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EXPERIMENTAL INVESTIGATION AND ANALYSIS FOR CHATTER OF FACE MILLING TOOL

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ABSTRACT

The Milling operation is the very basic machining operation in the manufacturing industry. Chatter is a topic of immense engineering. Chatter can be termed as self-excited vibrations during machining; these vibrations can affect the machine tool, the cutting condition, the work piece and the tool life. In high speed milling machine tool chatter must be avoided for better machine life, improve surface finish, and increase tool life. In this paper, chatter is reducing by change in damping value of tool holder by introducing shim in tool and changing shim material. Finite element method is use for find damping ratio of different shim material. Model analysis is done by ANSYS 15. Experiment work is done on CVM 640 milling machine with 63mm dia 4 inserts cutting tool, workpiece 2062 mild steel. Surface roughness data acquire with surface roughness tester SJ 210 for different shim material. Find out the best shim material for high speed milling operation based on better surface roughness achieve.

KEYWORDS Chatter, damping ratio, finite element method, model analysis, ANSYS, VMC

I. INTRODUCTION

In the present day manufacturing industry, high-speed milling (HSM) plays an important role. Some examples include the fabrication of moulds [1, 10] and the aeroplane building industry [3,]. The key benefit of high-speed milling is that a large amount of material can be cut in a short time span with relatively small tools due to the high rotational speed of the tool. There is also a demand for increasing the automation of the production. This means that tools and workpieces are changed automatically and that the process is being monitored constantly by various sensors in VMC

The machining of metals often accompanied by a violent relative vibration between work piece and tool is called chatter. There is three different types of mechanical vibrations are present as forced vibrations, free vibrations and self-excited vibrations these are present due to a lack of dynamic stiffness/rigidity of the machine tool system comprising tool, tool holder, work- piece and machine tool itself Successful machining operations depend upon the dynamic relationship between the work piece and cutting tool. Under certain circumstances, the motion of the tool against the work piece can produce a self-exciting system, resulting in large amplitude of vibrations. This vibration or chatter adversely affects the life of the tool, the quality of the cut, and the speed at which operations may be performed. Understanding and properly controlling the interaction of tool/work piece dynamics to control chatter can yield reduced costs and higher overall productivity.

II. LITERATURE REVIEW

Mayur S Ghormade and D.H.Pandya (2015) was study characteristic of the damped tool using finite element analysis (FEA). Damping ratio is one of the dynamic characteristic of system. Damping ratio of cutting tool with three different shims is predicted by using frequency response function and half band width method. An analytical model is simulated using MATLAB. The stability plot for dynamic turning system is obtained during cutting process with various modes, speed, width of cut and damping ratio. [1]

C.K. Toh (2004) Vibration analysis in high speed rough and finish milling hardened steel. High speed milling (HSM) as a cutting process the ability to machine difficult-to-cut workpiece materials with increased productivity due to an enhanced tool life. A literature survey, however, suggests that work on understanding the chatter vibration effects caused due to various cutter path orientation effects when HSM is scant. [2]

M. Zatarai, I. Bediaga, J. Mun˜oa, R. Lizarralde. (2008)Stability of milling processes with continuous spindle speed variation: Analysis in the frequency and time domains, and experimental correlation. This paper presents the general theory for analysis in the frequency domain and for any speed variation strategy. Results are compared with those obtained by semidiscretization and time integration, as well as with those obtained by experiments. [3]

Jérémie Monnin a,n, FredyKuster b, KonradWegener (2014) Optimal control for chatter mitigation in milling part1:Modeling and Control design. This paper presents an active system integrated in to a spindle unit. Two different optimal control strategies are investigated. The first one only considers the dynamics of the machine structure in the controller design and minimizes the influence of cutting forces on tool tip deviations. [4] A.Scippa.n, L.Sallese,N.Grossi,G.Campatelli (2015) Improved dynamic compensation for accurate cutting force measurements in milling applications. Optimizing the cutting operations and evaluating the presence of instabilities that could affect the effectiveness of cutting processes. A variety of specifically designed transducers are commercially available nowadays and many different approaches in measuring cutting forces are presented in literature. [5]

Avinash A. Thakre (2013) Optimization of Milling Parameters for Minimizing Surface Roughness Present work includes understanding the effects of various milling parameters such as spindle speed, feed rate, depth of cut and coolant flow on the surface roughness of finished products. The optimal parameters for surface roughness is obtained as spindle speed of 2500 rpm, feed rate of 800 mm/min, 0.8 mm depth of cut, 30 lit/min coolant flow. [6]

III. OBJECTIVE AND METHODOLOGY

1. Introducing the damper in the cutting tool system.
2. The main objective of research is to provide the new method to reduce the vibration and chatter problem in face milling for this purpose investation will carried out for introducing the shim attach with insert that provide damping.
3. Computational analysis.
4. Introducing different shim material and same will be verified experimentally as well.
5. Evaluate most suitable shim material for reduce chatter at vertical machining center.

Methodology used for this are Modeling, CAM simulation, CAD Simulation and analysis, Experimental investigation.

IV. COMPUTATIONAL WORK AND RESULT DISCUSSION

In order to make Finite element model ANSYS software is use. A geometric model of cutting tool holder is shown in Figure (1).

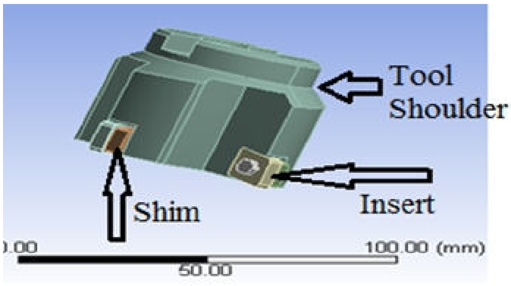


Fig. 1 Geometric model of Face Milling Tool

Modal analysis is done for find out Natural frequencies and vibration modes of Face mill tool.

Than harmonic analysis is done using mode frequency for find Frequency response curve. In present work analysis is done for all shim material and find out damping ratio. Damping ratio is predicted by using the half power bandwidth method. The bandwidth is the frequency difference between upper and lower frequencies for which the power has dropped to the half of its maximum value.

Frequency response graph was found using Harmonic analysis in ANSYS which is shown in Figure (2)

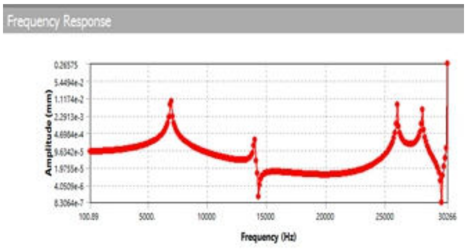


Fig. 2

Analysis is done for tool assembly. And find damping ratio taking three different shim materials which is shown in Table (1)

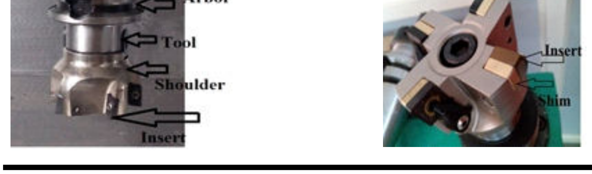
Table 1 Damping ratio of different shim material

Shim	Natural Frequency f	Damping Ratio
Aluminum	1.36E+05	0.00326
Brass	92927	0.00215
Carbide	1.59E+05	0.00168

Computational works show that the damping ratio is low in tool with brass shim and high in tool with aluminum shim. As per computational work conclude that the damping is change by changing shim material.

V. EXPERIMENTAL SET UP AND RESULT DISCUSSION

The experiments were carried out on the CVM 640 (VMC) Milling machine with two face milling tool one is special purpose face milling tool 63 mm dia 4 inserts cutting tool and second one is 63 mm dia 5 inserts, workpiece Plate of 75*25*300 mm of 2062 mild steel 130 BH work material were used for the experiments. The machining is done using CNMG 120412 (Carbide) insert. The experiments were conducted at constant feed per tooth 0.15. Three different cutting speed 200m/min, 250m/min, 300m/min are taken, three different depth of cut 0.8mm, 1.0mm, 1.2mm, without shim and with three different shim material Carbide, Brass and Aluminum are taken for experiments. Surface roughness is measured with SJ 210 surface roughness tester (-200 μm to 150μm). The experiment setup is shown in Figure (3) and (4)



(a) Without Shim **(b) With shim**

Fig. 3 (a) Without shim and (b) With shim

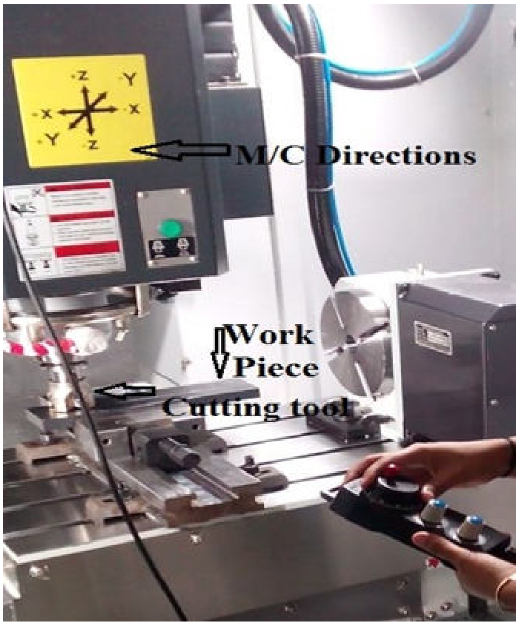


Fig. 4 VMC for milling operation

Combination without and with Shim material, Cutting speed and Depth of cut total 36 experiments are done. The lists of experiments are shown in Table (2) and (3)

Table 2 Experimental Table without Shim 5 inserts

No. of run	Cutting Speed (m/min)	Depth of Cut (mm)	Roughness (μm)
1	200	1.2	0.59
2	200	1.0	1.06
3	200	0.8	2.00
4	250	1.2	0.98
5	250	1.0	1.07
6	250	0.8	1.21
7	300	1.2	1.08
8	300	1.0	2.24
9	300	0.8	2.52

Table 3 Experimental Table with Shim 4 inserts

No. of run	Shim Material	Cutting Speed (m/min)	Depth of Cut (mm)	Roughness (μm)
10	Aluminium	200	1.2	2.00
11		200	1.0	3.31
12		200	0.8	5.25
13		250	1.2	6.38
14		250	1.0	6.05
15		250	0.8	5.58
16		300	1.2	6.65
17		300	1.0	4.82
18		300	0.8	6.92
19	Carbide	200	1.2	2.95
20		200	1.0	3.09
21		200	0.8	5.74
22		250	1.2	3.62
23		250	1.0	4.47
24		250	0.8	5.81
25		300	1.2	5.61
26		300	1.0	5.98
27		300	0.8	5.59
28	Brass	200	1.2	0.84
29		200	1.0	1.77

30		200	0.8	1.74
31		250	1.2	1.64
32		250	1.0	0.60
33		250	0.8	1.60
34		300	1.2	1.07
35		300	1.0	1.66
36		300	0.8	1.64

Experimental result as surface roughness for different cutting speed clearly shows that without shim surface roughness value range 0.59 to 2.52 µm and with brass shim surface roughness value 0.84 to 1.77 µm.

With Different shim material Aluminium has surface roughness value 2.00 to 6.92 µm. Carbide has surface roughness value 2.95 to 5.98 µm. Brass has surface roughness value 0.84 to 1.77 µm in carbide shim is used. With this the costs of brass shim having a less price then aluminium and carbide shim. Apart from this the numbers of inserts are also less with tool having shim this is also a cost effective.

VI. CONCLUSION

In the present work, a computational model is used for find out damping ratio and validated with the Experimental study to analyze the chatter in milling operation. The observation of this study can be used to reduce the chatter and improve surface roughness. In this work conclude that the without shim surface roughness is poor then Brass shim. Brass is best for high cutting speed 300 m/min and any depth of cut. Aluminum is not justified for use in operation. Carbide is poor at 300 m/min and any depth of cut. Also conclude that for surface roughness value show the good result in brass shim.

Using milling operation with 63mm diameter and 4 insert Brass Shim is also cost effective than conventional 63mm dia 5 insert face milling tool. Using milling operation with 63mm diameter and 4 insert Brass Shim also reduce finishing pass in milling operation that also increase production rate.

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