36	2.51
RANK	1	4	3	2

3.2 S/N Analysis for Hole Deviation at 1000 rpm and Feed rate 0.20.mm/rev

Table 5 S/N values Hole Deviation at 1000 rpm Feed rate: 0.20 mm/rev

Inlet Deviation R1	**Inlet Deviation R2**	**Inlet Deviation R3**	**AV VALVE**	**SSQ**	**S/N**
0.14	0.13	0.17	0.146667	0.0218	16.61
0.13	0.18	0.21	0.173333	0.031133	15.06
0.06	0.08	0.12	0.086667	0.008133	20.89
0.12	0.14	0.16	0.14	0.019867	17.01
0.17	0.14	0.19	0.166667	0.0282	15.49
0.26	0.23	0.2	0.23	0.0535	12.71
0.27	0.28	0.24	0.263333	0.069633	11.57
0.28	0.24	0.2	0.24	0.058667	12.32
0.21	0.21	0.2	0.206667	0.042733	13.69

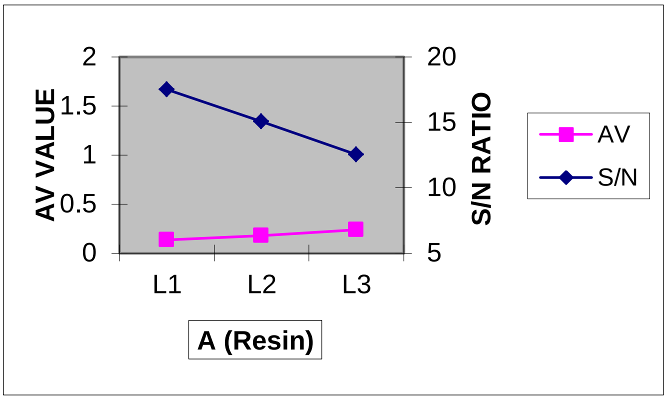

Figure 5. Plot of Resin vs. average values of S/N ratio

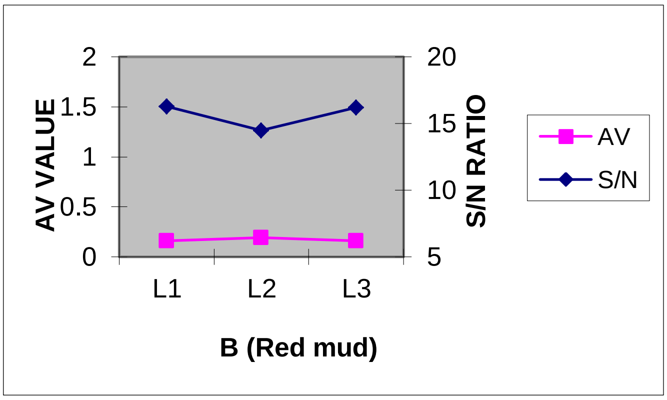

Figure 6. Plot of Red Mud vs. average values of S/N ratio

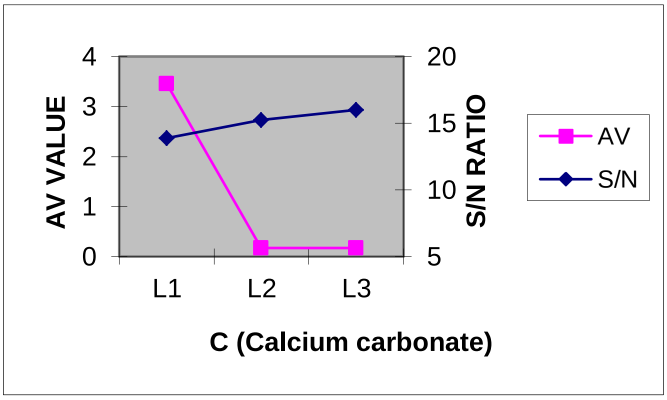

Figure 7 Plot of Calcium carbonate vs. average values of S/N ratio

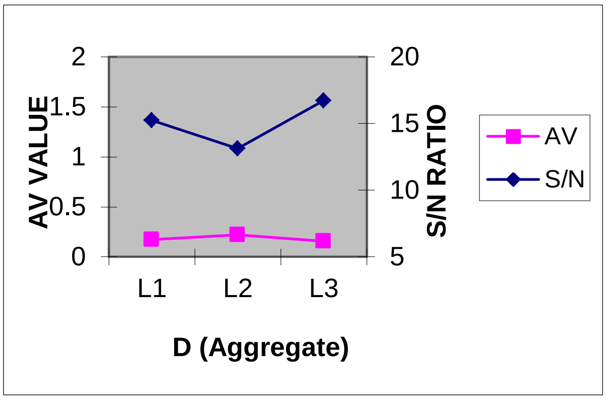

Figure 8 Plot of Aggregate vs. average values of S/N ratio

Table 6 Interaction between the factors

LEVEL	A(% of RESIN)	B(% of RM)	C(% of CC)	D(TYPE of CFA)
L1	17.52	15.06	13.88	15.26
L2	15.07	14.29	15.25	13.11
L3	12.52	15.76	15.98	16.74
Δ(MAX – MIN)	5	1.47	2.016	3.62
RANK	1	4	3	2

3.3 Effect of various constituents

In both the machining conditions, it has been found as shown in Figure 1 and Figure 5 that the hole deviation decreases with increase of resin content. Also from both interaction results as presented in Table 4 and Table 6 it has been found that the resin content is the major choice of concern in the drilling of the composites. In case of red mud, as shown in Figure 2 and Figure 6, it has been found that the hole deviation is minimum when the red mud content is at level 2. And from the interaction tables it can be seen that the red mud is least matter of concern in hole deviation while drilling.

Calcium carbonate showed least hole deviation at level 1 and it can be seen from Figure 3 and Figure 7 that the hole deviation increases with the increase of calcium carbonate content.

Minimum hole deviation has been found at level 2 having equal proportions of two types of sand aggregates according to their sieve size.

4. CONCLUSION

The results indicate that resin percentage in polyester polymer concrete will be the most significant factor to control damping. In case of resin, it has been found that S/N value is minimum for L3 (28% w/w). So it can be predicted that the hole deviation is less than higher amount of resin quantity. In case of Red Mud, it has been found that S/N value is minimum for level L2 (20% w/w). The deviation increases as we go for the upper or lower value of the filler. It can be predicted as the value of the filler increases voids increases, this leads to more hole deviation and when the amount of filler increases the material gets denser with more filler particles which decreases the bond strength and the hole deviation increases. In case of calcium carbonate, it has been found that S/N value is minimum for L1 (0.5% w/w). It can be predicted that as the value of the Calcium carbonate increases the material weakens which leads to increase the hole deviation.In case of aggregate, it has been found that S/N value is minimum for L2 (CFA2). It can be predicted that as the amount of aggregate decreases the material gets ductile which leads to increase the hole deviation. And as the vale of aggregates increases the material weakens and the hole deviation increases.

REFERENCES

[1] Bing Chen, Juanyu Liu (2007), “Mechanical properties of polymer-modified concretes containing expanded polystyrene beads”, Construction and Building Materials 21, pp. 7–11.
[2] Byung-Wan Jo, Seung-Kook Park, Do-Keun Kim (2008),“ Mechanical properties of nano-MMT reinforced polymer composite and polymer concrete”, Construction and Building Materials 22 ,pp. 14–20.
[3] Byung-Wan Jo, Seung-Kook Park, Jong-Chil Park (2008), “Mechanical properties of polymer concrete made with recycled PET and recycled concrete aggregates”, Construction and Building Materials 22, pp. 2281–2291.
[4] Antony, J. (2006), “Taguchi or Classical design of experiments: a perspective from a practitioner”, Sensor Review, Vol. 26 No3, pp. 227-230.
[5] Clifton James R. (1999), “Optimization of Polymer Concrete Composites”, NISTIR 6361.
[6] Chen Cheng-Hsin, Huang R. , Wu J.K. , Chien-Hung Chen (2006), “Influence of soaking and polymerization conditions on the properties of polymer concrete”, Construction and Building Materials 20, pp.706–712.
[7] Chiang et al. (2005), “Taguchi experimental design for manufacturing process optimisation using historical data and a neural network process model”, International Journal of

Quality & Reliability Management, Vol. 22 No 5, pp. 485-502.

[8] Erdogˇan Ozbay, Ahmet Oztas, Adil Baykasoglu, Hakan Ozbebek (2009), "Investigating mix proportions of high strength self-compacting concrete by using Taguchi method", Construction and Building Materials 23, pp. 694– 702.

[9] MANNA Alakesh (2008) Antony, J. (2002), Drilling of e-glass fibre reinforced polymer composite