Faculty of Mechanical and Manufacturing Engineering Technology

DESIGN AND DEVELOP A DAMPER TO REDUCE VIBRATION IN MILLING OPERATION

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing engineering technology (Process and Technology) with Honours. The member of the supervisory is as follow:

………………………………………………….

(Encik Mohammad Khalid bin Wahid)

ABSTRAK

Dalam kajian ini, peredam dengan gabungan lembaran getah neoprena dan penyerap kejutan hidraulik direka untuk mengurangkan getaran dalam operasi pengilangan. Tujuan projek ini memberi tumpuan kepada reka bentuk peredam dan data yang diperoleh dari dinamometer meja. Eksperimen ini termasuk pengukuran pemotongan daya, pengukuran amplitud, dan pengukuran kekasaran permukaan semasa operasi pengilangan. Objektif utama adalah untuk mengurangkan getaran dalam operasi pengilangan untuk meningkatkan interaksi permukaan lembaran getah dengan bahagian kerja dimana lembaran getah neoprene terbukti dapat mengurangkan bunyi yang dihasilkan oleh alat pemotong dan mesin dilampirkan pada peredam. Selain itu, penyerap kejutan hidraulik dimasukkan ke dalam peredam untuk memaksimumkan fungsinya untuk mengurangkan getaran dari alat pemotong. Dengan melambatkan dan mengurangkan magnitud getaran dimana tenaga kinetic bertukar kepada tenaga haba, graf nilai amplitud terhadap frekuensi lebih rendah yang membuktikan bahawa getaran berkurang.

ABSTRACT

In this paper, a damper with a combination of neoprene rubber sheet and hydraulic shock absorber is developed to reduce the vibration in the milling operation. The target of this project focus on the design of the damper and the data obtained from the table dynamometer. The experiment includes cutting force measurement, amplitude measurement, and surface roughness measurement during the milling operation. As the main objective is to reduce the vibration in milling operation, neoprene rubber sheet as a proven material that can reduce the noise generate by the cutting tool and machine is attached on a side of the damper, to increase the surface interaction of the rubber sheet with the work piece. On the other hand, a hydraulic shock absorber is inserted into the damper to maximize its function to reduce the vibration from the cutting tool. With the function of slowing down and reducing the magnitude of vibratory motions by turning the kinetic energy of suspension movement into heat energy, the value graph of amplitude against frequency can be lower, which prove that the vibration is reduced.

DEDICATION

To my beloved parents, Wong Kien Chong and Puah Meng Choo.

To my respected supervisor, Encik Mohammad Khalid bin Wahid.

To my lovely and helpful friends.

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LIST OF ABBREVIATION, SYMBOLS AND NOMENCLATURE

CNC	-	Computer Numerical Method
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
ASTM	-	American Society for Testing and Materials
µm	-	micrometre or micron
m	-	millimetre
cm	-	centimetre
s	-	second
kN	-	kilonewton
%	-	percent
rpm	-	revolution per minute
mm/min	-	millimetre per minute

CHAPTER 1

INTRODUCTION

1.1 Background

Vibration deteriorate the accuracy and productivity of precision machine tools and product. Basically, vibration is caused by axial movement and the vibration of the entire machine. The fluctuation in cutting force throughout clipping of chip and the existence of frictional force within the tool and the workpiece create the vibration even greater. However, the tool life may be affected if the vibration continuously occurs. Also, it leads to get poor surface finishing of the final product. Therefore, vibration in milling operation should be reduced. There are many methods to measure and predict vibration, identifying the dynamics of the structure, and the main important specification like ordinary frequency, damping ratio and use equations that model the dynamics within the cutting operation and the vibration of the structure is the traditional method.

Other than that, a vibrated cutting tool may decrease the productivity and the precision of the CNC machine. As the CNC machine widely used to perform precision machining of complex features in industry, this kind of problem should be solved quickly. Talking about CNC machines, for instance, the five-axis CNC machine, it can manage three linear axes and two rotary axes to move coincidentally. The orientation and the cutter's position can be determined simultaneously, in case of the surface of the work piece could be adapted better. Shorter machining time is the main benefits of CNC machine as it is computer numerical controlled. Despite the human error which could not be avoided, vibration should be reduced to ensure the quality of the product.

Table Dynamometer is the device to measure the vibration form the cutting tool toward the work piece, based on the data obtained such as cutting force and amplitude, the vibration could be determined. This device is put on the work space of CNC machine and beneath the work piece before the machining begin. Then, DynoWare is used to run and obtain the data. The result is clear and obvious as it is in graph form, showing the force against time on each single axis. Moreover, surface roughness of the workpiece will be measured by using surface roughness tester as an extra data to determine the vibration. By comparing the results which is one without damper and with the designed damper, the vibration could be determined.

1.2 Problem Statement

CNC machine performs precision machining of complex features in automotive and aerospace industry with strict quality requirement. The features of multi-axis cutting and various of cutting tools bring advantages to the operator to produce quality product in shorter time. However, there are still some limitation that happen when on the machining of CNC, vibration is the problem that usually faced and cannot be avoided, either it is in cutting cool itself or towards the work piece, especially the milling process. When the process is running, the force from X-axis, Y-axis, and Z-axis are generated toward work piece, making the work piece vibrates. Otherwise, the cutting tool vibrates itself as it is undergoing high speed turning. The higher speed the turning speed, the higher the vibration occurred.

High vibration will directly affect the measurement result of the product such as poor surface finishing and obtained low quality of the product. Moreover, there is also relationship between the vibration and the tool life of the cutting tool. High vibration may damage the cutting tool in term of the function and is quality.

1.3 Objectives

There are 3 objectives of this project which are:

i. To reduce the vibration in milling operation

ii. To improve chatter stability in milling machine

iii. To generate smooth and good surface finish of the product

1.4 Scope

This project scope consists of:

i. Design and develop a damper to reduce vibration in milling operation.

ii. Measure the cutting force and amplitude by using table dynamometer and DynoWare.

iii. Measure the surface roughness of the work piece by using surface roughness tester

iv. Compare the result of the measurement with and without damper.

1.5 Significant of Study

The finding of this study will attribute to the benefit of industries considering that vibration is an important defect which affect directly towards product and the cutting tools. With the aid of this damper, vibration could be reduced to obtain a better quality of product and reduce cost of manufacturing. Also, this benefit the operator to reduce time of operation. For the researcher, this study will help them understand the combination of the neoprene rubber sheet and the hydraulic shock absorber in a damper and its function and effect to the product.

1.6 Expected Results

At the end of this project, the main concern is to reduce the vibration in milling operation. With the design and the equipment used, hope that the result could be better comparing to the ones without the damper. Also, the surface roughness result to be obtained prettily which gives a smooth and good surface for the part.

CHAPTER 2

LITERATURE REVIEW

2.1 Five-Axes Simultaneous CNC Milling Machine

Standard five-axes CNC milling machine should have linear motion along the X, Y, and Z axes which are the translational axes. There are also the additional rotational axes which are A, B, and C axes. The mechanical components of the CNC machine will move along or around the stated axes to perform machining process.

According to Bologa et al. (2016) CNC (Computer Numerically Controlled) machine-tools are the most critical technological equipment in the sector of metal-cutting and machine building industry. the machine slides are moving on complex trajectories to develop the configuration of the machined part. Computer numerically controlled closed-loop systems are the essence components of these category of machines. Figure 2.1 shows the basic configuration of the 5-axis CNC machine.

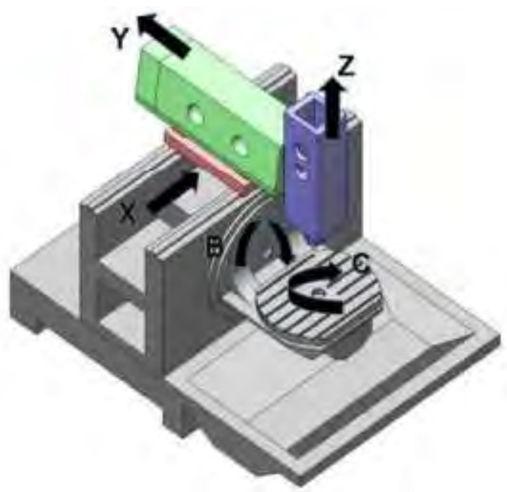

Figure 2.1: Configuration of 5-axis machine tool. Bologa et al. (2016)

Huge amount of shapes is allowed the user to be machined with the combination of the simultaneous movements on the three translational axes (X, Y, and Z). On the other hand, the additional one or two rotational axes (A, B, and C) act as the extra axes combining the translational axes can be used to machine more complicated shapes like spiral surfaces and aerospace part such as turbine blades. In figure 1, X, Y, and Z are the translational axes while A, B, and C are the rotational axes rotating around X, Y, and Z respectively.

There are many advantages that CNC machines could bring to the industry. For example, the autonomous machining of CNC obviously eliminates human error and improve accuracy. Furthermore, CNC machines can work around-the-clock daily and only stop for maintenance if needed. High production and scalability can be achieved as the CNC machines executes huge quantities and affords flexible scalability after the design and specification have been entered into machines. Moreover, CNC machines provide safer environment directly toward the operator, there is always a distance from the sharp tools from the operator. However, Operator required specified skill to run the machines.

In 2014, Feng et al. published a paper in which they described five-axis CNC system can regulate three linear axes and two rotary axes to move at the same time. The cutter's position and direction can be resolved at the same time, hence the cutter can better adapt to the workpiece surface. With the asset such as lesser machining time, greater machining accuracy and less number of fixtures, five-axes milling is generally used to machine impellers and structural parts in aeronautics and space industry.

In order to avoid problem such as mis-transfer data to the system, cutting down the machining time and rate, and boost the machining performance. CNC machines have the function to implement five-axes transformation. Which is, The CNC can convert the cutter's position and orientation with respect to the workpiece coordinate system into axes positions under the machine coordinate system. With such function, the CNC system can undoubtedly reimburse the rotary movements in actual-time. (Feng et al., 2014).

Similarly, Nojehdah et al. (2016) also found that five-axis CNC machine tool execute precision machining of complicated features in automotive, aerospace and power generation industries to cope with strict quality compulsion. It is stated that improper attainment of rotary axes extremely disturbs useful accuracy of machined features and increase complexity of root cause analysis. This problem may convince pricey blunder in machine tool repair or trouble-shooting tasks.

2.2 Conventional Milling Machine

In industry, from a small factory to a big company, a vertical milling machine is widely used. Milling machines has evolved so much from the pass, it can be found before the world war one, there are a lot of firms built milling machines all along. However, with the change of time, Computers and CNC machine tools continue to establish briskly, the need for a manual milling machine was affected.

The spindle axis is vertically oriented in the vertical mill, the cutting tools are gripped in the spindle and rotate on its axis. The spindle can commonly be extended, making the cutting and drilling process. There are two types of vertical milling, which are the bed mill and the turret mill. There is a stationary spindle in a turret mill and the table is allowed to move both perpendicular and parallel to the spindle axis to accomplish cutting. Bridgeport is the most common example. Also, there is always a quill equipped in turret mills which allows the cutting tools to be raised and lowered in a manner like a drill press. This type of machine offers two methods of cutting in vertical (z) direction: by raising or lowering the quill and by moving the knee. However, in the bed mill, the table moves only perpendicular to the spindle's axis while the spindle itself moves parallel to its own axis. Figure 2.2 showed the conventional vertical milling machine.

Figure 2.2: Conventional vertical milling machine

There are two distinct ways to cut materials, which are conventional milling and climb milling. The main contrast between both two techniques is the connection of the rotation of the cutter to the direction of feed. The cutter rotates against the direction of the feed in conventional milling which during the climb milling process, the cutter rotates with the feed. Backlash become the main reason for the traditional approach of conventional milling as the elimination of the lead screw and the nut in machine. However, climb milling has recently been identified as the favoured way to access a workpiece because there are more and more machines reimburse for backlash or have a backlash eliminator.