Investigation of Vibration Damping Technique for Improved Surface Finishing in Cnc Milling

B. Anil Kumar, Dr. J. Murali Naik, N. Jeevan Kumaar

M. Tech Scholar Department Of Mechanical Engineering

Associate Professor, Department Of Mechanical Engineering

Hod& Professor, Mechanical Engineering Department

Holy Mary Institute Of Technology And Science, Hyderabad

Abstract

The imperative objective of the science of metal cutting is the solution of practical problems associated with the efficient and precise removal of metal from work piece. It has been recognized that the reliable quantitative predictions of the various technological performance measures, preferably in the form of equations, are essential to develop optimization strategies for selecting cutting conditions in process planning. This paper summarizes an experimental study on the vibration damping based process strategies of surface finish enhancement presented in CNC milling operations. The paper considers the relation of surface finish to manufacturing industries in general and vibration as a factor that most influences quality of machined surfaces. The experimental and numerical analysis presented in this work provides an evaluation of various passive/active damping strategies to control vibrations during milling operations. The success of these methods is judged on their ability to decrease chatter, increase stability and ultimately deliver the surface quality demanded by my customer. The results of the study provide important resources for machining engineers in Academia and Industry, to improve surface finish by optimizing CNC milling processes. In this thesis experiments will be conducted to improve the surface finish quality of aluminum alloy work piece by using carbide tips. The type is bull nose tip. A series of experiments will be done by varying the milling parameters spindle speed, feed rate and depth of cut. The spindle speeds are 3500rpm, 3000rpm and 2000rpm. The feed rates are 200mm/min, 300mm/min and 400mm/min. Depth of cut is 0.2mm and 0.3mm and 0.4mm. Taguchi method is used to study the effect of process parameters and establish correlation among the cutting speed, feed and depth of cut with respect to the major machinability factor, surface finish. Validations of the modelled equations are proved to be well within the agreement with the experimental data.

Key words: vibration damping technique

1. INTRODUCTION

1.1 Milling machine

Milling machine is one of the important machining operations. In this operation the work piece is fed against a rotating cylindrical tool. The rotating tool consists of multiple cutting edges (multipoint cutting tool). Normally axis of rotation of feed given to the work piece Milling operation is distinguished from other machining operations on the basis of orientation between the tool axis and the feed direction; however, in other operations like drilling, milling, etc. the tool is fed in the direction parallel to axis of rotation. The cutting tool used in milling operation is called milling cutter, which consists of multiple edges called teeth. The machine tool that performs the milling operations by producing required relative motion between work piece and tool is called milling machine. It provides the required relative motion under very controlled conditions. These conditions will be discussed later in this unit as milling speed, feed rate and depth of cut.

1.2 TYPES OF MILLING MACHINES

Milling operation is broadly classified as peripheral milling and face milling .Peripheral milling this operation is also called plain milling operation. In this operation axis of rotating tool is always kept parallel to the surface being machined. This operation is done by the cutting edges on outside periphery of the milling cutter. Different type of peripheral milling operations are possible as described below. Slab Milling In this milling operation the cutter width extends beyond the work piece on both sides. Slotting it is also a type of milling operation, also called as slot milling operation.

Fig 1.1 milling machine

1.2.1 UP MILLING

It is also called conventional milling in this case movement of cutter teeth is opposite to the direction of feed motion.

1.2.2 DOWN MILLING

It is also called climb milling. In this case direction of cutter motion is the same so that of direction of feed motion.

1.3 FACE MILLING

In the operation of face milling, axis of the milling cutter remains perpendicular to the surface being milled. In this case cutting action is done by cutting edges of both sides (end and outside) periphery of the milling cutter. Depending upon the relative geometry of work piece and milling cutter face milling is different types as described below

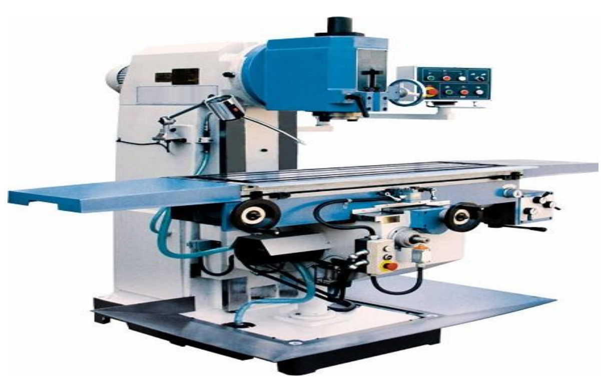

Fig 1.2 face milling

1.4 WORKING PRINCIPLE OF MILLING MACHINE

Working of a milling machine is based on the fact that milling cutter is fed against work piece. This is achieved by developing relative motion with precise control between work piece and rotating milling cutter. Feed motion is generally given to the work piece through its holding device. Cutting mechanism of the work piece in milling operations is milling cutter work piece

(1)Conventional

(2) Partial Face Milling

(3) End Milling Work piece Milling cutter Work piece Feed direction

(4) Profile Milling work piece milling cutter Work piece Pocket Milling cutter

(5) Pocket milling cutter Work piece feed direction Feed

(6) Surface Contouring

Same as that in milling operation on lathe this cutting takes place due to plastic deformation of metal by the cutting tool. Milling machine can also hold more than one cutter at a time. The holding device is supported by mechanism that can offer a selective portion of the work piece to milling cutter for its processing. Indexing is one of the examples of this type of processing.

Fig 1.3 working principle of milling machine

1.5 HEAD MILLING MACHINE

In case of head milling machine feed motion is given by hand and movements of the machine are provided by motor. This is simple and light duty milling machine meant for basic operations.

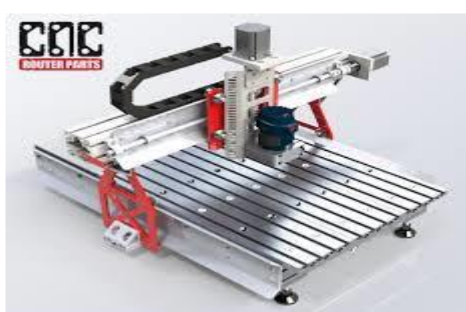

Fig 1.4 Head milling machine

1.6 FIXED BED TYPE MILLING MACHINE

It is also known as manufacturing type milling machine. Its table is mounted directly on the ways of fixed bed. Table movement is restricted to reciprocation only. Cutter is mounted on the spindle head which can move vertically on the column. Duplex milling machine has double spindle heads, one on each side of the table. Triplex milling machine has three spindle heads one each side of the table and third one is mounted on the cross rail.

Fig 1.5 Fixed bed type milling machine

1.7 PRINCIPAL PARTS OF A MILLING MACHINE

Generally columns and knee type milling machine is considered as typical milling machine. Principal parts of a typical milling machine are described as below. Base it provides rest for all parts of milling machine including column. It is made of grey iron by casting. Column it is a type of rigid vertical long box. It houses driving mechanism of spindle; table knee is also fixed to the guide ways of column.

1.7.1 KNEE

Knee can be adjusted at a height on the column. It houses the feed mechanism of the table and other controls.

1.7.2 SADDLE

Saddle is placed at the top of the knee. Saddle provides guide ways for the movement of the table.

1.7.3 TABLE

Table rests on the saddle. It consists of „T" shaped slots for clamping the work piece. Movements of the table (feed motions) are given in very controlled manner be lead screw. Overhanging Arm Overhanging arm is mounted on the column and serves a bearing support for the arbor. This arm is adjustable so that the bearing support may be provided near to the milling cutter. There can be more than one bearing supports to the arbor. Arbor it holds rotating milling cutters rigidly and mounted on the spindle. Sometimes arbor is supported at maximum distance from support of overhanging arm like a cantilever, it is called stub arbor. Locking provisions are provided in the arbor assembly to ensure its reliability.

1.8 FRONT BRACE MILLING

Front base is used to adjust the relative position of knee and overhanging arm. It is also an extra support fixed between the knee and overhanging arm for rigidity. Spindle is projected from the column face and provided with a tapered hole to accommodate the arbor. Performance of a milling machine depends on the accuracy

1.9 CUTTING PARAMETERS

There are three major cutting parameters to be controlled in any milling operation. These three parameters are cutting, speed, feed rate and depth of cut. These parameters are described below.

1.10 CUTTING SPEED

Cutting speed of a milling cutter is its peripheral linear speed resulting from operation. It is expressed in meters per minute. The cutting speed can be derived from the above formula.

V = Cutting speed (linear) in meter per minute, and

n = Cutter speed in revolution per minute.

Spindle speed of a milling machine is selected to give the desired peripheral speed of cutter.

1.11 FEED RATE

It is the rate with which the work piece under process advances under the revolving milling cutter. It is known that revolving cutter remains stationary and feed is given to the work piece through worktable. Generally feed is expressed in three ways.

1.12 FEED PER TOOTH

It is the distance travelled by the work piece (its advance) between engagements by the two successive teeth. It is expressed as mm/tooth (ft).

1.13 FEED PER REVOLUTION

Travel of work piece during one revolution of milling cutter. It is expressed asmm rev. and denoted by f(rev).

1.14 FEED PER UNIT OF TIME

Feed can also be expressed as feed/minute or feed/sec. It is the distance advances by the work piece in unit time (fm).

1.15 DEPTH OF CUT

Depth of cut in milling operation is the measure of penetration of cutter into the work piece. It is thickness of the material removed in one pairs of cutter under process. One pairs of cutter means when cutter completes the milling operation from one end of the work piece to another end. In other words, it is the perpendicular distance measured between the original and final surface of work piece. It is measured in mm.

1.16 MILLING MACHINE OPERATIONS

Milling operations described earlier were based on major categorization of milling. These were differentiated on the basis of relative position of milling cutter and Work piece. Their detailed description is given below.

Following different operations can be performed on a milling machine:

- Plain milling operation
- Face milling operation
- Side milling operation
- Straddle milling operation
- Angular milling operation
- Gang milling operation
- Form milling operation
- Profile milling operation
- End milling operation
- Saw milling operation
- Slot milling operation

- Gear cutting operation
- Helical milling operation
- Cam milling operation
- Thread milling operation

1.17 Vertical milling machine

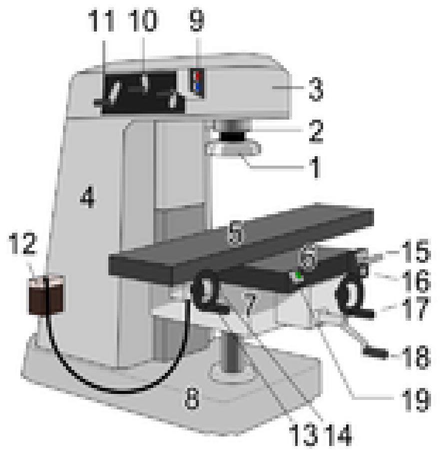

Fig 1.6 Vertical milling machine

Vertical milling machine parts

- milling cutter
- spindle
- top slide or overarm
- column
- table
- Y-axis slide
- knee
- Base

2. Related study

In this paper signal-to-noise ratio method is applied to find optimum process parameters for finishing operation of mild steel with the help of CNC milling machine and high speed steel tool used. The signal-to-noise ratio applied to find optimum process parameter for CNC finishing machining .A L9 orthogonal array and analysis of variance (ANOVA) are applied to study the performance characteristics of machining parameter (spindle speed, feed, depth, width) with consideration of high surface finish and high material removal rate (MRR) .The surface finishing and material removal rate have been identified as quality attributes and assumed to be directly related to productivity improvement. Results obtained by taguchi method and signal-to-noise ratio match closely with (ANOVA) and the feed are most effective factor for MRR. And spindle speed is the most effective factor for surface roughness. Multiple regression equation is formulated for estimating predicted value surface roughness and material removal rate.

3. Objectives

After studying this unit, you should be able to understand

- introduction and working principle of milling machine,
- different type of milling operations,
- different type of milling machine and their main parts,
- specifications of milling machines,
- different cutting parameters as setting of a milling machine,
- introduction and categorization of milling cutters,
- different operations that can be performed on a milling machine, and
- Indexing, different methods of indexing.

4. Methodology

4.1 Introductions to taguchi technique

- Taguchi defines Quality Level of a product as the Total Loss incurred by society due to failure of a product to perform as desired when it deviates from the delivered target performance levels.
- This includes costs associated with poor performance, operating costs (which changes as a product ages) and any added expenses due to harmful side effects of the product in use.

4.2 Taguchi Methods

- Help companies to perform the Quality Fix!
- Quality problems are due to Noises in the product or process system
- Noise is any undesirable effect that increases variability
- Conduct extensive Problem Analyses
- Employ Inter-disciplinary Teams
- Perform Designed Experimental Analyses
- Evaluate Experiments using ANOVA and Signal-to noise techniques

4.3 TAGUCHI PARAMETER DESIGN FOR TURNING PROCESS

In order to identify the process parameters affecting the selected machine quality characteristics of turning, the following process parameters are selected for the present work: cutting speed (A), feed rate (B) and depth of cut (C). The selection of parameters of interest and their ranges is based on literature review and some preliminary experiments conducted.

4.4 Selection of Orthogonal Array

The process parameters and their values are given in table. It was also decided to study the two – factor interaction effects of process parameters on the selected characteristics while turning. These interactions were considered between cutting speed and feed rate (AXB), feed rate and depth of cut (BXC), cutting speed and depth of cut (AXC).

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PROCESS PARAMETERS	LE VEL1	LEVEL2	LEVEL3
CUTTING SPEED(rpm)	2000	3000	3500
FEED RATE (mm/rev)	200	300	400
DEPTH OF CUT(mm)	0.2	0.3	0.4

4.5 Introductions to cutting forces and surface finish

Knowing the magnitude of the cutting forces in the turning process as function of the parameters and conditions of treatment is necessary for determining of cutting tool strength, cutting edge wearing, limit of the maximum load of the cutting machine and forecasting the expected results of the processing. In particular, during machining with high cutting speed, using modern materials and modern cutting machines imposes the necessity of studying physical phenomena in the cutting process and their mathematical modeling.

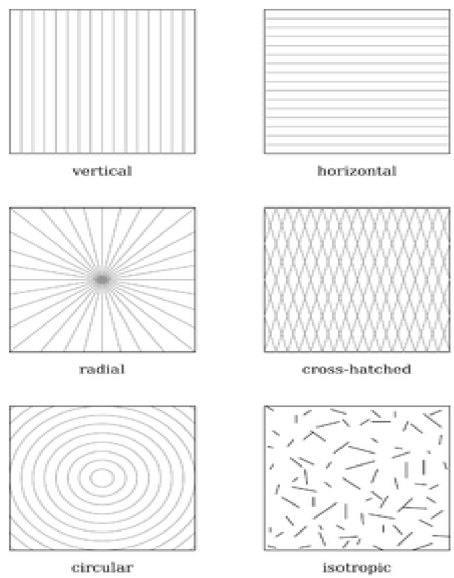

Fig 3.7 Examples of various lay patterns

4.6 Surface roughness

Surface roughness commonly shortened to *roughness*, is a measure of the finely spaced surface irregularities. In engineering, this is what is usually meant by "surface finish".

4.7 Waviness

Waviness is the measure of surface irregularities with spacing greater than that of surface roughness. These usually occur due to warping, vibrations, or deflection during machining.

4.8 EXPERIMENTAL INVESTIGATION

The experiments are done on the CNC milling machine with the following parameters:

4.8.1 CUTTING TOOL MATERIAL –cemented Carbide Tool

4.8.2 WORK PIECE MATERIAL – aluminum alloy

4.8.3 FEED – 200mm/min, 300mm/min, 400mm/min

4.8.4 CUTTING SPEED – 2000rpm, 3000rpm, 3500rpm,

DEPTH OF CUT – 0.2mm, 0.3mm, 0.4mm

Fig 3.8 Milling machine

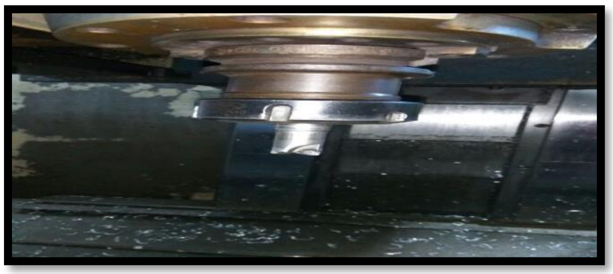

Fig 3.9 Milling cutter

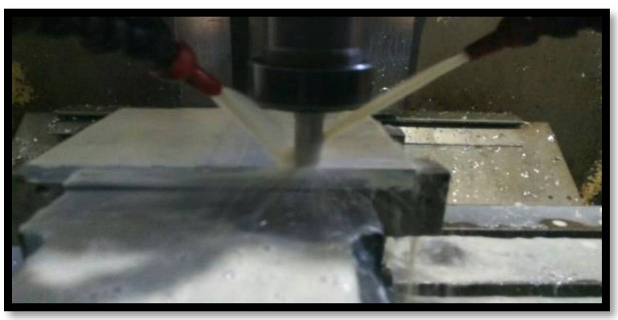

Fig 3.10 lubrication

Fig 3.11 machining process

5. Results

PROCESS PARAMETERS	LE VEL1	LEVEL2	LEVEL3
CUTTING SPEED(rpm)	2000	3000	3500
FEED RATE (mm/rev)	200	300	400
DEPTH OF CUT(mm)	0.2	0.3	0.4

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)
1	2000	200	0.2
2	2000	300	0.3
3	2000	400	0.4
4	3000	200	0.2
5	3000	300	0.3
6	3000	400	0.4
7	3500	200	0.2
8	3500	300	0.3
9	3500	400	0.4

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	Surface finish (R_a) µm
1	2000	200	0.2	1.09
2	2000	300	0.3	1.15
3	2000	400	0.4	1.24
4	3000	200	0.2	1.91
5	3000	300	0.3	2.21
6	3000	400	0.4	2.56
7	3500	200	0.2	3.12
8	3500	300	0.3	2.94
9	3500	400	0.4	2.87

5.1 Test report


केन्द्रीय उपकरण अभिकल्प संस्थान
CENTRAL INSTITUTE OF TOOL DESIGN
(भारत सरकार की सोसाइटी - सूक्ष्म, लघु और मध्यम उद्यम मंत्रालय)
(A Govt. of India Society - Ministry of Micro, Small & Medium Enterprises)
स्थापित : 1970
ESTD : 1970

संदर्भ :
Ref. :
CITD.W.O.No. ISO 5544

दिनांक :
Date :
06/05/2024 10 PM

INSPECTION REPORT

Name of the Party: M/s. DUN TECHNOLOGIES,HYDERBAD.

Surface finish Tester, Model Surtronic 3+, Rank Taylor Hobson Ltd., Made in England. Which is Periodically Calibrated using Reference Specimen Type 112/1534.
Lab Temperature 20 ± 2°c,

Aluminum alloy	
S.No	Surface finish (R_a) µm
1	1.09
2	1.15
3	1.24
4	1.91
5	2.21
6	2.56
7	3.12
8	2.94
9	2.87

Inspector Q.C
Inspection & Metrology
Central Institute of Tool Design
(Govt. of India- Ministry of MSME)

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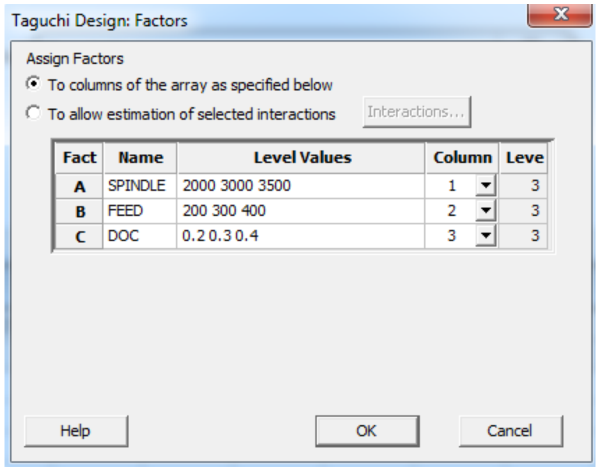
5.2 Optimization Of Surface Finish Using Minitab Software

Design of Orthogonal Array

First Taguchi Orthogonal Array is designed in Minitab17 to calculate S/N ratio and Means which steps is given below:

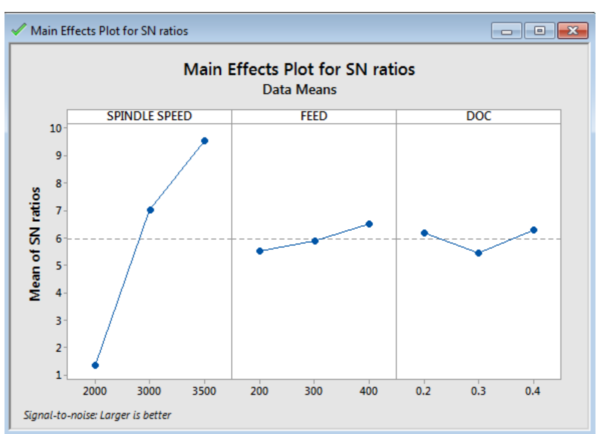


5.3 Optimization of parameters

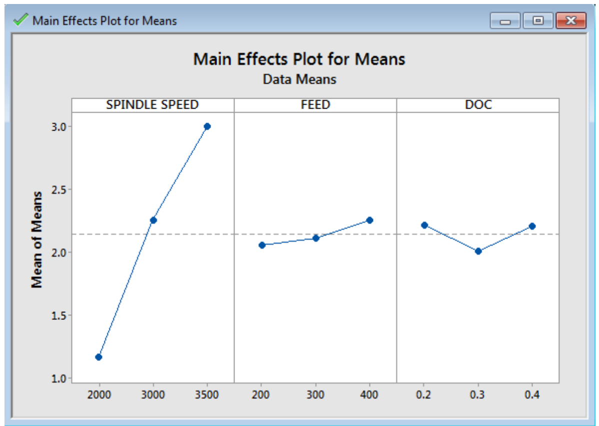
Worksheet 2 ***

↓	C1	C2	C3	C4
	SPINDLE SPEED	FEED	DOC	SURFACE FINISH
1	2000	200	0.2	1.09
2	2000	300	0.3	1.15
3	2000	400	0.4	1.24
4	3000	200	0.3	1.91
5	3000	300	0.4	2.21
6	3000	400	0.2	2.56
7	3500	200	0.4	3.12
8	3500	300	0.2	2.94
9	3500	400	0.3	2.87

5.4 S/n ratio plot



5.5 Means plot



6. Conclusion

In this thesis an attempt to make use of Taguchi optimization technique to optimize cutting parameters during high speed milling of aluminum alloy using cemented carbide cutting tool. The cutting parameters are cutting speed, feed rate and depth of cut for milling of work piece aluminum alloy. In this work, the optimal parameters of cutting speed are 2000rpm, 3000rpm and 3500rpm, feed rate are 200mm/min, 300mm/min and 400mm/min and depth of cut are 0.2mm, 0.3mm and 0.4mm. Experimental work is conducted by considering the above parameters. Cutting forces, surface finish and cutting temperatures are validated experimentally. By observing the experimental results and by taguchi, the following conclusions can be made: To get better surface finish, the optimal parameters are spindle speed – 3500rpm, feed rate – 200mm/min and depth of cut – 0.4mm.

References

1. Optimization of milling process parameters of en33 using taguchi parameter design approach mr. Dhole n.s. 1, prof. Naik g.r 2, mr. Prabhawalkar m.s. 3.

2. Optimization of process parameters of CNC Milling machine for mild steel using Taguchi design and Single to Noise ratio Analysis ANIL CHOUBEY1 , VEDANSH CHATURVEDI2 ,JYOTI VIMAL.

3. OPTIMIZATION OF MILLING PROCESS PARAMETERS - A REVIEW mihirthakorbhai Patel*

4. Optimization of Input Process Parameters in CNC Milling Machine of EN24 Steel 1Balinder Singh, 2Rajesh Khanna, 3Kapil Goyal, 4Pawan Kumar

5. Selection of Optimum Process Parameters in High Speed CNC End-Milling of Composite Materials Using Meta Heuristic Techniques – a Comparative Study Pare, V., Geeta, G., Krishna, C.M. Vikas Pare – Geeta Agnihotri – Chimata Krishna*

6. G. Petropoulos, I. Ntziantzias, C. Anghel, A predictive model of cutting forces in milling using Taguchi & response surface techniques, a proceeding of 1st International Conference on Experiments/Process/ System

7. C. C. Tsao, Grey–Taguchi method to optimize the milling parameters of aluminum alloy, International Journal on Advanced Manufacturing Technology (2009) 40:41–48

8. K.-D. Bouzakis1, R. Paraskevopoulou1, G. Giannopoulos, Multi-objective optimization of cutting conditions in milling using genetic algorithms, Proceedings of the 3rd International Conference on Manufacturing Engineering (ICMEN), 1-3 October 2008, Chalkidiki, Greece

9. Dalgobind Mahto and Anjani Kumar, Optimization of Process Parameters in Vertical CNC Mill Machines Using Taguchi's Design of experiments, ARISER Vol. 4 No. 2 (2008) 61-75