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EFFECTS OF TURNING PARAMETERS ON SURFACE ROUGHNESS OF HARDENED AISI420 STAINLESS STEEL

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Abstract: This paper presents the effects of process parameters on surface roughness of hardened AISI420 stainless steel using cemented carbide inserts. Plan of experiment is done with the help of design of experiment. A total number of 9 experiments were conducted with an orthogonal array. In this research work, four control factors like spindle speed, feed rate, depth of cut and insert nose radius are used as a input process parameters and work piece material (AISI 420 stainless steel) is hardened to a hardness 30HRC were investigated at three different levels. The turning operations are done on Fanuc controlled Laxmi lathe machine. Surface roughnesses of the machined parts are checked by using Mitutoyo surface roughness tester SJ-210. For the statistical representation MINITAB 19 statistical software was used. The effect of each process parameter on surface roughness was analyzed using one way ANNOVA. The graph shows that, surface roughness value increases with increase in feed rate while increase in spindle speed, depth of cut and insert nose radius decreases the surface roughness.

Index Terms – **Turning process, surface roughness, ANNOVA, carbide inserts, Minitab software.**

I. INTRODUCTION

Machining is one of the manufacturing process in which the dimensions, shape or surface properties of machined parts are changed by removing the excess material. The turning process is carried out using lathe machine and the automatic turning process is performed by Computer numerical control machine. Turning processes are widely used in automotive, aerospace and aircraft industries. Today's industries want to manufacture the parts at low cost and high quality in short time. Surface roughness is an important factor that greatly effects on product life. So, it is required to find out the surface roughness after the machining is done. Better surface finish and higher machining rate are desirable for better performance of any machining process. The influence of spindle speed, feed rate, depth of cut and insert nose radius on the material while machining, significance of each factor and also the interaction of input parameters on output can be founded easily. Taguchi was employed because it is difficult to make the analysis of input parameters simultaneously. One factor on one time gives influence on one factor of output. In this paper the attempts has been made on to find out the effect of cutting parameters on surface roughness in turning of hardened AISI 420 stainless steel. AISI 420 is one of the most popular high chromium and high-carbon steel. The researchers have studied the effect of various parameters using different methods on various materials but it was found that the experimental investigation needed to be carried out on hardened AISI 420 stainless steel considering its wide applications in motor vehicles, pump elements.

Krishna Yadav et. al. [1] optimized the surface roughness for aluminum alloy using Tungsten carbide tool. They used L9 orthogonal array for experimental design. Cutting speed, feed rate and depth of cut are used as process parameters. The experimental analysis was carried out for smaller the better using Taguchi approach. They showed Taguchi parameter design can successfully verify the optimum cutting parameters. They found that the depth of cut parameter has more effect on machining process that led to maximum surface roughness followed by cutting speed. J. Chandrasheker et. al. [2] used Taguchi method for optimization of cutting parameters for turning AISI 316 Stainless steel with diamond cutting tool. Did the experiment with four cutting parameters feed rate, speed, depth of cut and cutting fluid. Minitab statistical software was used for the analysis of experimental work which gives signal to noise ratio. The average of S/N ratio is calculated. The Minitab software gives the equation of surface roughness for work piece material. They obtained the best condition for cutting speed factor is level 3 (1025 rpm), for feed is level 2 (150 mm/rev), for depth of cut is level 2 (0.8mm), straight cutting oil in cutting fluids in level 3 for work piece material AISI stainless steel.

S. Hasan et. al. [3] analyzed the surface roughness produced by turning process on hard martensitic stainless steel using CBN cutting tool. The work piece tool material was hard AISI 440C martensitic stainless steel. At cutting speed of 225m/min with feed rate of 0.125mm/rev and 0.50mm depth of cut produces low surface roughness. The prediction of performance of martensitic stainless steel is very difficult because of its characteristics. It is very efficient to turn the hard-martensitic stainless steel at medium level cutting speed, high feed rate and high depth of cut. Ankit Dogra et. al. [4] used Taguchi method for optimization of cutting parameters for turning EN-8 steel cylindrical rods using Taguchi method. An orthogonal array L9 and Analysis of Variance are employed to investigate the turning conditions and machining was done using coated tool insert. The analysis showed that spindle speed varying from 175 to 475 rpm is the highest significant parameter followed by depth of cut from 0.5 to 1.5mm resulted in rapid increase in tool wear 0.22. They observed that the effect of speed was more critical than the depth of cut and rest of parameter as feed rate.

Gaurav Pant et. al. [5] optimized the surface roughness and MRR by taking feed, depth of cut and spindle speed as process parameters for Aluminum 6063 material using Taguchi method. From the analysis of the experimental observations they concluded that metal removal rate in CNC turning process is greatly influenced by cutting speed followed by depth of cut. They also observed that the feed is most significantly influences the Surface Roughness. Shivam Goyal et. al. [6] did the optimization of surface roughness and metal removal rate of AISI 1020 stainless steel using WNMG insert. They conducted experiments by taking cutting speed, feed rate and depth of cut as process parameters. An L9 orthogonal array, the signal-to-noise (S/N) ratio are employed to study the performance characteristics in the turning using WNMG332RP carbide insert with a nose radius of 0.8mm. Taguchi method is used to optimize surface roughness and material removal rate. The experimental result shows that on increasing depth of cut and feed rate, the combined S/N ratio increases while on increasing cutting speed the combined S/N ratio decreases. It results that cutting speed is most significantly influences the surface roughness followed by feed and in case of MRR, depth of cut is the most significant parameter followed by cutting speed.

II. SURFACE ROUGHNESS

The roughness of the part surface machined by a given process is referred to as surface roughness. Due to the increased knowledge and constant improvement of the surface textures gives the present machine age a great advancement. Due to the demands of greater strength and bearing loads smoother and harder surfaces are required. Conditions not being ideal so the surface being produced will have some irregularities and these irregularities can be classified into four categories are:

First order: This type of irregularities is arising due to inaccuracies in the machine tool itself for example lack of straightness of guide ways on which tool post is moving. Irregularities produced because of the weight of the material itself and deformation of work under the action of cutting forces are also considered in this category.

Second order: This order of irregularities is caused due to vibration of any kind such as chatter marks.

Third order: If the machine is perfect and completely free of vibrations still some irregularities are caused by machining due to characteristics of the process.

Fourth order: This type of irregularities is raised due to rupture of the material during the separation of the chip.

III. OBJECTIVES

The objectives of this research work are;

- To study the effect of various turning process parameters for surface roughness.
- To conduct experimental trial on turning for input process parameters like insert nose radius, spindle speed, feed rate and depth of cut.
- Plan of experiment by using design of experiment.
- To study the effect of inserts nose radius (CNMG), spindle speed, depth of cut and feed rate on hardened AISI420 stainless steel.
- To find out the most influencing parameter on surface roughness.

IV. METHDOLOGY

The research work is completed by following the below steps;

- Review of previous literatures related to optimization of turning process parameters like spindle speed, feed rate, insert nose radius, depth of cut in different engineering materials
- Selection of the appropriate orthogonal array and assigning the process parameters like insert nose radius, spindle speed, depth of cut, feed rate to the orthogonal array and conducted the experiments accordingly. A 25mm diameter and 80mm length AISI420 stainless steel bar was hardened to 30HRC. The experiments conducted on hardened AISI420 stainless steel. For experimentation CNMG inserts with varying nose radius (0.4, 0.8, 1.2mm) are used
- Plan of experiment is done with the help of design of experiment. L9 orthogonal array of "Taguchi method" is used for the experiments design.
- The effect of insert nose radius, spindle speed, depth of cut and feed rate on MRR and surface roughness found by using one way ANNOVA in MINITAB software.
- Analysis of the individual plot graph and concluding which process parameter affects strongly on surface roughness.

V. EXPERIMENTAL SET UP

For this study hardened AISI 420 stainless steel material is used to optimize the process parameter of surface roughness. The workpiece diameter is 25mm and length is 90mm which is shown in figure 1 and material chemical composition is given in Table 1. The workpiece (shown in figure 2) is hardened to 30HRC by heating it up to a temperature between 960°C-970°C, for a period of 2-3 hour then it is cooled by oil quenching. The cemented carbide inserts with varying nose radius (0.4, 0.8, 1.2mm) was used. To perform the experiments LL15T L3 CNC machine was used as shown in figure 3.

Table 1: Chemical composition of AISI 420 stainless steel.

Element	C	Si	Mn	S	P	Cr	Cu	Fe
Weight	0.18	0.3	0.85	0.02	0.03	12.3	0.15	86.0

Figure 1: Workpiece (AISI420 SS) before hardening

Figure 2: Workpiece (AISI420SS) after hardening

Figure 3: CNC machine used for experimentation

Figure 4: Roughness tester SJ-210 used for SR measurement

In this research work Mitutoyo surface roughness tester SJ-210 is used for to find out the surface roughness which is as shown in figure 4. There are two reasons to select this type of tester first one its easy operation and other is its easy availability.

VI. EXPERIMENTAL WORK

The experiments were carried out on LL15T L3 CNC lathe machine of Laxmi motor works ltd. installed at Blue line engineers, M.I.D.C. Gokul shirgaon, Kolhapur. In CNC machine, the turning operation was completed on hardened AISI 420 stainless steel as workpiece using cemented carbide tipped tool with varying insert nose radius (0.4mm, 0.8mm and 1.2mm) as the cutting tool. The geometry of cutting tool is given in table 2. After machining we checked the surface roughness (Ra) value of the workpiece with the help of the surface roughness tester. An L9 orthogonal array was used for design of experiment. On the basis of trial run investigations, the following process parameters have been selected. Their levels as selected given in table 3.

Table 2: Tool geometry

Tool	Approach angle	Rake angle	Inclination angle	Insert nose radius (mm)
1	90°	6°	5°	0.4
2	90°	6°	5°	0.8
3	90°	6°	5°	1.2

Table 3: Process parameters with their levels

Parameters	Level 1	Level 2	Level 3
Spindle speed (rpm)	1800	1850	1900
Feed (mm/rev)	0.1	0.15	0.2
Depth of cut (mm)	1.0	1.2	1.4
Insert nose radius (mm)	0.4	0.8	1.2

VII. RESULT AND DISCUSSION

After the experimentation, data is collected. The experimental values of surface roughness are shown in table 4.

Table 4: Experimental results

Sr. No.	Spindle speed (rpm)	Feed (mm/ rev)	Depth of cut (mm)	Insert nose radius (mm)	SR (μm)
1	1800	0.1	1.0	0.4	1.30
2	1800	0.15	1.2	0.8	1.14
3	1800	0.2	1.4	1.2	1.23
4	1850	0.1	1.2	1.2	0.57
5	1850	0.15	1.4	0.4	1.36
6	1850	0.2	1.0	0.8	1.82
7	1900	0.1	1.4	0.8	0.70
8	1900	0.15	1.0	1.2	0.75
9	1900	0.2	1.2	0.4	2.10

7.1 Analysis of plot for surface roughness

The individual effect of turning process parameters on surface roughness is analyzed using one way ANNOVA in MIMITAB 19 software.

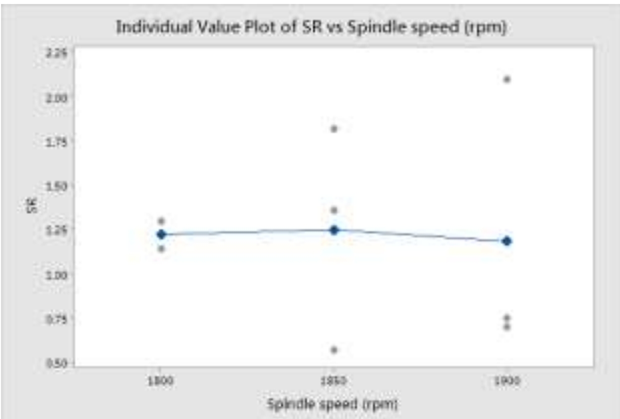

Fig. 5: Response graph of SR vs. spindle speed

Figure 5 shows the relation between surface roughness versus spindle speed. According to this figure, surface roughness decreases with increase in spindle speed.

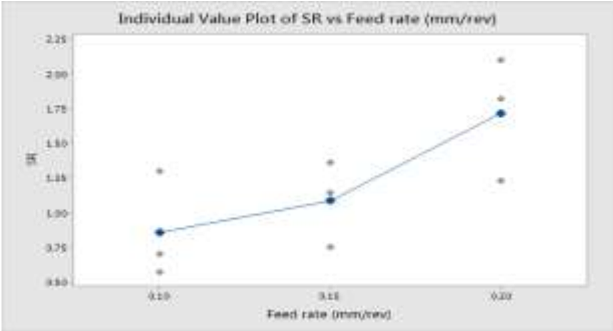

Fig. 6: Response graph of SR vs. feed rate

Figure 6 shows the relation between surface roughness versus feed rate. According to this figure, surface roughness increases with increase in feed rate.

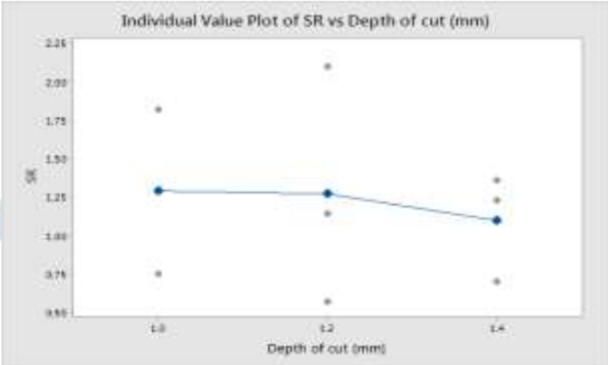

Fig. 7: Response graph of SR vs. depth of cut.

Figure 7 shows the relation between surface roughness versus depth of cut. According to this figure, surface roughness decreases with increase in depth of cut.

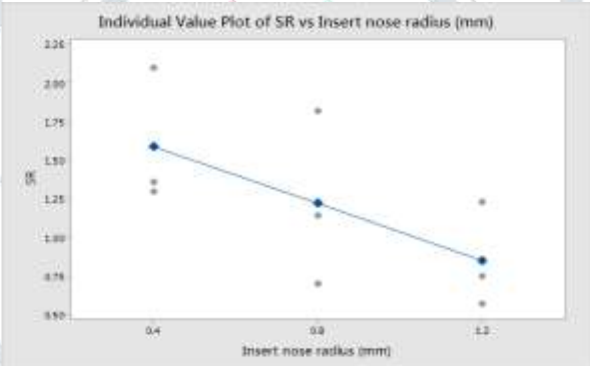

Fig. 8: Response graph of SR vs. insert nose radius

Figure 8 shows the relation between surface roughness versus insert nose radius. According to this figure, surface roughness decreases with increase in insert nose radius.

VIII. CONCLUSIONS

Turning tests were performed on hardened AISI 420 stainless steel workpiece using cemented carbide inserts with varying nose radius (0.4, 0.8, 1.2 mm). The influences of cutting speed, feed rate, depth of cut and insert nose radius were investigated on the machined surface roughness. Based on the results obtained and analysis the following conclusions have been drawn:

- **Spindle speed:** Increase in spindle causes reduction in surface roughness value.
- **Feed rate:** Increase in feed rate causes increase in surface roughness value.
- **Depth of cut:** Increase in depth of cut causes decrease in surface roughness value.
- **Insert nose radius:** Increases in insert nose radius causes decreases in surface roughness value.

REFERENCES

[1] Krishna Yadav, Ankit Kumar Saxena, Angad Yadav, Ashish Kumar 2019. Optimization of machining parameters for turning of Aluminum alloy LM4 using Taguchi method. International research journal of engineering and technology, Vol. 5, Issue 4, 3595-0072.

[2] J. Chandrasheker, Mahipal Manda, D.V. Kumar, “Optimization of cutting parameters for turning AISI 316 stainless steel based on Taguchi method”, IOSR Journal of mechanical and civil engineering volume 14, Issue 1 Ver.1, 2017, pp. 01-09.

[3] S. Hasan, B. and Bin Omar 2008. Surface roughness analysis on hard martensitic stainless steel. Journal of achievement in material and manufacturing engineering, volume 26.

[4] Ankit Dogra, Hartaj Singh, Dharmpal, Vishal Singh, Sunil Kumar 2016. optimization of turning parameters on En-8 Steel cylindrical rods using Taguchi methodology. International journal for research in applied science and engineering technology, Volume 4, Issue 12, 2321-9653.

[5] Gaurav Pant, ShivasheeshKaushik, Dr. D. K. Rao, Kripal Negi , Ankit Pal, Deep Chandra Pandey 2017. Study and analysis of material removal rate on lathe operation with varying parameters from CNC lathe machine. International Journal on Emerging Technologies, 0975-8364.

[6] Shivam Goyal, Varanpal Singh Kandra, Prakhar Yadav 2016. Experimental study of turning operation and optimization of MRR and surface roughness using Taguchi method. International journal of innovative research in advanced engineering, volume3, 2349-2763.

[7] M. Kaladhar and Chi. Srinivasa Rao 2011. Determination of optimal process parameters during turning of AISI 304 austenitic stainless steel using Taguchi method and ANNOVA. International Journal of lean thinking volume 3.

[8] Prem S. Sapariya, Dr. Suketu Y. Jani, Jayprakash A. Rana, "Validate the optimum turning process parameters on Aluminium 6061 for surface roughness and MRR", Journal of emerging technologies and innovative research, Vol.. 6, 2019, 223–228.

[9] Rajamurthy. G., Rakesh. V., Ramesh. P., Sundar. C., "An experimental analysis of turning operation in EN 31 alloy" International journal of trend in scientific research and development Vol. 2, Issue 2, 2018, 2456-6470.

[10] S. Amarnath Reddy, Mr. J. Sree Hari, "Optimization of cutting parameters in turning operation by using Taguchi method", International journal of trend in scientific research and development, Volume 3, Issue 1, 2018, 2456-6470.

[11] Atul P. Kulkarni, V. G. Sargade, "machinability studies of austenitic stainless steel (AISI304) using PVD cathodic arc evaporation system deposited AlCrN/TiAlN coated carbide inserts", International conference on design and manufacturing, 2013, pp. 907-914.

[12] R. A. Muley, A. R. Kulkarni, R. R. Deshmukh, "Optimization of surface roughness and material removal rate in turning of AISI D2", International Journal of Mechanical and Production Engineering, volume-4, Issue-7, Jul.2016, pp. 46-48.

[13] K. Palanikumar, B. Durgaprasad, A. Srithar, "experimental investigation and surface roughness analysis on hard turning of AISI D2 steel using coated carbide inserts", Procedia engineering 97, pp.72-77, 2014.

[14] G. Krolczyk, P. Nieslony, S. Legutko, "Microhardness and Surface Integrity in Turning Process of Duplex Stainless Steel (DSS) for Different Cutting Conditions", Journal of Materials Engineering and Performance, December 2013.

[15] D. Philip Selvaraj, P. Chandramohan, "Optimization of surface roughness of AISI304 Austenitic stainless steel in dry turning operation using Taguchi design method", International Journal of engineering, science and Technology, Volume 5, No.3, 2010.