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Comparative Assessment of Carbide Insert and Cermet Insert on Surface Roughness in Boring of ASTM A48 Grey Cast Iron

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Abstract: ***Boring is the operation which is extensively used to enlarge and finish the internal holes. The operation requires minimum roughness value. In this experiment, the surface roughness value (Ra) was optimized by varying the spindle speed, depth of cut and feed. The Taguchi design was used to optimize the parameters, MINITAB 17 was the software used for optimization. The work material used for the experiment is ASTM A48 Grey cast iron. Two separate tools are used to bore the internal hole, which are Carbide tool and cermet tool. The Ra value was measured by using the instrument Surftest SJ 410, Mitutoyo. By Taguchi method it was found that Feed rate is the principal factor among the selected process parameters that influences the Ra value in boring operation. Cermet tool gives more surface finish or minimum value of Ra as compared to carbide tool. Thus it is more convenient for performing boring operation for the current material.***

Keywords: ASTM A48 grey cast iron, Surface roughness, Boring, Cermet

1. Introduction

In the manufacturing industry subtractive machining processes make a unique identity. The main consideration in the manufacturing process is customer satisfaction. Customer satisfaction mainly deals with the performance of the product and quality. All metal based manufacturing industries focused to increase the quality of machined part without increasing the production cost at maximum material removal rate and minimum tool wear rate. The surface roughness is the key characteristics in the quality of the product.

Boring is one of the most commonly used subtractive machining operation in manufacturing industries. The boring is used to enlarge the diameter of hole that been already drilled or cast.

In normal case the machine operator selected feed and depth of cut but it will not give us better result. Hence it is necessary to optimize the process parameters to get better result. In order to get better surface finish and material removal rate proper setting of cutting parameters is very much important before the process takes place. Many subtractive production processes are there, turning, milling, boring, etc. Here it aims to optimize the process parameters in boring operation of cast iron for minimum surface roughness.

2. Literature Review

Vivek Pande et.al [1] (2014) wrote a paper “Application of Taguchi Approach for Optimization Roughness for Boring operation of E 250 B0 for Standard IS: 2062 on CNC TC”. In the paper he used IS 2062 steel. He designed the experiment with Taguchi L16 orthogonal array, ANOVA was used to optimize the parameters. MINITAB and EXCELL are the software used for the experimentation. He concluded that the surface roughness is mainly affected by spindle speed, nose radius and feed rate. As the spindle speed increases the surface roughness decreases.
Ramesh Kumar Gupta et.al [2] (2012) conducted an experiment and wrote the paper “Investigation of Cutting Parameters for Surface Roughness of Mild Steel in Boring Process Using Taguchi Method”. Here mild steel is used as work material. He found that the surface roughness depends on the spindle speed and feed rate.

R. A Muley et al [3] conducted an experiment to find the optimum parameters in order to have easy and economic machining. This paper represent the optimization of material removal rate and surface roughness for a given range of cutting parameters in turning. High chromium high carbon steel (AISI D2) was selected as a work material and mixed ceramic (Al_2O_3 + TiN) coated with TiN is used as cutting tool (insert). There he found that when cutting speed increasing higher cutting temperature will produce this will make the material softer and plastic therefore surface roughness will be low.

Harsimran Singh Sodhi**,** et al [4] investigates Taguchi parameter optimization methodology is applied to optimize cutting parameters in boring. The boring parameters evaluated are, cutting Speed, feed rate, and depth of cut, of the material each at three levels. The results of analysis show that feed rate and cutting speeds have present significant contribution on the surface roughness and depth of cut have less significant contribution on the surface roughness.

Wasis Nugroho, Nor Bahiyah Baba et al [5] conducted an investigation on surface roughness in the boring (internal turning) process of a workpiece which made of medium carbon steel (AISI 1050). The study investigated four parameters affecting the surface roughness of boring process namely damper position, feed rate, depth of cut and insert radius. And he concluded that, the most significant factor that contributes to surface roughness is insert radius.

3. Experimental Investigation

3.1 Selection of work material

For performing boring operation ASTM A48 grey cast iron (grade 20) is selected. They were in the form of cylindrical rod. Grey cast iron is a type of cast iron that has a graphite microstructure. The work material ASTM A48 grey cast iron shown in Figure 1.

Figure 1: work material (ASTM A48 grey cast iron)

3.2 Selection of cutting tool

In this work the cutting tool selected to do boring operation are carbide tool and cermet tool of 80 degree point angle. The carbide tool is made by sandvik coromant and the cermet tool is manufactured by Kyocera tools. Both tools selected for boring operation are CCMT.

3.3 Experimental Plan and Cutting Conditions

The experiments were carried out on a CNC Turning Centre machine (HMT Stallion 100S). Specimens of Ø50mm x 50 mm size were used for the experimentation. For the present experimental work the three process parameters at four levels have been decided.

Table 1: Process variables and their limits

Process Variables or Control Factors	Factor level			
	Level 1	Level 2	Level 3	Level 4
Speed (Vc) (m/min)	70	90	120	150
Feed (f) (mm/rev)	0.1	0.2	0.3	0.4
Depth of cut (ap) (mm)	0.8	1	1.2	1.4

3.4 Surface Roughness Measurement

The inspection and assessment of surface roughness of machined work piece can be carried out by using mitutoyo surftest SJ-410 is shown in Figure 2. It is a shop-floor type surface roughness measuring device.

Figure 2: Mitutoyo surftest SJ-410

3.5 Experimental Design

According to Taguchi's orthogonal array theory L16 orthogonal array is adopted for the whole experimentation for boring operation of ASTM A48 grey cast iron. In L16 orthogonal array, 16 experimental runs are conducted and the corresponding outputs is evaluated by Taguchi optimization technique. Table 2 shows the standard structure of L16 orthogonal array which levels of each parameters are taken as 1, 2, 3 and 4 respectively.

Table 2: Taguchi's L16 Orthogonal Array

Sl	Speed (Vc) m/min	Feed (f) mm/rev	Doc (ap) Mm
1	70	0.1	0.8
2	70	0.2	1.0
3	70	0.3	1.2
4	70	0.4	1.4
5	90	0.1	1.0
6	90	0.2	0.8
7	90	0.3	1.4
8	90	0.4	1.2
9	120	0.1	1.2
10	120	0.2	1.4
11	120	0.3	0.8
12	120	0.4	1.0
13	150	0.1	1.4
14	150	0.2	1.2
15	150	0.3	1.0
16	150	0.4	0.8

4. Result and Discussion

4.1 Experimental Results

The results of the experiments have been shown in Table 3. Surface Roughness is measured by using the instrument Surftest SJ 410 Mitutoyo.

Table 3: Experimental Results

Sl. No	Speed (Vc) m/min	Feed (f) mm/rev	Depth of cut (ap) mm	Surface roughness (Ra)μm	
				Carbide insert	Cermet insert
1	70	0.1	0.8	1.916	2.37
2	70	0.2	1	4.889	3.218
3	70	0.3	1.2	4.482	3.81
4	70	0.4	1.4	4.787	5.839

5	90	0.1	1	3.267	2.448
6	90	0.2	0.8	3.258	3.486
7	90	0.3	1.4	3.924	3.234
8	90	0.4	1.2	4.306	3.666
9	120	0.1	1.2	2.033	1.267
10	120	0.2	1.4	4.043	2.355
11	120	0.3	0.8	3.897	2.275
12	120	0.4	1	4.484	3.929
13	150	0.1	1.4	1.7	0.8
14	150	0.2	1.2	2.572	1.981
15	150	0.3	1	3.008	2.723
16	150	0.4	0.8	4.076	2.995

4.2 Taguchi analysis of surface roughness for carbide tool

Table 4: Signal to Noise ratios of Surface roughness values (carbide insert).

Sl.No	Speed (Vc) m/min	Feed (f) mm/rev	Depth of cut (ap) mm	Surface roughness (Ra)µm	S/N Ratio
1	70	0.1	0.8	1.916	-5.6479
2	70	0.2	1.0	4.889	-13.784
3	70	0.3	1.2	4.482	-13.029
4	70	0.4	1.4	4.787	-13.601
5	90	0.1	1.0	3.267	-10.283
6	90	0.2	0.8	3.258	-10.259
7	90	0.3	1.4	3.924	-11.874
8	90	0.4	1.2	4.306	-12.681
9	120	0.1	1.2	2.033	-6.1627
10	120	0.2	1.4	4.043	-12.134
11	120	0.3	0.8	3.897	-11.814
12	120	0.4	1.0	4.484	-13.033
13	150	0.1	1.4	1.700	-4.6090
14	150	0.2	1.2	2.572	-8.2054
15	150	0.3	1.0	3.008	-9.5656
16	150	0.4	0.8	4.076	-12.204

Table 5: Response Table for Means of Ra (carbide insert)

Level	Speed m/min	Feed mm/rev	Doc mm
1	4.018	2.229	3.287
2	3.689	3.691	3.912
3	3.614	3.828	3.348
4	2.839	4.413	3.614
Delta	1.179	2.184	0.625
Rank	2	1	3

From the Response Table for means of Ra values which is shown in Table 5, it indicates that surface roughness is decreasing with the increase in speed from 70 mm/min to 150 mm/min. and the minimum roughness value obtained at 150 mm/min. The surface roughness value increase with increase in feed, the minimum surface roughness obtained at 0.1mm feed.

The ranks indicate the relative importance of each factor to the response. Based on the response table, various graph can be plotted, *Ra* v/s Speed, *Ra* v/s Feed, *Ra* v/s Depth of cut which is shown in Figure 3.

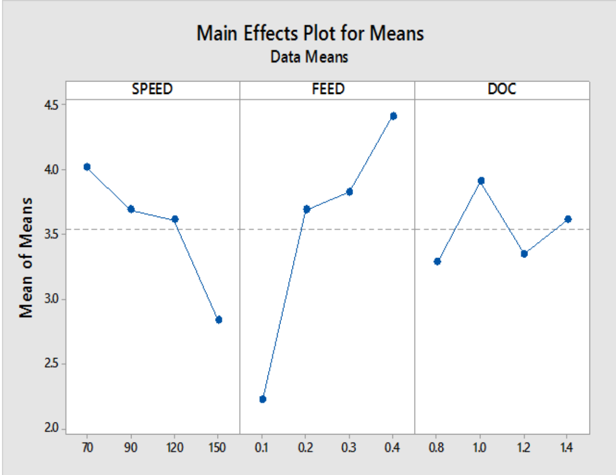

Figure 3: mean values of Ra v/s Speed, Feed and Depth of cut- Carbide tool

Table 6: Response Table for Signal to Noise Ratios of Ra - carbide insert

Level	Speed m/min	Feed mm/rev	Depth mm
1	-11.148	-3.847	-8.752
2	-10.025	-8.594	-9.629
3	-7.130	-9.413	-7.724
4	-5.557	-12.006	-7.756
Delta	5.591	8.159	1.905
Rank	2	1	3

The response table for Signal to Noise Ratios of Ra values which (carbide insert) is shown in Table 6, it indicates that Feed is the main influencing factor followed by speed and depth of cut during the boring operation. The ranks indicate the relative importance of each factor to the response. The graph based on the response table is shown in Figure 4.

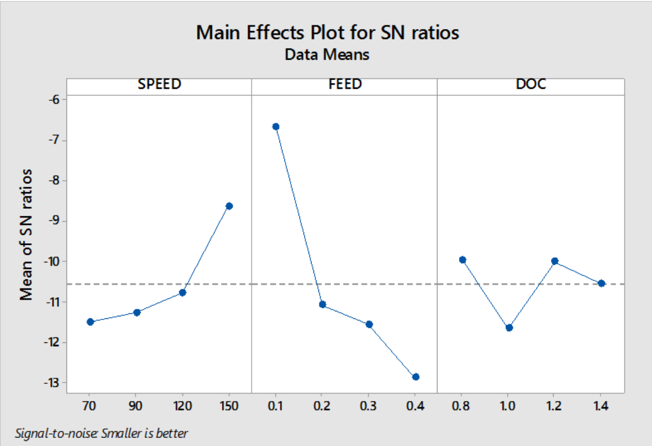

Figure 4: S/N Ratios of Ra v/s Speed, Feed and Depth of cut- Carbide insert

4.3 Taguchi analysis of surface roughness for cermet tool

Table 7: Signal to Noise ratios of Surface roughness values (cermet insert)

Sl. No	Speed (Vc) m/min	Feed (f) mm/rev	Depth of cut (ap) mm	(Ra) µm	S/N Ratio
1	70	0.1	0.8	2.370	-7.4950
2	70	0.2	1.0	3.218	-10.151
3	70	0.3	1.2	3.810	-11.618
4	70	0.4	1.5	5.839	-15.326

5	90	0.1	1.0	2.448	-7.7762
6	90	0.2	0.8	3.486	-10.846
7	90	0.3	1.5	3.234	-10.194
8	90	0.4	1.2	3.666	-11.283
9	120	0.1	1.2	1.267	-2.0555
10	120	0.2	1.5	2.355	-7.4398
11	120	0.3	0.8	2.275	-7.1396
12	120	0.4	1.0	3.929	-11.885
13	150	0.1	1.5	0.800	1.9382
14	150	0.2	1.2	1.981	-5.9377
15	150	0.3	1.0	2.723	-8.7010
16	150	0.4	0.8	2.995	-9.5279

Table 8: Response Table for Means (cermet insert)

Level	SPEED m/min	FEED Mm/rev	DOC mm
1	3.809	1.721	2.782
2	3.208	2.760	3.080
3	2.457	3.011	2.681
4	2.125	4.107	3.057
Delta	1.685	2.386	0.399
Rank	2	1	3

Figure5 shows the main effect plot for surface roughness for cermet insert. The results show that with the increase in cutting speed there is a continuous decrease in surface roughness. However, with the increase in depth of cut there is an increase in surface roughness. Based on analysis using Fig: 5 low value of surface roughness was obtained at cutting speed of 150 m/min, feed of 0.1mm/rev and depth of cut of 1.2 mm.

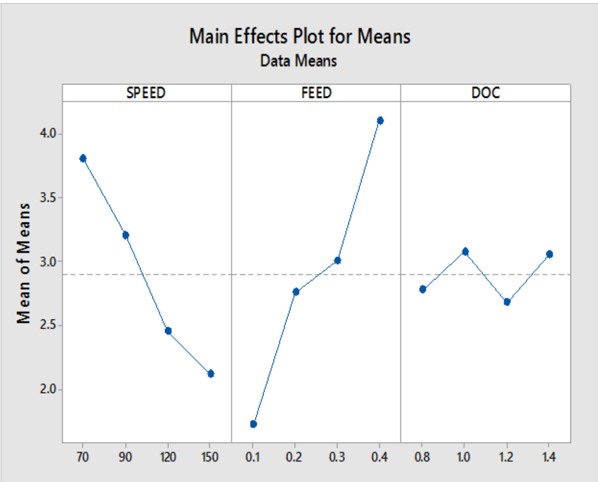

Figure 5: Mean values of Ra v/s Speed, Feed and Depth of cut- Cermet insert

Table 9: Response Table for SN Ratio-cermet insert

Level	SPEED m/min	FEED mm/rev	DOC mm
1	-11.148	-3.847	-8.752
2	-10.025	-8.594	-9.629
3	-7.130	-9.413	-7.724
4	-5.557	-12.006	-7.756
Delta	5.591	8.159	1.905
Rank	2	1	3

The response table for Signal to Noise Ratios of Ra values which is shown in Table 9, it indicates that Feed is the main influencing factor followed by speed and depth of cut during the boring operation. The ranks indicate the relative importance of each factor to the response. The graph based on the response table is shown in Figure 6.

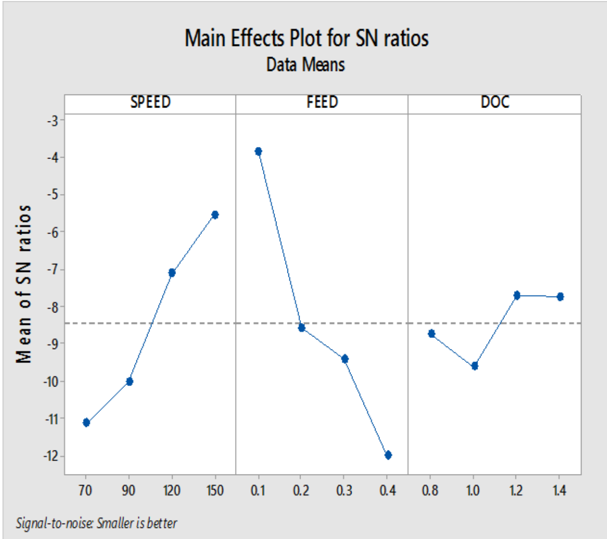

Figure 6: S/N Ratios of Ra v/s Speed, Feed and Depth of cut- Cermet insert

4.4 Analysis of Variance (ANOVA)

The analysis of variance (ANOVA) is the technique used for analyzing the experimental results from table. It is used for identifying the factors which are significantly affect the performance measures. The results of the ANOVA with the surface roughness are shown in table 10 and 11.

Table 10: Analysis of Variance for Surface Roughness for carbide insert

Source	DF	Seq SS	Adj MS	F	P	Percentage of contribution (%)
speed	1	20.551	6.850	2.68	0.141	15.75
feed	3	87.122	29.041	11.35	0.007	66.8
doc	3	7.404	2.468	0.96	0.468	5.6
Error	6	15.349	2.558			11.76
Total	15	130.42				

Table 10 shows the results of ANOVA for Surface Roughness using carbide insert. It is observed from the ANOVA table feed is the most significant cutting parameter.

Table 11: Analysis of Variance for Surface Roughness for cermet insert

Source	DF	Seq SS	Adj MS	F	P	Percentage of contribution (%)
speed	3	6.8784	2.2928	7.12	0.021	33.06
feed	3	11.5149	3.8383	11.91	0.006	55.35
Doc	3	0.4755	0.1585	0.49	0.701	2.28
Error	6	1.9332	0.3222			9.29
Total	15	20.8020				

Table 11 shows the results of ANOVA for Surface Roughness using cermet insert. It is observed from the ANOVA table, the feed (55.35%) is the most significant cutting parameter followed by speed (33.06%) and depth of cut (2.28%).The error contribution is (9.29%) for surface roughness.

4.5 Comparative Study of Carbide Insert and Cermet Insert

Graphs are plotted using the result obtained mentioned in table 4. From above analysis it is clear that feed is more affective parameter than speed. So the comparative study is based on feed as a variable parameter. Graphs are plotted as surface roughness verses feed, keeping speed constant.

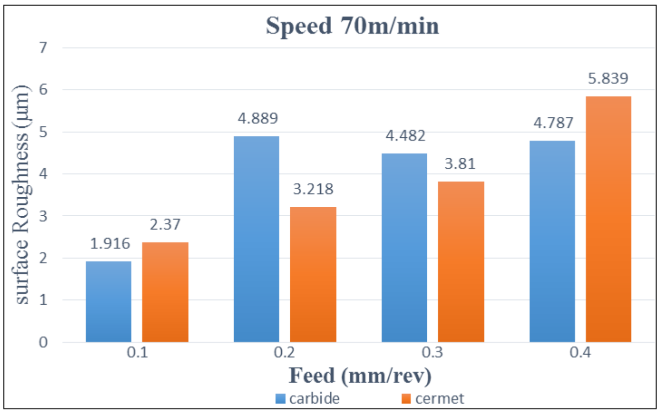

Figure 7: Comparison of carbide insert and Cermet insert under constant Cutting speed of 70 m/min

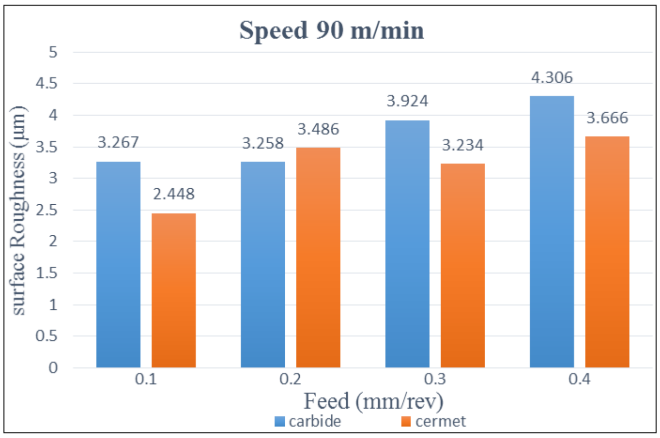

Figure 8: Comparison of carbide insert and Cermet insert under constant cutting speed of 90 m/min

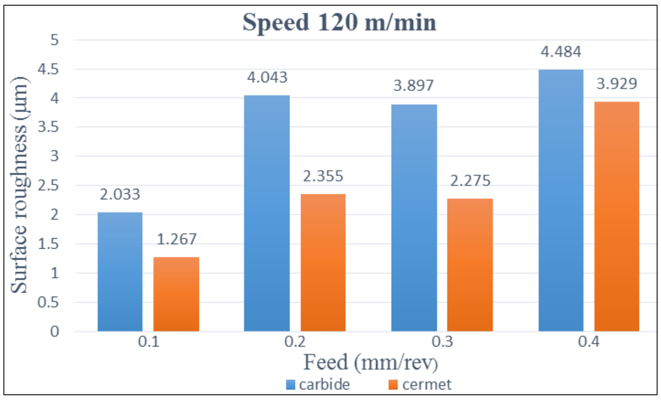

Figure 9: Comparison of carbide insert and Cermet insert under constant cutting speed of 120 m/min

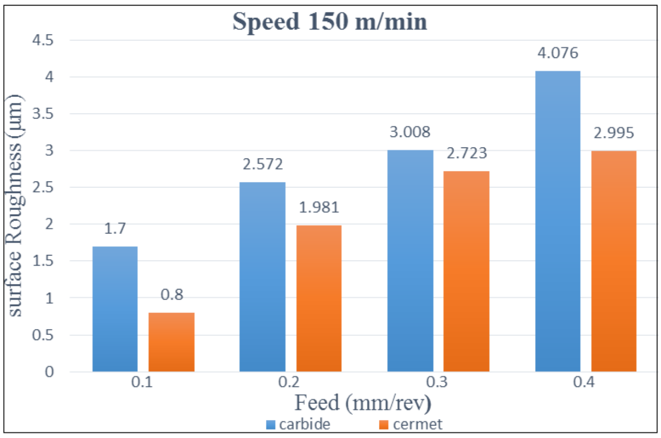

Figure 10: Comparison of carbide insert and Cermet insert under constant Cutting speed of 150 m/min

Figures 7, 8, 9 and 10 shows the comparative relation between the surface roughnesses gained from carbide insert and that from cermet insert. Here we can conclude that cermet insert provide lower roughness (Ra) of the worked surface, as compared to carbide inserts.

4.5 Validation

4.5.1 Regression Analysis

The regression analysis is used to generate the mathematical equation for finding surface roughness. The obtained equations from regression analysis for surface roughness are,

For carbide tool,

Ra = 3.08 - 0.01345 speed + 6.69 feed + 0.208 doc (1)

For cermet tool,

Ra = 3.093 - 0.02122 speed + 7.41 feed + 0.214 doc (2)

4.5.2 Simulated Annealing

The above equations (1) and (2) are optimized using Simulated annealing toolbox from MATLAB with lower bound and upper bound as (70, 0.1, 0.8) and (150, 0.4, 1.4) respectively.

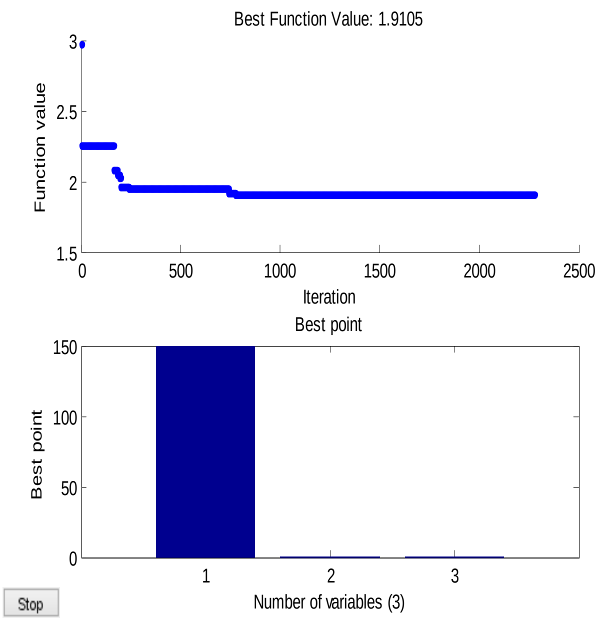

Figure 11: Carbide insert best Function value and Best point graph for Ra

The Figure 11 shows the best function value and best point for minimum Surface roughness after 2276 iterations. The optimum value for speed, feed and depth of cut is found to be 149.737 m/min, 0.1 mm/rev and 0.839 mm respectively. The function value of Ra is found to be 1.9105

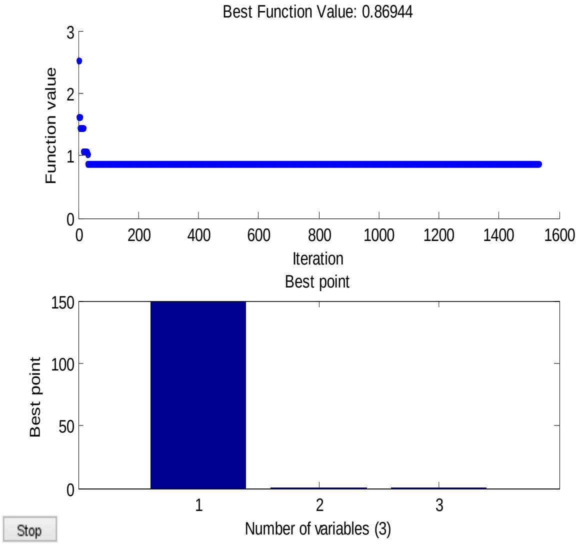

Figure 12: Best Function value and Best point graph for Ra-Cermet insert

The Figure 12 shows the best function value and best point for maximum Material removal rate after 1964 iterations. The optimum value for speed, feed and depth of cut is found to be 148.229 m/min, 0.101mm/rev and 0.818 mm respectively. The function value of Ra is found to be .86944.

Table 12: Confirmatory Test Ra

S. No	parameters	Carbide insert value	Cermet insert value
1	Cutting Speed (Vc)(m/min)	149.737	148.229
2	Feed rate (f)(mm/rev)	0.1	.101
3	Depth of cut (ap)(mm)	.839	.818
4	Predicted-Ra(µm) found from simulated annealing	1.9105	.86944
5	Experimental-Ra (µm)	1.9766	.895
6	% of Error	3.45	2.93

5. Conclusions

The effects of the process parameters such as, cutting speed, feed, depth of cut, on the response characteristic surface roughness, was studied on ASTM A48 grey cast iron material in CNC boring. Based on the results obtained, the following conclusions can be postulated.

Cermet tool gives more surface finish when compared to carbide tool for performing boring operation on ASTM A48 grey cast iron (grade 20). It can be used at higher speeds.

Taguchi method suggests R_a value mainly depends on feed,. Cutting speed is the second major factor that influences the R_a value.

The best combination at which the operation can perform and gives good surface finish for ASTM A48 grey cast iron (grade 20) with Carbide tool in the current experiment is 150 m/min speed - 0.1 mm feed – 1.4 mm depth of cut. And that for cermet tool in the current experiment is 150 m/min speed - 0.2 mm feed - 1.2 mm depth of cut

References

[1] Vivek Deshpande, Mihir Patel (2014) " Application of Taguchi Approach for Optimization Roughness for Boring operation of E 250 B0 for Standard IS*: 2062 on CNC TC"*: IJEDR vol 2.)

[2] Ramesh Kumar Gupta, Harisimran Singh Sodhi, Dhiraj Prakash Dhiman, Raminder Singh Bhatia (2012) "Investigation of Cutting Parameters For Surface Roughness of Mild Steel In Boring Process Using Taguchi Method*"*: International Journal of Applied Engineering research

[3] R.A.Muley, A.R.kulkarni, R.R.Deshmukh (2016) "optimization of surface roughness and material Removal rate in turning of AISI D*2"* International Journal of Mechanical And Production Engineering, ISSN: 2320-2092.

[4] Gourav Bansal, Harsimran Singh Sodhi and Jasmeet Singh (2014) Optimization of Machining Parameters for MRR in Boring Operation Using RSM, IJRMET vol 4.

[5] Wasis Nugroho, Nor Bahiyah Baba and Adi Saptari (2016) "optimization on surface roughness of boring process by varying damper position", ARPN Journal of Engineering and Applied Sciences ISSN 1819-6608

[6] M. Kaladhar, K. Venkata Subbaiah, Ch. Srinivasa Rao and K. Narayana Rao (2010) "optimization of process parameters in turning of AISI 202 austenitic stainless steel", ARPN Journal of Engineering and Applied Sciences. ISSN 1819-6608

[7] Show-Shyan Lin and Ming-Tsan Chuang (2009), "Optimization of 6061T6 CNC Boring Process Using the Taguchi Method and Grey Relational Analysis",The Open Industrial and Manufacturing Engineering Journal.