Experimental Investigation of Optimum Cutting Conditions for T4 Medium Carbon Steel using TiN as a Cutting Tool

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Abstract— In process planning or NC part programming, optimal cutting conditions are to be determined using reliable mathematical models representing the machining conditions of a particular work-tool combination. The development of such mathematical models requires detailed planning and proper analysis of experiments. In this paper, the experimental investing of optimal cutting conditions for TiN-coated carbide tools and T4 medium carbon steel material are discussed on the basis of machining experiments for the optimization of a multi pass turning operation with such work-tool combinations.

Key words: Operation (Turning), Surface Roughness, Optimum Machining

I. INTRODUCTION

In a machining process, roughing operation plays an important role in reducing a particular work piece from the original stock to the desired shape and size. In order to achieve the economic objective of this process, optimal cutting conditions have to be determined. Although one can determine the desirable cutting conditions for roughing based on experience or handbook data, it does not ensure that the data obtained will be optimal or near optimal for that particular machine setting and environment. In order to determine the optimal cutting conditions, reliable work-tool combination based on the machining data collected on a specific machine.

The main objectives of this work are: (a) to study the effects of depth of cut, feed rate and cutting speed on the tool life, cutting forces and power consumption for Tin coated carbide tools and Rochling T4 medium carbon steel using experimental technique;(b) to investigate the influence of each one on the cutting process progress outputs as roughness.

II. LITERATURE REVIEW

Parametric analysis and optimization of Cutting Parameters for turning operations based on Taguchi Method by Dr. S.S.Mahapatra Amar Patnaik Prabina Ku. Patnaik **[1]** in this paper they have conducted experiment work and done on Genetic Algorithm to optimization the experimental values.

On-line optimization of the turning using an inverse process neurocontroller, Transactions of ASME, Journal of Manufacturing Science and Engineering by R. Azouzi, M. Guillot,**[2]** Process modeling and optimization are the two important issues in manufacturing products. The manufacturing processes are characterized by a multiplicity of dynamically interacting process variables

Surface roughness prediction models for fine turning; International Journal of Production Research by A. Mital, M. Mehta**[3]** a greater attention is given to accuracy and surface roughness of product by the industry these days. Surface finish has been one of the most important considerations in determining the machinability of materials. Surface roughness and dimensional accuracy are the important factors required to predict machining performances of any machining operations.

Present situation and future trends in modeling of machining operations. Progress Report of the CIRP working group on Modeling of machining operations by C.A. Van Luttervelt, T.H.C. Childs, I.S. Jawahir, F. Klocke, P.K. Venuvinod.**[4]** The predictive modeling of machining operations requires detailed prediction of the boundary conditions for stable machining. The number of surface roughness prediction models available in literature is very limited. Most surface roughness prediction models are empirical and are generally based on experiments in the laboratory. In addition it is very difficult in practice, to keep all factors under control as required to obtain reproducible results. Generally these models have a complex relationship between surface roughness and operational parameters, work materials and chip-breaker types.

Multimachining output—multi independent variable turning research by response surface methodology, International Journal of Production Research by K.Taraman [5] used Response Surface Methodology (RSM) for predicting surface roughness of different materials. A family of mathematical models for tool life, surface roughness and cutting forces were developed in terms of cutting speed, feed, and depth of cut.

Surface roughness model for turning, Tribology International by R.A. Lindbergand M.Hasegawa [6] conducted 33 factorial designs to conduct experiments for the surface roughness prediction model. They found that the surface rough increased with an increase in cutting speed.

Operation By Use Of A Full Factorial Design Yves Beauchamp,ext[7] The main objective of this study is to investigate cutting parameter effects of surface roughness in a lathe dry boring operation. A full factorial design was used to evaluate the effect of six (6) independent variables (cutting speed, feed rate, depth of cut, tool nose radius, tool length and type of boring bar) and their corresponding two-level interactions. In this experiment, the dependant variable was the resulting first cut surface roughness (Ra).

Determination of optimal cutting conditions using design of experiments and optimization Techniques M. S. CHUAT[8] In process planning or NC part programming, optimal cutting conditions are to be determined using reliable mathematical models representing the machining conditions of a particular work-tool combination. The development of such mathematical models requires detailed planning and proper analysis of experiments. In this paper, the mathematical models for TiN-coated carbide tools and Rochling T4 medium carbon steel were developed based on the design and analysis of machining experiments. The models developed were then used in the formulation of objective and constraint functions for the optimization of a multipass turning operation with such work- tool combinations

III. OBJECTIVES

- To find the optimum machining parameters in order to get the minimum surface roughness.
- The objectives considered in this paper are surface roughness to be minimized.

IV. EXPERIMENTAL SETUP

The present study has been done through the following plan of experiment.

Initially taken 27 samples of turning operation in finishing cut the values of the speed, feed and depth of cut and their respective surface roughness. The value obtained in this by varying three parameter is taken in to consideration. In this paper the optimal machining parameters for continuous profile machining are determined with respect to the minimum production time, subject to a set of practical constraints, cutting force, power and dimensional accuracy and surface finish.

The full development of machining process planning is based on optimization of the economic criteria subject to technical and managerial constraints. The economic criteria are the objectives of machining operations in terms of quality.

- Checking and preparing the Centre Lathe ready for performing the machining operation.
- Cutting rochling T4 medium carbon steel bars by power saw and performing initial turning operation in Lathe to get desired dimension (of diameter 59 mm and length 100mm) of the work pieces.
- Performing straight turning operation on specimens in various cutting environments involving various combinations of process control parameters like: spindle speed, feed and depth of cut.
- Measuring surface roughness and surface profile with help of a portable stylus- type profilometer, Talysurf (TaylorHobson, urtronic 3+, UK)

V. EXPERIMENTAL DETAILS

Turning is one of the most common of metal cutting operations. In turning, a work piece is rotated about its axis as single-point cutting tools are fed into it, shearing away unwanted material and creating the desired part. Turning can occur on both external and internal surfaces to produce an axially-symmetrical contoured part. Parts ranging from pocket watch components to large diameter marine propeller shafts can be turned on a lathe. The capacity of a lathe is expressed in two dimensions. The maximum part diameter, or "swing," and the maximum part length, or "distance between centers."

The general-purpose engine lathe is the most basic turning machine tool. As with all lathes, the two basic requirements for turning are a means of holding the work while it rotates and a means of holding cutting tools and moving them to the work. The work may be held on one or by both its ends. Holding the work by one end involves gripping the work in one of several types of chucks or collets. Chucks are mounted on the spindle nose of the lathe, while collets usually seat in the spindle. The spindle is mounted in the lathe's "headstock," which contains the motor and gear train that makes rotation possible. Directly across from the headstock on the lathe is the "tailstock." The tailstock can hold the work by either alive or dead center. Work that is held at both ends is said to be "between centers." Additionally, longer work pieces may have a "steady rest" mounted between the headstock and tailstock to support the work. Typically work pieces are cylindrical, but square and odd shaped stock can also be turned using special chucks or fixtures.

Lathe cutting tools brought to the work may move in one or more directions. Tool movement on the engine lathe is accomplished using a combination of the lathe's "carriage", Motion perpendicular to the work is called the "X" axis. On an engine lathe this motion is provided by the cross slide mounted on the carriage" cross slide", and "compound rest". The carriage travels along the machine‘s bed ways, parallel to the work piece axis. This axis is known as the "Z" axis. At top the cross slide is the "compound rest," which can be rotated to any angle and secured. The compound rest also holds the "tool post," where tools are mounted. Tools may also be mounted in the tailstock for end-working operations.

A. Cutting Tool

Titanium nitride, TiN

1) TiN

General-purpose coating for improved abrasion resistance. Colour – gold, hardness HV (0.05) – 2300, friction coefficient – 0.3, thermal stability – 600°C.

B. Workpiece Material

T4 Medium Carbon Steel
COMPOSITION: Carbon (C) = 0.45% Silicon (Si) = 0.25% Manganese (Mn) = 0.70

Variables		**Values of different levels**		
Designation	**Description**	**Low**	**Medium**	**High**
D	Depth of cut (mm)	1	1.41	2
F	Feed rate (mm/rev)	0.2	0.26	0.35
V	Cutting speed (m/min)	150	178	212

Table 1: Process Variables & Their Limits

Roughness measurement has been done using a portable stylus-typeprofilometer, Talysurf (Taylor Hobson, Surtronic 3+, UK).

Experiments have been carried out using Taguchi‘s L27 Orthogonal Array (OA) experimental design which consists of 27 combinations of spindle speed, longitudinal feed rate and depth of cut. According to the design catalogue prepared by Taguchi, L 27 Orthogonal Array design of experiment has been found suitable in the present work. It considers three process parameters (without interaction) to be varied in three discrete levels. The experimental design has been shown in Table 4 (all factors are in coded form). The coded number for variables used in Table 4.3 and 4.4 are obtained from the following transformation equations:

By obtain Taguchi‘s L27 Orthogonal Array the experiment have be conducted and the value of the particular feed, speed and depth of cut are given below.

VI. EXPERIMENTAL RESULTS

Std.	Run	Depth of cut mm	Feed Rate mm/rev	Cutting Speed Mm/min	Ra µm
1	7	1	0.2	150	2.086
2	22	1.41	0.2	150	2.338
3	6	2	0.2	150	2.522
4	10	1	0.26	150	4.326
5	13	1.41	0.26	150	4.714
6	14	2	0.26	150	5.044
7	16	1	0.35	150	6.887
8	17	1.41	0.35	150	7.2362
9	21	2	0.35	150	7.788
10	5	1	0.2	178	3.414
11	27	1.41	0.2	178	3.618
12	4	2	0.2	178	3.773
13	8	1	0.26	178	5.966
14	3	1.41	0.26	178	6.1983
15	9	2	0.26	178	6.363
16	23	1	0.35	178	8.041
17	11	1.41	0.35	178	8.197
18	24	2	0.35	178	8.303
19	25	1	0.2	212	4.391
20	1	1.41	0.2	212	4.521
21	18	2	0.2	212	4.608
22	19	1	0.26	212	6.868
23	15	1.41	0.26	212	6.994
24	26	2	0.26	212	7.071
25	12	1	0.35	212	8.536
26	2	1.41	0.35	212	8.304
27	2	2	0.35	212	8.653

Table 2: Experimental Results

VII. CONCLUSION

In this paper, the application of RSM on the hard turning of T4 steel with Titanium nitride, TiN tool has led to obtain the surface roughness (Ra) and investigating the influences of the machining parameters. The optimum values of the machining parameters have been studied and computed. The foremost conclusions which can be drawn are as follows:

- The analysis of machining parameters using experimental technique allows investigating the influence of each one on the cutting process progress outputs as surface roughness of the work piece.
- Additionally, this study shows that the feed rate and workpiece hardness have significant statistical influences on the surface roughness. The effects of two-factor interactions feed rate and depth of cut, cutting speed and work piece hardness, cutting speed and feed rate and Work piece hardness and feed rate also to be important.
- The best surface roughness was achieved at the lower feed rate and the highest cutting speed.

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