

Parametric Optimization for Material Removal Rate, Tool Wear Rate and Interface Temperature during Turning of AISI D3 Steel under Dry and Lubricated Condition Using Taguchi Approach

B.Yaswanth Reddy¹, R.K.Suresh²

PG Scholar, Department of Mechanical Engineering, Srialahasteeswara Institute of Technology, Srialahasti, AP,
India¹

Asst. Professor (Sr.), Department of Mechanical Engineering, Srialahasteeswara Institute of Technology, Srialahasti,
AP, India²

ABSTRACT: The objective of this paper is focused on turning of AISI D3 Steel using PVD coated cemented carbide tool cutting inserts. The experiments were performed on a KIROLOSKAR model center lathe using three input cutting parameters, cutting speed, feed and depth of cut. The responses measured were Material removal rate(MRR), Tool wear rate(TWR) and Interface temperature. Taguchi technique has been used to optimize the controllable process parameters. The contributing effects of various hard turning parameters on each response were also studied using analysis of variance (ANOVA). Metal cutting fluids changes the performance of machining operations because of their lubrication, cooling, and chip flushing functions. Typically, in the machining of hardened steel materials, no cutting fluid is applied in the interest of low cutting forces and low environmental. Impacts. Minimum quantity lubrication (MQL) presents itself as a viable alternative for machining with respect to tool wear, heat dissipation, and machined surface quality. Minimum quantity lubrication (MQL) refers to the use of cutting fluids of only a minute amount typically of a flow rate of 50 to 500 ml/hour which is about three to four orders of magnitude lower than the amount commonly used in flood cooling condition.. The objective of this work is to determine the influence of lubricant on wear and frictional force with AISI D3 Steel. Further an attempt has been made to identify the influence of Mustard oil in reducing the wear and frictional force. Further a regression is modelled as a function of cutting parameters to predict values for response characteristics in comparison with experimental values within reasonable limits. Based on the main effects plots and signal to noise ratio (S/N) obtained through taguchi approach, were used to relate the optimum level for surface roughness chosen from the considered three levels of cutting parameters.

KEYWORDS: AISI D3 steel, PVD insert, MRR, TWR, Interface temperature, Taguchi, ANOVA

I. INTRODUCTION

The important goal in the modern industries is to manufacture the product with lower cost and with high quality in short span of time. There are two main practical problems that engineers face in a manufacturing process, the first is to determine the values of process parameters that will yield the desired product quality (meet technical specifications) and the second is to maximize manufacturing system performance using the available resources. The challenge of modern machining industry is mainly focused on achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact. Today metal cutting process places major portion of all manufacturing processes. Within these metal cutting processes the turning operation is the most fundamental metal removal operation in the manufacturing industry. Increase in productivity and the quality of the

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

machined parts are the main challenges of metal based industry. There has been increased interest in monitoring all aspects of machining process. Material removal rate, Tool wear rate and Interface temperature between tool and work are the important parameters needed to be considered in manufacturing industry to ensure cost effectiveness of the final product as well as improved productivity..In the present work, AISI D3 steel was selected as work material which finds application in the manufacture of Blanking & Forming dies, press tools, punches, bushes, forming rolls and many more.

II. LITERATURE REVIEW

Varaprasad Bhemuni, Srinivasa Rao Chelamalasetti, etal[1] made an attempt to develop a model and predict the tool wear and nodal temperature of hard turned AISI D3 hardened steel using Response Surface Methodology (RSM). The combined effects of cutting speed, feed rate and depth of cut are investigated using contour plots. RSM based Central Composite Design (CCD) is applied as an experimental design.

W.H.Yang & Y.S Tang [2] envisages that the Taguchi method is a powerful tool to design optimization for quality and is used to find the optimal cutting parameters for turning operations. An orthogonal array , the signal to noise ratios and ANOVA are employed to investigate the cutting characteristics of S45C steel bars using Tungsten carbide cutting tools. Through this study, not only optimal cutting parameters for turning operations obtained, but also the main cutting parameters that affect the cutting performance in turning operations are found.

Gurpreet singh etal[3] conducted experiments En31 steel under dry and minimum quantity lubrication conditin using a conventional lathe.. The Results of surface roughness obtained during Dry and Vegetable based oil Minimum quantity lubrication werecompared with each other and indicated that the surface roughness of inimum quantity lubrication is 20-35% lower than Dry cutting.

Dhar, N.R et al [4] has experimentally investigated the effect of Minimum Quantity of Lubrication (MQL) by vegetable oil-based cutting fluid on machinability of steel, the result obtained from this study using uncoated carbide tool i.e. MQL systems enabled reduction in average chip-tool interface temperature up to 10%.

Sharma Vishal S. et al [5] has suggested the Cooling techniques for improved productivity in turning. It overview the major advancement in techniques as minimum quantity lubrication (MQL)/near dry machining (NDM), high pressure coolant (HPC), cryogenic cooling, compressed air cooling and use of solid lubricants/coolants. These techniques have resulted in reduction in friction and heat at the cutting zone, hence improved productivity of the process. A brief survey of modeling/FEA techniques is also performed

Abhang L.B et al [6] has experimentally investigated the performance of MQL machining of alloy steel with 10% boric acid by weight mixed with SAE- 40 base oil during turning of EN-31 steel using tungsten carbide cutting tool. Minimum quantity lubricant has reduced the chip-tool interface temperature by 20 to 30% in this study

R.K.Suresh etal[7] focuses on an approach based on Grey relational analysis and Desirability function analysis for optimizing the process parameters during turning of AISI D3 steel with CVD coated tool with multiple performance characteristics. Experimentation were carried out on a Conventional lathe using L9 orthogonal array based on Taguchi design of experiments. The influence of spindle speed, feed and depth of cut were analyzed on the performance of surface roughness, material removal rate, interface temperature and flank wear . From the study, it is concluded that machining performance is significantly improved.

J.S Dureja etal[8] attempts to investigate tool wear (flank wear) and surface roughness during finish hard turning of AISI D3 steel (58HRC) with coated carbide (TiSiN-TiAlN coated) cutting tool. Taguchi L9 (3)3 orthogonal array has been applied for experimental design. S/N ratio and ANOVA analyses were performed to identify significant parameters influencing tool wear and surface roughness. The cutting speed and feed were the most significant factors influencing tool wear (flank wear), and feed is the most significant factor influencing surface roughness (Ra).

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Alaattin Kacal et al [9] dealt with experimental results of high speed hard turning of hardened AISI S1 cold work tool steel with ceramic and CBN cutting tools. The results obtained from the experiments were evaluated graphically and by using ANOVA which is one of the statistical techniques

III. METHODOLOGY USED

Taguchi method:

The objective of the robust design is to find the controllable process parameters setting for which Noise or variation as a minimal effect on the product or process functional characteristics. It is to be noted that the aim is not to find the parameter setting for the uncontrollable noise variables but the controllable design variables. To attain this objective, the control parameter also known as inner array variables, are systematically varied as stipulated by the inner orthogonal array. For the each experiment of inner array, a series of new experiments is conducted by varying the level settings of the uncontrollable noise variables. The level combinations of noise variables are done using the outer orthogonal array. The interference of noise on the performance characteristics can be found using the ratio where S is the standard derivation of the performance parameters of the each inner array experiment and N is the total number of experiment in the outer orthogonal array. This ratio indicates the functional variation due to noise. Using this result, it is possible to predict which control parameter settings will make the process in sensitive to noise. Taguchi method focus on robust design through use of

1. Signal to noise ratio.
2. Orthogonal array.

Analysis of variance(ANOVA):

Analysis of variance (ANOVA) is a statistical method of determining the existence of several While the aim of ANOVA is to detect the difference among several populations means the technique requires the analysis of different forms of variance associated with random samples under the study hence it is called ANOVA. The original idea of ANOVA was devolved by the English statistician sir Ronald A fisher during the first part of this century. most of the early work in this area deal with the agricultural experiments where crops were given different treatments, such as being grown using different kinds of fertilizes. The researchers wanted to determine whether all treatments under study were equally effective or whether some treatments were better than others

IV.EXPERIMENTATION

In the present study, three turning parameters were selected with three levels as shown in Table 2. The experimentation was carried out using L9 orthogonal array based on Taguchi design of experiments. The work material selected for this experiment is AISI D3 steel of 40 mm diameter, length 100 mm. The chemical composition of AISI D3 steel is given in Table.1

The turning tests were carried out on Kirloskar model centre(TURN MASTER) lathe machine to determine the responses characteristics for various runs of experiment. The material removal rate (mm3/min) is calculated using formula:

$$MRR = [\pi/4(D_1^2 - D_2^2)L]/t \text{ mm}^3/\text{min}$$

Where, D_1 = Diameter of the work piece before turning.mm

D_2 = Diameter of the work piece after turning.mm

L = Length of turning, mm

t = Machining time, min

The tool-work interface temperature is read from Infrared pyrometer. The tool wear rate is calculated using the following formula:

$$TWR = (W_1 - W_2)/t \text{ g/hr}$$

Where, W_1 = weight of the insert before machining operation

W_2 = weight of the insert after machining operation

t = Machining time, hour

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Table: 1 Chemical composition of AISI D3 steel

Ellement	Carbon	Silicon	Mn	Ni	Cr	Mo	S	P	Al	B
% composition	2.179	0.511	0.511	0.05	12.63	0.178	0.021	0.025	0.178	0.065

Table: 2 Process parameters and their levels

Process parameters	Level 1	Level 2	Level 3
Spindle speed(rpm)	450	710	1120
Feed(mm/rev)	0.05	0.071	0.09
Depth of cut(mm)	1.0	1.5	2.0

Table 3, 4,5 depicts the experimental data and results corresponding to dry, minimum quantity lubrication and flooded lubrication conditions respectively.

Table :3 Experimental data and results-Dry condition

Expt No	Spindle speed	Feed	Depth of cut	Material removal rate(mm ³ /sec)	Tool wear rate(g/hr)	Interface temperature (°C)
1	450	0.05	1.0	22.839	0.4285	32.12
2	450	0.071	1.5	44.571	0.2834	37.44
3	450	0.09	2.0	90.198	0.7125	42.48
4	710	0.05	1.5	50.725	0.3028	42.30
5	710	0.071	2.0	84.123	0.4500	46.62
6	710	0.09	1.0	46.064	0.2950	36.14
7	1120	0.05	2.0	143.313	0.8182	40.30
8	1120	0.071	1.0	45.649	0.1358	38.02
9	1120	0.09	1.5	254.431	0.9729	36.65

Table :4 Experimental data and results-Minimum quantity lubrication condition

Expt No	Spindle speed	Feed	Depth of cut	Material removal rate(mm ³ /sec)	Tool wear rate(g/hr)	Interface temperature (°C)
1	450	0.05	1.0	24.424	0.2130	34.73
2	450	0.071	1.5	42.841	0.2857	34.24
3	450	0.09	2.0	77.957	0.3789	34.42
4	710	0.05	1.5	39.267	0.3428	34.84
5	710	0.071	2.0	76.353	0.4500	35.38
6	710	0.09	1.0	76.661	0.5902	35.22
7	1120	0.05	2.0	98.148	0.5538	35.80
8	1120	0.071	1.0	59.774	0.7200	35.58
9	1120	0.09	1.5	113.630	0.9729	35.60

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Table :5 Experimental data and results-Flooded lubrication condition

Expt No	Spindle speed	Feed	Depth of cut	Material removal rate(mm ³ /sec)	Tool wear rate(g/hr)	Interface temperature (°C)
1	450	0.05	1.0	37.870	0.1978	36.74
2	450	0.071	1.5	24.369	0.2927	38.80
3	450	0.09	2.0	89.584	0.4000	46.80
4	710	0.05	1.5	50.405	0.3396	43.14
5	710	0.071	2.0	88.834	0.4357	63.02
6	710	0.09	1.0	54.889	0.5902	39.98
7	1120	0.05	2.0	92.936	0.5435	49.78
8	1120	0.071	1.0	53.196	0.7200	41.04
9	1120	0.09	1.5	97.112	0.9231	25.83

Table 6 and 7 signifies values of means and signal to noise ratio corresponding to MRR under dry condition

Table:6 Response table for Means corresponding to MRR (Dry condition)

Level	Spindle speed	Feed	Depth of cut
1	52.54	72.29	38.18
2	60.30	58.11	116.58
3	147.80	130.23	105.88
Max-Min	98.26	72.12	78.39
Rank	1	3	2

Table7: Response table for signal to noise ratios corresponding to MRR (Dry condition)

Level	Spindle speed	Feed	Depth of cut
1	31.22	34.60	33.09
2	38.40	34.89	35.29
3	40.24	40.16	41.48
Max-Min	9.03	5.36	8.39
Rank	1	3	2

Table 8 and 9 signifies values of means and signal to noise ratio corresponding to TWR under dry condition

Table:8 Response table for Means corresponding to TWR (Dry condition)

Level	Spindle speed	Feed	Depth of cut
1	0.4748	0.5165	0.2864
2	0.3493	0.2897	0.5197
3	0.6423	0.6602	0.6602
Max-Min	0.2930	0.3704	0.3738
Rank	3	2	1

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Table:9 Response table for signal to noise ratios corresponding to TWR (Dry condition)

Level	Spindle speed	Feed	Depth of cut
1	7.086	6.494	11.769
2	9.305	11.743	7.189
3	6.441	4.595	3.874
Max-Min	2.864	7.148	7.895
Rank	3	2	1

Table 10 and 11 signifies values of means and signal to noise ratio corresponding to Interface temperature under dry condition

Table:10 Response table for means corresponding to Interface temperature (Dry condition)

Level	Spindle speed	Feed	Depth of cut
1	37.35	38.24	35.43
2	41.69	40.69	38.80
3	38.32	38.42	43.13
Max-Min	4.34	2.45	7.71
Rank	2	3	1

Table:11 Response table for signal to noise ratios corresponding to Interface temperature (Dry condition)

Level	Spindle speed	Feed	Depth of cut
1	-31.39	-31.59	-30.97
2	-32.35	-32.15	-31.76
3	-31.66	-31.67	-32.68
Max-Min	0.96	0.56	1.72
Rank	2	3	1

Table 12 and 13 signifies values of means and signal to noise ratio corresponding to MRR under MQL condition

Table:12 Response table for Means corresponding to MRR (MQLcondition)

Level	Spindle speed	Feed	Depth of cut
1	48.41	53.95	53.62
2	64.09	59.66	65.25
3	90.52	89.42	84.15
Max-Min	42.11	35.47	30.53
Rank	1	2	3

Table:13 Response table for signal to noise ratios corresponding to MRR (MQL condition)

Level	Spindle speed	Feed	Depth of cut
1	32.74	33.16	33.66
2	35.74	35.27	35.21
3	38.83	38.88	38.44
Max-Min	6.08	5.72	4.78
Rank	1	2	3

Table 14 and 15 signifies values of means and signal to noise ratio corresponding to TWR under MQL condition

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Table:14 Response table for Means corresponding to TWR (MQL condition)

Level	Spindle speed	Feed	Depth of cut
1	0.2925	0.3699	0.5077
2	0.4610	0.4852	0.5338
3	0.7489	0.6473	0.609
Max-Min	0.4564	0.2774	0.0729
Rank	1	2	3

Table:15 Response table for signal to noise ratios corresponding to TWR MQL condition)

Level	Spindle speed	Feed	Depth of cut
1	10.915	9.288	6.956
2	6.939	6.890	6.807
3	2.742	4.417	6.833
Max-Min	8.173	.872	0.149
Rank	1	2	3

Table 16 and 17 signifies values of means and signal to noise ratio corresponding to Interface temperature under MQL condition

Table:16 Response table for means corresponding to Interface temperature (MQL condition)

Level	Spindle speed	Feed	Depth of cut
1	34.46	35.12	35.18
2	35.15	35.02	34.89
3	35.66	35.08	35.20
Max-Min	1.20	0.06	0.31
Rank	1	3	2

Table:17 Response table for signal to noise ratios corresponding to Interface temperature (MQL condition)

Level	Spindle speed	Feed	Depth of cut
1	-30.75	-30.91	-30.92
2	-30.92	-30.90	-30.85
3	-31.04	-30.90	-30.93
Max-Min	0.30	0.01	0.08
Rank	1	3	2

Table 18 and 19 signifies values of means and signal to noise ratio corresponding to MRR under Flooded condition

Table:18 Response table for Means corresponding to MRR (Flooded condition)

Level	Spindle speed	Feed	Depth of cut
1	50.61	60.40	48.65
2	64.71	55.47	57.30
3	81.08	80.53	90.45
Max-Min	30.47	25.06	41.80
Rank	2	3	1

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Table:19 Response table for signal to noise ratios corresponding to MRR (Flooded condition)

Level	Spindle speed	Feed	Depth of cut
1	32.78	34.99	33.62
2	35.94	33.74	33.84
3	37.88	37.86	39.13
Max-Min	5.09	4.12	5.50
Rank	2	3	1

Table 20 and 21 signifies values of means and signal to noise ratio corresponding to TWR under Flooded condition

Table:20 Response table for Means corresponding to TWR (Flooded condition)

Level	Spindle speed	Feed	Depth of cut
1	0.2988	0.3610	0.5027
2	0.4618	0.4915	0.5205
3	0.7295	0.6378	0.4671
Max-Min	0.4307	0.2768	0.0534
Rank	1	2	3

Table:21. Response table for signal to noise ratios corresponding to TWR Flooded condition)

Level	Spindle speed	Feed	Depth of cut
1	10.843	9.573	7.170
2	6.929	6.725	6.857
3	2.937	4.411	6.683
Max-Min	7.906	5.162	0.487
Rank	1	2	3

Table 22 and 23 signifies values of means and signal to noise ratio corresponding to Interface temperature under Flooded condition

Table:22 Response table for means corresponding to Interface temperature (Flooded condition)

Level	Spindle speed	Feed	Depth of cut
1	40.78	43.22	39.25
2	48.71	47.62	41.75
3	44.71	43.36	53.20
Max-Min	7.93	4.40	13.95
Rank	2	3	1

Table:23 Response table for signal to noise ratios corresponding to Interface temperature (Flooded condition)

Level	Spindle speed	Feed	Depth of cut
1	-32.16	-32.65	-31.87
2	-33.57	-33.34	-32.40
3	-32.98	-32.72	-34.45
Max-Min	1.41	0.70	2.58
Rank	2	3	1

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Table 24, 25 and 26 signifies the percentage contribution made by each process parameter on the response characteristics namely MRR, TWR and Interface temperature respectively under dry condition.

Table: 24 ANOVA for the response MRR in case of dry condition

Souce of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	Percent contribution
Spindle speed	2	16790	8395	3.082	40.128
Feed	2	8758	4379	1.607	20.930
Depth of cut	2	10848	5421	1.990	25.912
Residuals	2	5449	2724		13.02
Total	2				100.000

Table 25 ANOVA for the response TWR in case of dry condition

Souce of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	Percent contribution
Spindle speed	2	0.1297	0.0648	1.5300	20.358
Feed	2	0.2093	0.1046	2.4864	32.849
Depth of cut	2	0.2139	0.1069	2.5413	33.576
Residuals	2	0.0842			13.214
Total	2				100.000

Table:26 ANOVA for the response Interface temperature in case of dry condition

Souce of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	Percent contribution
Spindle speed	2	31.101	15.551	2.0469	21.148
Feed	2	11.205	5.603	0.7673	7.619
Depth of cut	2	89.556	29.852	22.255	60.898
Residuals	2	15.195	7.597		10.332
Total	2				100.000

Table 27, 28 and 29 signifies the percentage contribution made by each process parameter on the response characteristics namely MRR, TWR and Interface temperature respectively under MQL condition.

Table:27 ANOVA for the response MRR in case of MQL condition

Souce of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	Percent contribution
Spindle speed	2	2717	1358	7.908	40.802
Feed	2	2176	1088	6.400	30.678
Depth of cut	2	1424	712	9.188	21.385
Residuals	2	340	170		5.106
Total	2				100.000

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Table:28 ANOVA for the response TWR in case of MQL condition

Souce of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	Percent contribution
Spindle speed	2	0.3196	0.1597	35.779	70.503
Feed	2	0.1166	0.0583	13.053	25.721
Depth of cut	2	0.0082	0.0041	0.917	1.804
Residuals	2	0.0089	0.0045		1.971
Total	2				100.000

Table:29 ANOVA for the response Interface temperature in case of MQL condition

Souce of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	Percent contribution
Spindle speed	2	2.1625	1.0812	17.135	87.592
Feed	2	0.00527	0.0026	0.04173	0.2153
Depth of cut	2	0.1748	0.0874	0.3856	7.083
Residuals	2	0.1262	0.0631		5.112
Total	2				100.000

Table 30, 31 and 32 signifies the percentage contribution made by each process parameter on the response characteristics namely MRR, TWR and Interface temperature respectively under flooded condition.

Table:30 ANOVA for the response MRR in case of Flooded condition

Souce of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	Percent contribution
Spindle speed	2	1395.544	697.772	3.106	23.964
Feed	2	1057.483	528.742	2.364	18.159
Depth of cut	2	2921.245	1460.623	6.502	50.162
Residuals	2	449.301	224.651		7.715
Total	2				100.000

Table:31 ANOVA for the response TWR in case of Flooded condition

Souce of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	Percent contribution
Spindle speed	2	0.2866	0.1433	93.933	69.701
Feed	2	0.1160	0.0580	38.017	28.209
Depth of cut	2	0.0055	0.0027	1.816	1.347
Residuals	2	0.0031	0.0015		0.742
Total	2				100.000

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Table:32 ANOVA for the response Interface temperature in case of Flooded condition

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	Percent contribution
Spindle speed	2	163.164	81.582	33.581	19.767
Feed	2	153.333	76.666	31.558	18.076
Depth of cut	2	504.082	252.041	103.746	61.068
Residuals	2	4.859	2.4294		0.588
Total	2				100.000

V. CONCLUSION

The analyzed results from turning AISI D3 steel with PVD coated cemented carbide inserts revealed the following conclusions

DRY

- **Material removal rate**

1. The optimal combination of process parameters for maximum material removal rate is obtained at 450 rpm, 0.09 mm/rev feed and 1.50 mm depth of cut
2. It is observed that spindle speed is the most influential controlling factor on material removal rate variation followed by depth of cut
3. Feed is found to be insignificant on material removal rate
4. The ANOVA related that the percentage contribution of Spindle speed (40.128%) is the dominant parameter followed by depth of cut (25.912%) for material removal rate.

- **Tool wear rate**

1. The optimal combination of process parameters for minimum tool wear rate is obtained at 1120 rpm, 0.071 mm/rev feed and 1.0 mm depth of cut
2. It is observed that depth of cut is the most influential controlling factor on material removal rate variation followed by feed.
3. Spindle speed is found to be insignificant on tool wear rate
4. The ANOVA related that the percentage contribution of Depth of cut (33.576%) is the dominant parameter followed by feed (32.849%) for tool wear rate.

- **Interface temperature**

1. The optimal combination of process parameters for minimum interface temperature is obtained at 710 rpm, 0.09 mm/rev feed and 1.0 mm depth of cut
2. It is observed that depth of cut is the most influential controlling factor on interface temperature variation followed by spindle speed
3. Feed is found to be insignificant on interface temperature
4. The ANOVA related that the percentage contribution of Depth of cut (60.898%) is the dominant parameter followed by spindle speed (21.148%) for interface temperature

SQL

- **Material removal rate**

1. The optimal combination of process parameters for maximum material removal rate is obtained at 1120rpm, 0.09 mm/rev feed and 2.00 mm depth of cut
2. It is observed that spindle speed is the most influential controlling factor on material removal rate variation followed by feed
3. Depth of cut is found to be insignificant on material removal rate
4. The ANOVA related that the percentage contribution of Spindle speed (40.802%) is the dominant parameter followed by feed (30.678%) for material removal rate

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

- **Tool wear rate**

1. The optimal combination of process parameters for minimum tool wear rate is obtained at 450 rpm, 0.05 mm/rev feed and 2.0 mm depth of cut
2. It is observed that spindle speed is the most influential controlling factor on material removal rate variation followed by feed.
3. Depth of cut is found to be insignificant on tool wear rate
4. The ANOVA re related that the percentage contribution of Spindle speed (70.503%) is the dominant parameter followed by feed (25.721%) for tool wear rate.

- **Interface temperature**

1. The optimal combination of process parameters for minimum interface temperature is obtained at 450 rpm, 0.09 mm/rev feed and 1.5 mm depth of cut
2. It is observed that spindle speed is the most influential controlling factor on interface temperature variation followed by depth of cut
3. Feed is found to be insignificant on interface temperature
4. The ANOVA re related that the percentage contribution of spindle speed (87.592%) is the dominant parameter followed by depth of cut (7.083%) for interface temperature

Flooded lubrication

- **Material removal rate**

1. The optimal combination of process parameters for maximum material removal rate is obtained at 1120rpm, 0.09 mm/rev feed and 2.00 mm depth of cut
2. It is observed that depth of cut is the most influential controlling factor on material removal rate variation followed by spindle speed
3. Feed is found to be insignificant on material removal rate
4. The ANOVA re related that the percentage contribution of depth of cut (50.162%) is the dominant parameter followed by spindle speed (23.964%) for material removal rate

- **Tool wear rate**

1. The optimal combination of process parameters for minimum tool wear rate is obtained at 450 rpm, 0.05 mm/rev feed and 2.0 mm depth of cut
2. It is observed that spindle speed is the most influential controlling factor on material removal rate variation followed by feed.
3. Depth of cut is found to be insignificant on tool wear rate
4. The ANOVA re related that the percentage contribution of Spindle speed (69.701%) is the dominant parameter followed by feed (28.209%) for tool wear rate.

- **Interface temperature**

1. The optimal combination of process parameters for minimum interface temperature is obtained at 450 rpm, 0.05 mm/rev feed and 1.0 mm depth of cut
2. It is observed that depth of cut is the most influential controlling factor on interface temperature variation followed by spindle speed
3. Feed is found to be insignificant on interface temperature
4. The ANOVA re related that the percentage contribution of depth of cut (61.068%) is the dominant parameter followed by spindle speed (19.767%) for interface temperature

REFERENCES

1. Bhemuni, V., Chelamalasetti, S.R. and Kondapalli, S.P. (2014) Effect of Machining Parameters on Tool Wear and Nodal Temperature in Hard Turning of AISI D3 Steel. *Open Access Library Journal*, 1: e627.
2. W.H Yang & Y.S Tang, Design optimization of cutting parameters based on Taguchi method, *Journal of Materials processing Technology* 84(1998) 122-129

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

3. Gurpreet singh, Dr. Sehjpal singh, Ajay kumar, Experimental evaluation of machining performance into turning of En 31 steel with dry and vegetable based oil minimum quantity lubrication, International journal of research in Mechanical Engineering and Technology, Vol.2, Issue 2, Mar 2013
4. Dhar, N.R and Khan, M. M. A., (2006), "A study of effects of MQL on temperature, force, tool wear and product quality in turning AISI 9310 steel". Net Field wise Seminar on Manufacturing and Material Processing, issue 2, pp. 2006, 30-35
5. Sharma, V.S., Dogra, Manu., and Suri, N.M., "Cooling techniques for improved productivity in turning". International Journal of Machine Tools & Manufacture 49 2009, pp- 435–453.
6. Abhang, L B., Hameedullah, M., "Experimental Investigation of Minimum Quantity lubricants in Alloy Steel Turning",. International Journal of Engineering Science and Technology, Volume 2(7), 2010, pp. 3045 – 3053.
7. R.K.Suresh, P.Venkataramaiah and G.Krishnaiah, "GRA & DFA based multi objective optimization during turning of AISI D3 steel using CNMG insert" Elixir Mechanical Engineering 85 (2015) 34294-34298
8. J.S Dureja, Rupinder singh, Manpreet S. Bhatti, Production and Manufacturing Research: An open access journal , Sep 2014
9. Alaattin Kacal , Ferhat Yildirim, High speed hard turning of AISI SI cold work tool steel, Acta Polytechnica Hungarica, Vol 10, No. 8, 2013