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Employing a Carbide Machine for Turning Stainless Steel, Parametric Optimization Succeeded

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Abstract

The turning technique known as "microturning" entails machining work pieces with dimensions between 1 and 999 micrometers. Stainless steel is being picked as the material for the work piece because it is one of the most significant and commonly used materials nowadays. Three parameters are selected for the machining process: depth of cut, feed, and cutting speed. Reducing cutting forces—the feed force, the push force, and the cutting force—is the experiment's primary goal. The experiment's goals are to limit forces, decrease chip thickness, minimize surface roughness, and minimize tool wear. A dynamometer was used to measure the forces as the experiment was conducted on a lathe. Dry machining is the method of operation. The ideal settings for more effective machining are found using the Taguchi method and gray relational analysis. The statistical program Minitab is utilized for the analysis portion.

I. INTRODUCTION

Now a day the main motive of the industries is to reduce cost and maximize their profit through improving their technology. In production engineering there is a lot of scope for improvement. A lot of efforts are being made to improve the productivity and machinability of the machines to satisfy the daily increasing needs. Sometime it happens that if we increase the surface finish or decrease the forces then the cost of machining increases in very large amount. So we have to optimize the things in such a way that it should fulfill our both the needs i.e. the cost and quality of product should be optimized. The machining process that takes place at dimensions between 1 and 999 micrometers is referred to as micromachining. Among these is the microturning process. Conventional machining is what microturning is. However, in this instance, the product's and the workpiece's sizes are extremely comparable. As the work piece gets smaller, the machining gets harder and harder. In the case of micromachining, manual machining is therefore virtually impossible. Thus, computerized control devices are employed in this instance.

SIZE EFFECT:-

The phenomenon of size effect arises from a shallow incision. When the depth of cut diminishes, it results in a non-linear increase in specific cutting energy. The link between the section chip and the shear force total agent on the tool in the cutting direction is known as the specific energy of cutting.The impact of scale is caused by the processed material being plowed due to the negative rake angle, the hardening of the material worked in the micrometer scale, the pressure on the face side resulting from the elastic spring back, and the dependence of the speed of deformation and dislocation density.

II. DESIGN OF EXPERIMENTS

Assume that each of the three input variables has three levels. In order to cover every scenario, we must conduct 3 * 3 * 3 = 27 experiments. It would take too much time and effort to complete these many runs. Thus, the experiment's design is complete. If we follow the Taguchi L9 experiment instead of performing all these tests, we will cover every potential combination.

Process variables come in two varieties. both manageable and unpredictable. Another term for the uncontrollable forces is noise.

Statistical process control and design of experiments, although two instruments closely related to the improvement and optimization of processes, design of experiments provides a more effective method than the statistical process control. It is a statistical method passive look at the process and then expects some information that leads to a useful change. Information passive cannot provide useful information if the process is in control. However, the design of experiments is a statistical method active: a series of tests are actually performed on the process, making changes in input, and observing the corresponding changes of the outputs. This leads to information that can lead to the improvement of processes.

GUIDANCE FOR DESIGNING EXPERIMENT

1. Problem identification and declaration: It's critical to thoroughly create all theories regarding the issue at hand as well as the trial's particular goals. Emphasis must be placed on input from all relevant stakeholders, including engineering, marketing, customers, quality, management, and operators. This aids in a better understanding of the procedure and, ultimately, the problem's resolution.
2. Selecting the necessary components for the experiment, as well as the intervals at which they should be adjusted and the precise amounts at which they should be made, are important decisions. Making the right decision requires process knowledge, which combines theoretical comprehension with practical experience. For the screening factor, the number of factor levels ought to be limited. Every issue that might be important needs to be looked into. Experience after the fact shouldn't be given too much weight.
3. Choosing the answer variable: When choosing the response variable, make sure it genuinely offers insightful data on the process you're researching. The standard deviation, average, or both are frequently selected as response variables.
4. Selecting an experimental design should be done in accordance with the sample size.
5. Conducting the experiment: To make sure everything is proceeding as it should, close supervision must be maintained throughout. A mistake at this point usually means the experiment is ruined.
6. Data analysis: To analyze the findings and conclusions, statistical techniques are used. Software and graphical techniques are also employed.
7. Conclusion and Recommendation: a plan of action was suggested following the analysis of the data, which led to the practical findings from the experiment.

III. EXPERIMENT SETUP

A KISTLER 9272 dynamometer was used to measure the machining forces during the experiment, which was conducted on an HMT NH26 lathe.

Fig 3.1: Attached W/P in chuck

Fig 3.2: Tool, dynamometer and W/P assembly

EXPERIMENTAL CONDITION:-

Table 3.1: Experimental Condition

Workpiece material	AISI 304 STEEL
Inserts used	Cemented carbide insert without coating (grade ISO P30)
Insert designation	SCMT 12 04 08
Tool Geometry	−6°,−6°,6°,6°, 15°, 75°, 0.7 (mm)
Cutting velocity(m/min)	38.48,65.97,112.31
Feed(mm/rev)	0.04,0.05,0.07
Depth of cut (mm)	0.1,0.2,0.3
Environment	Dry

TOOL DESIGNATION:
SCMT 12 04 08 12

Indicates that each cutting edge is 12 mm long, while 04 indicates that the insert's nominal thickness is 4 mm.08 indicates a 0.8 mm nose radius.

WORKPIECE PROPERTIES:

Steel AISI 304
This steel is a standard austenitic chromium nickel alloy.
CHEMICAL COMPOSITION:-
Table 3.2: Element Weight Details

ELEMENT	WEIGHT%
C	0.07
Mn	1.99
Si	0.99
Cr	18-19
Ni	8.0-10
P	0.044
S	0.02

MECHANICAL PROPERTIES:-
Table 3.3: Properties List

Density (kg/m^3)	8
Poisson's ratio	0.27-0.30
Elastic Modulus(Gpa)	192
Tensile Strength(Mpa)	510

Yeild strength(Mpa)	200
Elongation(%)	39
Hardness(HRB)	87

EXPERIMENTAL DATA:-

TABLE 3.4 –ORTHOGONAL ARRAY L9(3^3)OF THE EXPERIMENT RUNS AND RESULTS

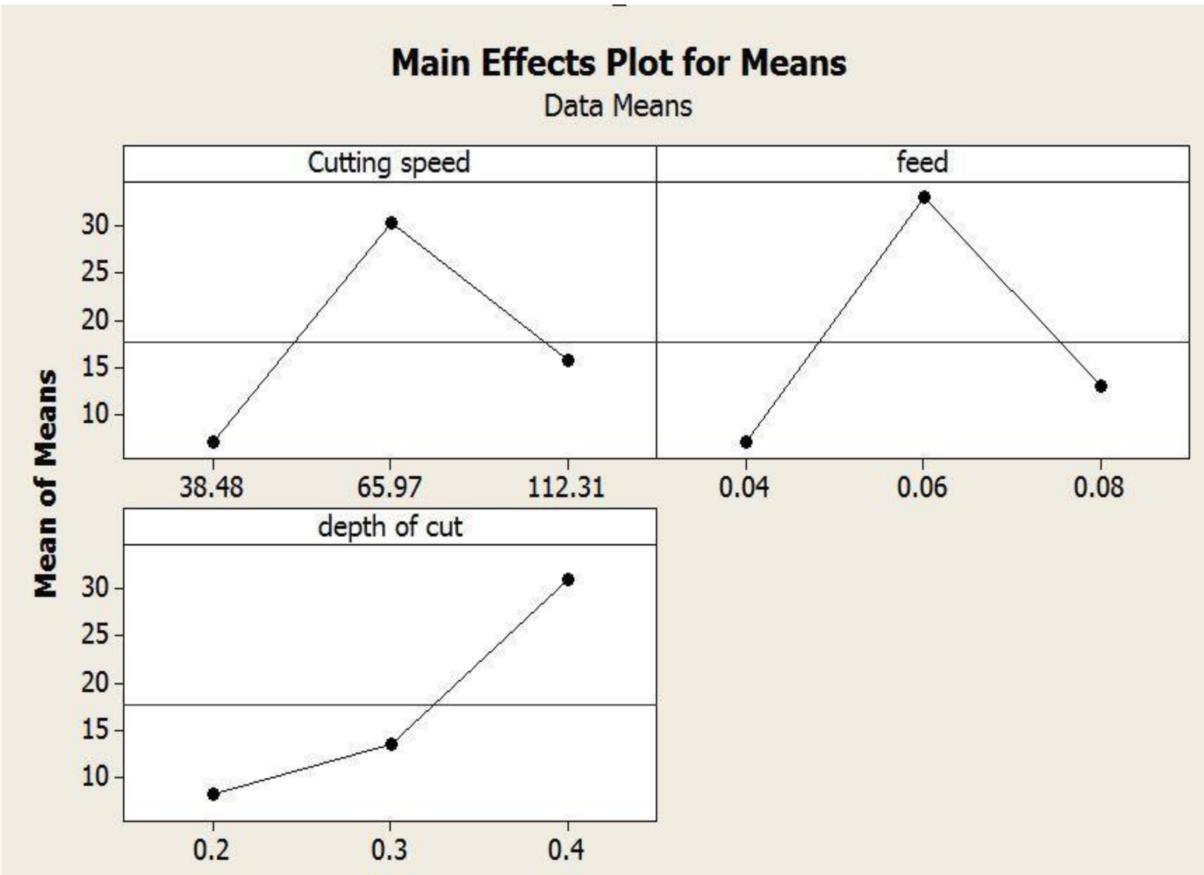
RUN NO.	Cutting speed	feed	Depth of cut	Fx	Fy	Fz	SR	TOOL WEAR	CHIP THICKNESS
1	38.48	0.04	0.2	9	4	4	3.6	0.071	0.08
2	38.48	0.06	0.3	6	1	4	0.8	0.137	0.11
3	38.48	0.08	0.4	6	4	6	2.5	0.057	0.14
4	65.97	0.04	0.3	6	1	4	0.44	0.113	0.808
5	65.97	0.06	0.4	81	88	45	3.2	0.143	0.1
6	65.97	0.08	0.2	4	6	6	2.6	0.078	0.11
7	112.31	0.04	0.4	6	1	6	0.8	0.094	0.08
8	112.31	0.06	0.2	12	4	4	1.2	0.11	0.11
9	112.31	0.08	0.3	29	12	14	1.4	0.112	0.13

Analysis using Taguchi Method:-

Table 3.5 Analysis Using Taguchi Method

Cutting speed	feed	Depth of cut	Fx	Fy	Fz	SR	TOOL WEAR	CHIP THICKNESS	SN RA1	STDE1	MEAN1
38.48	0.04	0.2	9	4	4	3.6	0.071	0.08	-14.0128	3.1823	4.1342
38.48	0.06	0.3	6	1	4	0.8	0.137	0.11	-10.3067	2.508	2.3874
38.48	0.08	0.4	6	4	6	2.5	0.057	0.14	-12.7533	2.519	3.7114
65.97	0.04	0.3	6	1	4	0.44	0.113	0.808	-10.2699	2.5745	2.3106
65.97	0.06	0.4	81	88	45	3.2	0.143	0.1	-35.1429	41.511	43.4686
65.97	0.08	0.2	4	6	6	2.6	0.078	0.11	-12.7768	2.4996	3.7356
112.31	0.04	0.4	6	1	6	0.8	0.094	0.08	-11.682	2.9597	2.7788
112.31	0.06	0.2	12	4	4	1.2	0.11	0.11	-15.5011	4.6537	4.262
112.31	0.08	0.3	29	12	14	1.4	0.112	0.13	-23.74	11.6646	11.3024

Fig 3.3:- Different curves has been plotted



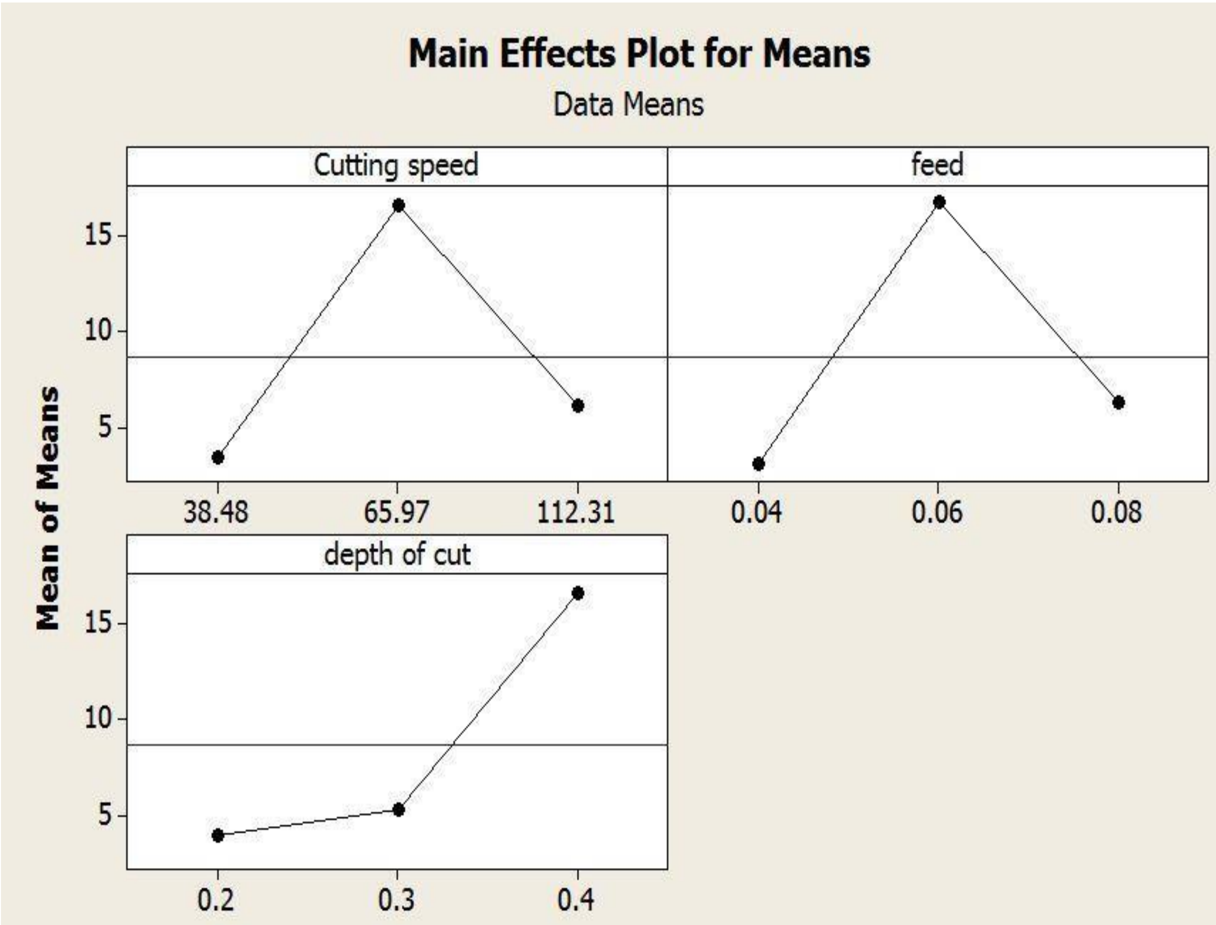


Fig 3.4:- Mean Effect plot for Means

Response Table for S/N Ratio:-

Table 3.6 S/N Ratio

LEVEL	CUTTINGSPEED	FEED	DEPTHOFCUT
1	1.414	1.667	1.843
2	3.655	3.339	2.200
3	2.181	2.233	3.206
DELTA	2.241	1.662	1.362
RANK	1	2	3

RESPONSE TABLE FOR MEANS:-

Table 3.7 Means Response

LEVEL	CUTTINGSPEED	FEED	DEPTHOFCUT
1	0.8502	0.8251	0.8088
2	0.6797	0.7100	0.7809
3	0.7824	0.7771	0.7225
DELTA	0.1705	0.1151	0.0863
RANK	1	2	3

IV. RESULT & DISCUSSION

The experiment yielded the following conclusions, which led us to focus on optimizing the modeling of TURNING process parameters in stainless steel material. For example

1. The ideal values for these three process parameters are: feed rate = 0.06; cutting speed = 32.98; and cut depth = 0.3.
2. The lowest value for feed rate in the second level, cutting speed in the first level, and document in the second level happened at 1.09, according to the larger-the-best S/N ratio graph.
3. The residual versus fitted value graph shows that the points do not form a standard platform. It so displays no errors.
4. Five points are tightly spaced at the slop of the standardized residual versus percent on the normal probability plot of residuals.
5. The experiment is correct since all of the points in the normal probability plot of the residuals for the mean and S/N ratio are close to the line.
6. A properly distributed graph is represented by a histogram graphic. Our experimental analysis is accurate as a result.

V. CONCLUSION

In order to optimize the turning process, experiments are designed and carried out on a lathe machine using a solid carbide insert and stainless steel as the work piece material. For the goal of optimizing multi-responded control parameters in the turning process, the intended Grey based relational Taguchi technique is advantageous. This study's primary goal was to identify the ideal feed rate, cutting speed, and depth of cut settings in order to reduce forces, tool wear, chip thickness, and surface roughness.

It is discovered that the ideal values are feed of 0.059 mm/rev, cutting depth of 0.29 mm/rev, and cutting speed of 32.97 m/min.

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