Analysis of the Effects of Parameters on Alloy Steel during Computer Numeric Control (CNC) Turning

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Abstract

Turning is one of the important manufacturing processes used now days. Metal is removed in the form of chips. In turning work piece is kept stationary (but rotates) while tool moves along the axis of rotation. CNC turning machine is controlled by various process parameters and the cutting conditions to get efficient work. This Study aims to find the relation between those process parameters on the output parameters like MRR, Surface finish etc. The most common parameters controlling the processes are speed, feed, depth of cut, tool geometry, coolant, work material etc. Analyzing these effects also helps in optimizing the parameters to get work efficiently. Various techniques are available for solving such type of problems out of which Taguchi method is the most widely used technique for the optimization.

Keywords: CNC Turning, Alloy steel, MRR, Surface roughness.

Introduction

In modern industries the main focus is on the achievement of high quality product at an economic price that's why machining operation has become the core of the manufacturing industry. Much of modern day machining is carried out by computer numerical control (CNC), in which computers are used to control the movement and operation of the mills, lathes, and other cutting machines. Turning is one of the manufacturing processes controlled with the help of computer. Turning is a machining process in which work piece is kept stationary but tool moves along the axis of rotation of work piece. The efficiency or the output of the operation depends upon various input parameters. Several experimental investigations have been carried out over the years in order to study the effect of cutting parameters, tool geometries on the work pieces surface integrity using several work pieces. Nowadays, manufacturing industries specially concerned to dimensional accuracy and surface finish. In order to obtain optimal cutting parameters, manufacturing industries have depended on the use of handbook based information which leads to decrease in productivity due to sub-optimal use of machining capability this causes high manufacturing cost and low product quality [1].

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So quality of surface produced is an important factor to be optimized. Vibration in machine tool is directly affecting the surface finish of the work material in turning process. So vibration of a machine tool is one of the major factors limiting its performance [2]. Similarly there are many factors like speed, feed, depth of cut, tool geometry, cutting force, coolant etc. which directly or indirectly affect the MRR and Surface roughness of work piece. For engineering applications a no of materials used are Low carbon steel among all the materials, which is known as mild steel, containing 0.05 % to 0.26 % of carbon (e.g. AISI 1018). They cannot be modified by heat treatment and are cheap, but engineering applications are restricted to use non-critical Components due to its properties. The study is done on the Alloy Steel due to its wide variety of application in industries like automobile industries, structural steels application, Tool and dies steels application etc. According to the literature survey done, Taguchi is the most widely used method for optimization. Similarly there are many method used to find the effect of process parameters on the performance of machining operation.

Methodology

Following are the various techniques used to solve optimization or performance analysis. Most of the author uses Taguchi method due to its simple use and efficient result, some author also use techniques like MADM, Gray rational analysis etc.

Taguchi Method

Among all the available methods, Taguchi design is one of the most powerful and convenient method for analyzing of experiments. Taguchi is most widely used in the development of new products and in quality control processes. Most of the researcher uses taguchi method due to its advantages likes easy to apply, efficient and systematic method etc.

Grey Relational Analysis

While optimizing the responses in single objective optimization, the effects of process parameters on other performances have not been considered. But in actual practice, all the performance parameters must be optimized to achieve optimum condition for best result to get higher productivity as well as higher reliable products. Experimental results were first normalized and then the grey relational coefficient was calculated from the normalized experimental data to express the relationship between the desired and actual experimental data.

MADM (Multi Attribute Decision Making)

MADM is an established and powerful analytical tool that can be used to help objectify decision-making where a number of options or choices exist. In MADM, several options according to some criteria are ranked and selected. Ranking and selecting will be made among decision alternatives described by some criteria (factors) through decision-maker knowledge and experience. Multi-attribute decision-making (MADM) is the well-known branch of decision making which deals with decision problems through a number of qualitative and quantitative criteria [3].

Literature Review

Kaladhar M et al. studied and find out the optimizing machining parameters in turning of AISI 202 austenitic stainless steel using CVD coated cemented carbide tools [4]. During the experiment, process parameters such as speed, feed, depth of cut and nose radius are used. Results were obtained; Feed and Nose Radius are the most significant factors. Philip Selvaraj D et al. perform their experiment on AISI 304 and Concluded that feed rate, cutting speed and DOC affects the surface roughness by 51.84%, 41.99% and 1.66% respectively [5]. Satheesh Kumar N et al. concluded that the better surface finish may be achieved by turning carbon alloy steels at low feed rate and high spindle speeds [6]. Five different carbon alloy steels used for turning are SAE8620, EN8, EN19, EN24 and EN47. Singh V et al. conduct experiment and in his research work he studied the effect and optimization of machining parameters on surface roughness and material removal rate (MRR) in a turning operation using the Taguchi method [8]. The experimental studies are conducted under varying cutting parameters including cutting speed, feed rate, depth of cut and cutting nose radius of insert. An L9 orthogonal array, the signal-to-noise (S/N) ratio are employed to the study the performance characteristics in the turning of AISI 1045 Mild steel using WNMG331RP, WNMG332RP and WNMG333RP carbide inserts on CNC turning center. The conclusions revealed that the feed rate and nose radius were the most influential factors on the surface roughness and Material Removal Rate (MRR) in CNC turning process is greatly influenced by depth of cut followed by cutting speed. For simultaneous optimization of Surface roughness (Ra) and material removal rate (MRR) depth of cut is the most significant parameter affecting the performance followed by the nose radius. Kumar R et al. experiment was performed with different combination values of input parameters [9]. Equal weightage has been assigned to all input parameter and a (Multi attribute decision making) MADM approach was been used. The input parameters taken were speed, feed and DOC and he observed that Speed 1500 (rpm), Feed 0.12 (mm/rev.), D.O.C (mm) 1 and Nose radius at 1.2 are the appropriate best input parameters for cutting which will give an efficient output. Rawat U et al. performs their work in dry condition and the output parameter is the cutting force [10]. The work material used is SS316L. They found that optimum spindle speed is 48m/min, the optimum feed rate is 0.067 mm/rev and the optimum depth of cut is 0.75mm. Apart from these researches, there are several other researches in the same field which were carried out in the past. Sahu M et al. shows that the Taguchi parameter design is an effective way of determining the optimal cutting parameters for achieving low tool wear, low w/p surface temperature and high MRR [12]. They concluded that the percent contributions of depth of cut (60.85%) and cutting speed (33.24%) in affecting the variation of tool wear are significantly larger as compared to the contribution of the feed (5.70%), The significant parameters for w/p surface temperature were cutting speed and depth of cut with contribution of 41.17% and 34.45% respectively and Depth of cut (51.1%) was only significant parameter followed by feed (25.5%) on material removal rate (MRR). So the optimal combination of cutting parameters for maximum MRR was obtained at 250 m/min cutting Speed, 1 mm depth of cut and 0.25 mm/rev feed.

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Table 1.Conclusions of Researchers by taking different Input and Output Parameters

No.	Year	Author's Name	Material	Input Parameters	Output Parameters	Conclusion
1	2010	M. Kaladhar, K. Venkata, Subbaiah, Ch. Srinivasa Rao, K. Narayana Rao	AISI202 austenitic stainless steel	Speed, Feed, DOC, Nose Radius	Surface Roughness	Feed and Nose Radius are the significant factors
2	2010	D. Philip Selvaraj, P. Chandramohan	AISI 304 Austenitic stainless steel	Speed, Feed, DOC	Surface Roughness	Concluded that feed rate, cutting speed and DOC affects the surface roughness by 51.84%, 41.99% and 1.66% respectively.
3	2012	N. Satheesh Kumar, Ajay Shetty, Ashay Shetty, Ananth K, Harsha Shetty	SAE8620, EN8, EN19, EN24, EN47	Spindle, Speed, Feed Rate	Surface Roughness	Better surface finish may be achieved by turning carbon alloy steels at low feed rate and high spindle speeds.
4	2013	J. M. Gadhiya, P. J. Patel	AISI 1018 Mild Steel	Speed, Feed, DOC	Surface Roughness	Cutting speed and feed have high contribution on surface roughness and Depth of cut had less effect for surface roughness.
5	2013	Virender Singh, Tasmeem Ahmad Khan	AISI 1045	Speed, Feed, DOC, Nose Radius	Surface roughness, MRR	MRR is greatly influenced By DOC followed by cutting speed, Feed is most significantly influences the Ra followed by nose radius Simultaneous optimization of (Ra) and (MRR), DOC is the most significant parameter affecting followed by the nose radius.
6	2013	Raman Kumar,	EN24	Speed,	Surface	Speed 1500 (rpm),

		Raman Kumar, Jaspreet Singh Rai, Navneet Singh Virk	alloy steel	Feed, DOC, Nose Radius	roughness, MRR	Feed 0.12 (mm/rev.), D.O.C (mm) 1 and Nose radius at 1.2 is the appropriate best input parameters setting.
7	2014	Umashankar Rawat, Mithun Shah, R. M. Patil	SS316L	Speed, Feed, DOC	Cutting Force	Optimum spindle speed, Feed rate and DOC are 48m/min, 0.067 mm/rev and 0.75mm resp.
8	2014	Shrikant S. Jachak, Vinay R. Pandey	AISI 1055 Steel	Speed, Feed, DOC, Cutting flow rate	Surface Roughness, Tool life	Adhesive bonded tool can be used for optimizing the turning process parameters
9	2014	Meenu Sahu, Komesh Sahu	AISI D2 Steel	Speed, Feed, DOC	Tool wear, w/p surface temperatur e, MRR.	Percent contributions of DOC (60.85%) and speed (33.24%) in affecting the tool wear. For w/p surface temperature cutting speed and DOC have contribution of 41.17% and 34.45% respectively. DOC (51.1%) and Feed (25.5%) on (MRR).
10	2014	Puneet Saini, Shanti Parkash, Devender Choudhary	EN-24 Alloy Steel	Speed, Feed, DOC	Surface Roughness	Surface roughness is mainly affected by feed rate and DOC. Cutting parameters for better quality Surface finish is as :- i) Spindle speed = 2800rpm. ii) Feed rate= 0.1 mm/min. iii) Depth of cut =0.5 mm.
11	2014	P. P. Shirpurkar, P. D. Kamble,	EN 24 steel	Speed, Feed, DOC,	Surface Roughness	Surface Roughness is most affected by nose radius (42.98%),

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		S. R. Bobde, V. V. Patil		Nose Radius		cutting speed (29.37%) and feed rate (6.51%).
12	2014	Sushil Kumar Sharma, Sandeep Kumar	Mild Steel (1018)	Speed Feed DOC	Surface Roughness	Most significant parameters are Feed and Speed.
13	2015	Prajwal kumar Patil, Rajendrakumar Kadi Suresh Dundur, Anil Pol	AISI 316 Austenitic Stainless Steel	Speed, Feed, DOC	Surface Quality, Hardness	Feed has the highest influence on surface roughness. DOC has the highest influence on hardness. Optimal combination process parameters for minimum *Ra* is obtained at 150 rpm, 0.2 mm/rev and 1.5mm. The optimal process parameters for maximum hardness are 180 m/min cutting speed, 0.3 mm/rev feed, 1.5 mm DOC.
14	2015	Krupal Pawar, R. D. Palhade	HSS(M2)	Speed, Feed, DOC, Nose Radius	Surface Roughness, MRR	MRR is highly influenced by feed rate then nose radius. Ra is highly influenced by Nose radius then Feed. For both simultaneously most influencing parameter is nose radius
15	2015	A. H. A. Shah, A. I. Azmi, A. N. M. Khali	S45C Carbon Steel	Speed, Feed, DOC	Tool Wear, Surface Roughness, MRR	optimum parameter setting found in the current study are spindle speed of 3000 RPM and feed rate of 0.2 mm/rev.
16	2016	Abhishek Prakash	EN36C Steel	Speed, Feed, DOC	MRR, Surface Roughness	The feed has the greatest influence on MRR and Surface roughness

						Optimal conditional for MRR as the feed (0.1 rev/min) is a dominant parameter Speed (600 rpm) and depth of cut (0.1mm). Optimal condition for Surface roughness are depth of cut (0.1mm), feed (0.5 rev/min), and speed (900 rpm).

Conclusion

From the above literature review we found that almost every researcher has taken speed, Feed and DOC as their input parameters and Surface Roughness as their output parameter. A few researchers have taken parameters like nose radius as input and MRR as output parameter. Most of the researcher used Taguchi method to optimize the parameters due to its simplicity. We found that Feed is the main factor responsible for the surface roughness of the work piece followed by nose radius and speed. For MRR main factor is depth of cut, followed by speed. Wear of the tool and surface temperature of the tool is mostly influenced by DOC, where other parameters have least affect.

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