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Experimental investigation and optimization of turning parameters on delrin using response surface methodology

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Abstract
The modern machining industries is mainly focused on achieving high quality, in terms of part/component accuracy, surface finish, high production rate and increase the product life with lesser environmental impact. We have so much of manufacturing methods in industries and they are Milling, Welding, Forging, Machining, Casting, Drilling, and Turning methods. The method will be selected based on the Manufacturing cost, Productivity time, and other factors. Turning is one of the processes for removal of material in the form of chips manner from the specimen. Many of the authors surveyed is that in turning process the main affecting parameters is machining time. The selection of optimal cutting parameters is a very important issue for every machining process in order to improve the quality of machining products and reduce the machining costs. This project work investigates the effects of cutting parameters like spindle speed, feed and depth of cut on material removal rate in turning on DELRIN material. The experiment is carried out on CNC machine. The Response Surface Methodology(RSM) is used as the optimisation technique. In RSM box behnken method is used. L_{17} Orthogonal array is used to formulate the experimental layout .Genetic Algorithm(GA) is used to find out the optimum cutting conditions.

Keywords: Turning process, Delrin, RSM, Material Removal Rate, GA

Introduction
In manufacturing industries right now the main aim is to reduce the time of manufacturing products with high quality. Engineers facing two main non-theoretical problems in a manufacturing process that is to determine the values of optimum process parameters that will yield the desired product quality and to maximize manufacturing system performance using the available resources. Manufacturing process is a part of production process which is directly concerned with the dimensions of the part being produced. It does not cover the delivery, handling or storage of parts. All the processes used in manufacturing involve for converting the ingot materials into usable products may be classified into three major groups as primary is an shaping processes, then secondary is an machining processes, then final process is an surface finishing processes.
Turning is a machining process in which in which a cutting tool, typically a non-rotary tool bit, describes a helix tool path by moving more or less linearly while the work piece rotates The tool axes of movement may be literally a straight line, or they may be along set of curves or angles, but they are essentially linear (in the non-mathematical sense).
Turning is the removal of material from the cylindrical specimen. Turning is used to reduce the diameter of a work piece, usually to a specified dimension and to produce a smooth finish metal on the metal. Often the work piece will be turned so that consecutive sections have different diameters. Generally, the term “turning” is reserved for to generate the external surfaces by this cutting action, when this same principle is applied to internal surfaces is called boring.
Turning can be carried out in a lathe or it can be done by using an automated lathe. Nowadays such type of automation is computer numerical control, which is known as CNC.
Some researchers are used statistical and intelligent techniques to predict the optimum level of input parameters like Taguchi Design of experiments, Fuzzy Logic, Response Surface Methodology, GA, GRA, and Neural Network based on the experimental analysis. The level

of input process parameters have selected based on the machine specifications and manufacturer recommendations. The experimental investigations are carried out to predict the optimum level of input parameters

Literature Review

Turning is the removal of material from the cylindrical specimen. Turning is used to reduce the diameter of a work piece, usually to a specified dimension and to produce a smooth finish metal on the metal. Normally the input parameters considered for this research work are speed, Feed rate, Depth of cut the test specimen. The literature assessment on the turning process is crucial to study the effect of process parameters on the specimen.

Peter engal et al (1995) investigated the wear behaviour of the delrin disc, impact wear tests were performed by using a pivotal hammer device with a spherical striking force. In this work both dry and lubricated contacts were investigated in order to compare wear mechanism. Finally authors concluded that lubrication may tend both to aggravate the plastic contact information and to generate internal cracking.Poganik et al (2012) studied the parameters affecting the running in and long term behaviour of plastic/steel contacts at sliding distances sufficiently long to ensure. Steady state sliding conditions, which is very Significant for an evaluation of the performance in real scale applications. Christopher porter et al (1970) studied the molecular relaxations in delrin. Dielectric loss in delrin has been measured at temperatures both below and above the crystalline melting point. They found that there is a considerable conductivity loss which obscures the low frequency portion of the loss spectrum of delrin. Read et al (1961) investigated the molecular motions in the polymer. The authors concluded that a single broad dielectric relaxation process with the low temperature relaxation is suitable for delrin material.

Coates et al (1978) studied the plastic deformation behaviour of linear polyethylene and poly oxy methylene. They are studied as a function of strain rate over a very wide range of plastic. In this true stress–strain-strain rate relationships for each polymer under given conditions such as pressure, temperature were determined.James s.fister et al (1985) studied the biocompatibility of delrin150 for total joint prostheses. The materials were implanted into muscles and bones as solid cylinders. The polymer implants reacts with the tissue in a mild manner.The macroscopic and histologic study of the organs revealed no evidence of systematic toxicity attributable to the delrin 150 implants. Arun Kumar Parida et al (2014) studied the influencing parameters on machining of GFRP composites. Taguchi method was used as optimisation technique and L9 orthogonal array was used for conducting experiments. For surface roughness feed rate and depth of cut was found to be the most significant factor. Manjunatha. R et al (2014) investigated the optimisation of turning parameter on EN19 steel with coated carbide tool. Taguchi based Grey relational analysis was used as optimization technique and ANOVA was used to find the most significant factor. Depth of cut mostly influences the feed force and tangential force while feed rate was the significant factor for surface roughness.

Rambabu et al (2015) investigated the cutting parameters in turning operation of aluminium 7075 alloy. Multiple regression analysis is used to show the effects of cutting parameters on the surface roughness. The results reveal that tool traverse feed observed to have more influence on the mean of surface finish and mean of material removal rate. Krishnakant et al (2012) conducted turning operation on EN24 steel to optimize the Material Removal Rate (MRR). They find out the optimum value for speed, feed and depth of cut. They used Taguchi method. From the result, it is understood that for MRR, the significant factor is depth of cut.

Experimental Work

The experiments were conducted on the CNC machine is shown in Figure A. In this experimental work, Derlin material is used for investigation. The specimen was prepared from the raw materials having the dimensional area of about diameter 32mm and length 75 mm is shown in Figure B. The mechanical property of test specimen is given in Table 1. The selection of machining parameters is most important for achieving better mechanical properties.

The significant process parameters predicting the turning performance characteristics are speed, Feed Rate, Depth of Cut can be used within the range available in the machine requirements and manufacturer suggestion is shown in Table 2. The experiments were carried out by the proper selection of input parameters to enhance Material Removal Rate.

Table 1: Mechanical Properties

Elements	Values
Tensile strength	9000 psi
Rockwell hardness	R118
Impact strength	1.5 ft-lbs/in
Compressive strength	5200 psi

Fig A: CNC Machine

Fig B: Test Specimen

Table 2: Levels and Factors

Input parameters	Level (-1)	Level (+1)
Speed(rpm)	500	1000
Feed(mm/rev)	0.15	0.25
Depth of cut(mm)	1.5	2.5

4. Results and Discussions

4.1 Experimental Result of Material Removal Rate

The 17 experiments were conducted using CNC machine. After conducting the experiment MRR is calculated by dividing the difference of weight before machining and weight after machining by machining time. Time is calculated by stop watch.

Table 3: Experimental Result of Material Removal Rate

STD	RUN	Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)	Material removal rate (gram/min)
6	1	1000	0.20	1.50	20.01
15	2	750	0.20	2.00	21.4
11	3	750	0.15	2.50	24.79
5	4	500	0.20	1.50	12.57
1	5	500	0.15	2.00	14.46
8	6	1000	0.20	2.50	28.4
3	7	500	0.25	2.00	14.5
10	8	750	0.25	1.50	15.96
13	9	750	0.20	2.00	21.6
2	10	1000	0.15	2.00	24.75
14	11	750	0.20	2.00	23.5
12	12	750	0.25	2.50	25.4
9	13	750	0.15	1.50	16.66
7	14	500	0.20	2.50	15.01
17	15	750	0.20	2.00	22.68
16	16	750	0.20	2.00	24.79
4	17	1000	0.25	2.00	23.8

4.1.2 Interaction Effect of Speed and Feed on Material Removal Rate

The above curve shows the interaction and direct effect of speed and feed on material removal rate. As the spindle speed increases from 500 rpm to 1000 rpm the material removal rate increases from 15.5 g/min to 25 g/min. If the feed increases there is no change in the material removal rate. From that it is clear that the feed does not have a significant effect on material removal rate.

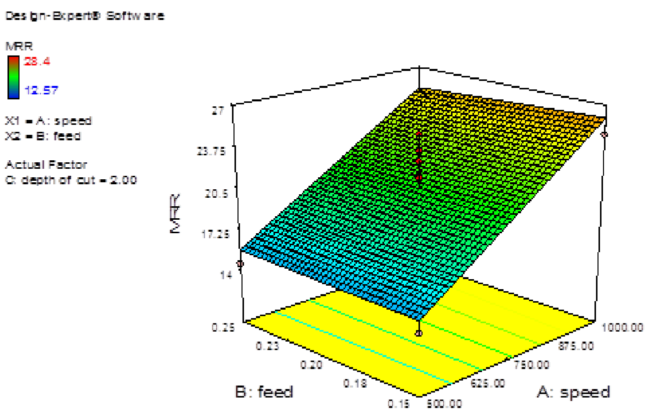

Fig C: Interaction Effect of speed and feed on MRR

4.1.3 Interaction Effect of Feed and Depth of Cut on Material Removal Rate

The above curve shows the interaction and direct effect of feed and depth of cut on material removal rate. As the depth of cut increases from 1.5 mm to 2.5 mm the material removal rate increases from 15g/min to 24.75 g/min. If the feed increases there is no change in the material removal rate. From that it is clear that the feed does not have a significant effect on material removal rate.

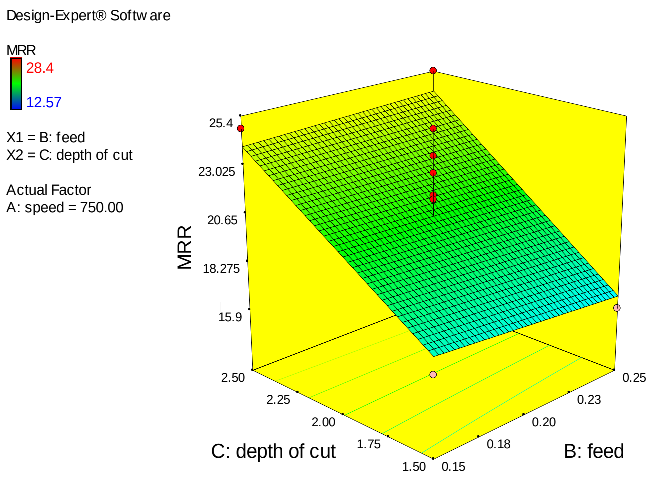

Fig D: Interaction Effect of Feed and depth of cut on MRR

4.1.4 Interaction Effect of Speed and Depth of Cut on Material Removal Rate

The above curve shows the interaction and direct effect of speed and depth of cut on material removal rate. As the spindle speed increases from 500 rpm to 1000 rpm the material removal rate increases from 10 g/min to 20 g/min. If the depth of cut increases 1.5 mm to 2.5mm the material removal rate increases from 11g/min to 18g/min. From that it is clear that speed and depth of cut have a significant effect on material removal rate.

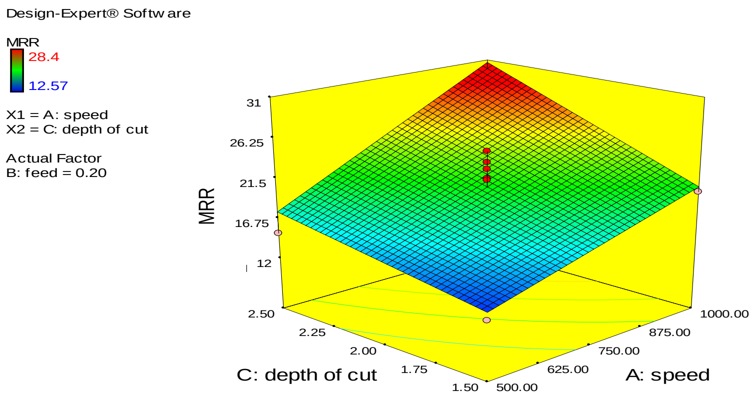

Fig E: Interaction Effect of speed and depth of cut on MRR

4.2 Comparison of Actual vs. Predicted Material Removal Rate

Using the regression equation predicted material removal rate is calculated for all 17 experiments and error is calculated by subtracting the actual MRR from predicted MRR and it is tabulated below.

Table 4: Comparison of Actual vs Predicted Material Removal Rate

std	run	speed(rpm)	feed(mm)	depth of cut (mm)	act.MRR(g/min)	pre.MRR(g/min)	error(g/min)
6	1	1000	0.2	1.5	20.01	19.0125	0.9975
15	2	750	0.2	2	21.4	22.794	-1.394
11	3	750	0.15	2.5	24.79	24.05	0.74
5	4	500	0.2	1.5	12.57	11.8825	0.6875
1	5	500	0.15	2	14.46	14.2025	0.2575
8	6	1000	0.2	2.5	28.4	29.0875	-0.6875
3	7	500	0.25	2	14.5	14.4475	0.0525
10	8	750	0.25	1.5	15.96	16.7	-0.74
13	9	750	0.2	2	21.6	22.794	-1.194
2	10	1000	0.15	2	24.75	24.8025	-0.0525
14	11	750	0.2	2	23.5	22.794	0.706
12	12	750	0.25	2.5	25.4	24.455	0.945
9	13	750	0.15	1.5	16.66	17.605	-0.945
7	14	500	0.2	2.5	15.01	16.0075	-0.9975
17	15	750	0.2	2	22.68	22.794	-0.114
16	16	750	0.2	2	24.79	22.794	1.996
4	17	1000	0.25	2	23.8	24.0575	-0.2575

4.3 Experimental Study of Material Removal Rate Using Genetic Algorithms

The material removal rate should be maximum.So that more amount of material will be removed from the workpiece. Finding suitable input parameter for maximum MRR is important one. This is accomplished by using genetic algorithm. Genetic algorithm is non-traditional approach based on the dynamics of ntural genetics to find out the best solutions for the given problem

4.3.1 Implementation of GA

The coding of GA is done using microsoft visual studio 2008 as front end and MS ACCESS 2007 as Backend. Table 5 shows the parameter setting of coded GA.

Table 5: Parameter setting of coded GA

Sl. No.	Parameter	Value
1	Population Size	100
2	Cross over Probability	0.7
3	Mutation probability	0.02
4	No. of generations	1000

The algorithm runs for 20 times. Table 6 shows the first 20 iterations of best trial run in GA. Among 1000 iterations, ten different ranges of best trial runs in GA are shown in Table 5.15.Table 5.16 shows the optimised input parameter for MRR

Table 6: First 20 iterations of best trial run in GA

Iteration No	Speed	Feed	Depth	MRR
381	750.24	0.2	1.93	22.28
826	750.24	0.2	1.93	22.28
382	750.24	0.2	1.93	22.28
380	750.24	0.2	1.93	22.28
852	750.24	0.22	1.93	22.07
741	750.24	0.25	1.93	21.25
765	750.24	0.25	1.93	21.25
764	750.24	0.25	1.93	21.25
763	750.24	0.25	1.93	21.25
762	750.24	0.25	1.93	21.25
761	750.24	0.25	1.93	21.25
760	750.24	0.25	1.93	21.25
872	750.24	0.25	1.93	21.25
302	750.24	0.25	1.93	21.25
333	750.24	0.25	1.93	21.25
740	750.24	0.25	1.93	21.25
301	750.24	0.25	1.93	21.25
739	750.24	0.25	1.93	21.25
335	750.24	0.25	1.93	21.25

Table 7: ten different ranges of best trial runs

Iteration No	Speed	Feed	Depth	MRR
381	750.24	0.2	1.93	22.28
852	750.24	0.22	1.93	22.07
741	750.24	0.25	1.93	21.25
116	625.61	0.22	1.93	19.07
148	625.61	0.25	1.93	18.33
617	625.12	0.25	1.93	18.31
190	563.05	0.25	1.93	16.38
731	562.56	0.25	1.93	16.36
359	531.28	0.2	1.93	16.07
767	531.28	0.25	1.93	15.26

Table 8 optimized input parameter for MRR

The optimized value of MRR obtained from the input parameter is shown in the above table.

Iteration no	Speed (rpm)	Feed(mm/rev)	Depth of cut (mm)
381	750.24	0.2	1.93

5. Conclusions

Three factors i.e. Speed, Feed and Depth of cut along with three levels of each factor were considered. By obtaining the result of GA, Graphs,following conclusion is given:

1) For Material Removal Rate the siginificant factor is speed and depth of cut.
2) The optimum cutting parameter for Material Removal Rate is obtained at the Speed at 750.24 rpm, Feed at 0.2 mm/rev and Depth of cut at 1.93 mm.

6. References

1. Peter.A.Engel,"Impact of delrin disc", impact wear, in k.c.ludema (ed.), friction, Lubrication and wear technology, 1992, chapter 18 in ASM handbook pp.263-270
2. A.Poganik, M.Kalin,"Parameters influencing the running in and long term tribological behaviour of polyamide against polyactal and steel ",wear,pp 290-291,2012.
3. Christopher h.porter,James h.l.lawler, "A dielectric study of molecular relaxation in polyoxymethyleneat high temperatrures", macromolecules, vol. no. 3, pp. 309-314, may 1970.
4. B.e.read and G.williams,"Dielectric and dynamic properties of polyoxymethylene"(DELRIN), app.polym.sci, pp.239-255, 1961.
5. P.D.Coates and I.M.Ward,"the plastic deformation behaviour of linear polyethylene and polyoxymethylene " journal of materials science 13,19786.
6. S. Sakthivelu, T. Anandaraj, M. Selwin, Multi-Objective Optimization of Machining Conditions on Surface Roughness and MRR during CNC End Milling of Aluminium Alloy 7075 Using Taguchi Design of Experiments, Mechanics and Mechanical Engineering, Volume-21, Issue-1 (2017) 95–103.
7. James S.fister and Vincent a.memoli,"Biocompatibility of delrin150", journal of biomedical materials research, vol19, pp.519-533, 1985.p.
8. Arun Kumar Parida, Ratnakar Das, A. K. Sahoo, B.C. Routara, "Optimization of cutting parameters for surface roughness in machining of GFRP composites with graphite/ fly ash filler", 3rd International conference on materials processing and characterization, Procedia materials science 6, pp. 1533- 1538, 2014.
9. M.Ravichandran, M.Meignanamoorthy and S.Sakthivelu, Optimization of material removal rate in CNC drilling of AA6063 using Taguchi method, International Journal of Research in Advanced Technology, Volume-1,Issue-9, November- 2016, 1-3.
10. Krishankant, Jatin Taneja, Mohit Bector and Rajesh Kumar,"Application of taguchi method for optimizing turning process by the effects of machining parameters," International journal of engineering and advanced technology, vol. 2, no. 1, October 2012.
11. Nandhakumar, S., R. Vijayakumar, Senthil Padmavathy, and N. Nagasundaram. "Optimization of Cutting Parameters during Turning of AISI-310 Using Response Surface Methodology." Applied Mechanics and Materials 854 (2017): 45-51.