ARPN Journal of Engineering and Applied Sciences

OPTIMIZATION OF ROUND SHAPE PORTABLE VACUUM CLAMPING BASED ON MACHINING PARAMETERS

N. Ab Wahab[1], Mohd. Khairulazwan Bin Mustapha[1], Abdul Khahar Bin Nordin[1], M. Zahari[2], N. Abd Mutalib[2], R. Mohd. Nor[2] and N. Syuhada Nasir[1]

[1]Faculty of Mechanical and Manufacturing Engineering Technology, UniversitiTeknikal Malaysia Melaka, Hang Tuah Jaya, Durian Tunggal, Melaka, Malaysia

[2]Faculty of Electric and Electronic Engineering Technology, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, Durian Tunggal, Melaka, Malaysia

E-Mail: norfariza@utem.edu.my

ABSTRACT

The aim of this project is to optimize the round shape portable vacuum clamping based on machining parameters. The selected machining parameter is spindle speed, depth of cut and feed rate. The vacuum clamping was tested to evaluate and analyse the result of surface roughness and time setting. The result shows that the portable round shape vacuum clamping is the best clamping system compare with conventional vise in term of setup time. The time is taken for setting the workpiece on the clamping device for vacuum clamping is 13.6 seconds which is faster than conventional vise 54.7 seconds. For surface roughness, the smooth surface is 1.627 µm at 910 RPM of spindle speed. 910 RPM spindle speed is most suitable for machining 0.5mm depth of cut on portable round shape vacuum clamping.

Keywords: clamping, vacuum, vacuum clamping, milling machine, surface roughness, roughness.

INTRODUCTION

Vacuum could be a space within which there's no matter or during which the pressure is so low that any particles within the space don't have an effect on any operation being carried on there. It a condition well beneath ordinary barometrical weight and is estimated in units of weight (the Pascal). A vacuum is made by removing air from a space utilizing a vacuum pump or by minimizing the weight utilizing a brisk stream of liquid, as in Bernoulli's rule. Milling process requires the clamping of the workpiece during machining (Wahab *et al.*, 2018).

Clamping with vacuum innovation is effective and universal. It will enlarge the process reliability when clamping large, flat metal-work pieces with smooth base surfaces on CNC machining centers or conventional machines. Vacuum clamping guarantees very short set-up times. Even parts that are difficult to clamp mechanically are often simply and quickly clamped without the danger of distortion. Besides that, vacuum clamping system also can be used in other materials such as woods, plastics, and non-ferrous metals industries for fast and simple machining. The usually very complicated geometry of parts used in the aerospace industry oftentimes needs the use of clamping solutions matched specifically to the application. Most precision and careful handling of the workpiece are important. With the portable vacuum clamping, it's possible to clamp even very thin workpiece securely without damaging them. Any arguments in favour of vacuum clamping systems are the reduced set-up times andthe high level of flexibility (Ab Wahab *et al.*, 2018). The assorted size and shape allowed vacuum clamping system to be exchanged in very short time and make the facilitating flexible handling of a wide range of workpiece is forms. Vacuum technology is often used in production systems, automation and handling of workpieces as vacuum grippers in a standard design are more affordable compared to competing technologies (Straub *et al*., 2018).

There are advantages in using vacuum clamping which is a high force of holding materials, reduced clamping time, clamping of non-magnetic parts, clamping of thin parts and foils without deformation, a broad range of machining and materials applications. With all these advantages, vacuum clamping could be the best clamping method for general clamping system for different parts and materials. Smart clamping systems improve support and reduce deflections during machining (Delport *et al.*, 2017). Special clamping devices induce high costs which lead to a reduction of the profitability, especially for workpieces with a high complexity and a small number of production units (Klotz *et al.*, 2014).

RESEARCH METHODOLOGY

All the experiment will be carried out in the Jabatan Teknologi Kejuruteraan Pembuatan (JTKP) laboratory at Universiti Teknikal Malaysia Melaka (UTeM). The tools for measurement process also provide by JTKP laboratory. Furthermore, all the data and result will be gathered to perform the analysis and analyse the outcome. Figure-2.1 below shown the overall process flow:

To study the effects of a different cutting parameter on machining performance

The function of this experiment is to define whether this product can hold workpiece better, smooth surface roughness and faster in clamping. This experiment will be conduct on the milling machine at JTKP laboratory. End mill cutter will be used to perform the experiment and using face mill operation. Each experiment, same end mill cutter will be used which is the 8mm diameter and 4 flutes. Three machining parameters are involved in this experiment which is the depth of cut, spindle speed and feed rate. Ten experiments will be done using different spindle speed (Revolution per minutes), 410 RPM, 500 RPM, 580 RPM, 660 RPM, 750 RPM, 830 RPM, 910 RPM, 1000

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RPM, 1160 RPM and 1330 RPM but constant value of the depth of cut is 0.5mm and feed rate is 40mm/min. The length of each experiment will be 50mm and maintain the feed rate at 40mm/min. The workpiece is mild steel with a dimension of 100mmx100mmx1.5mm.

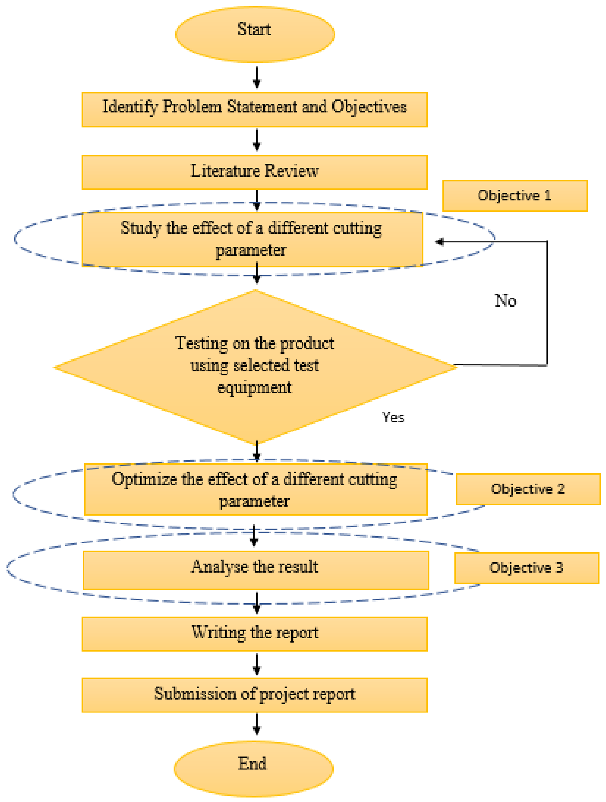

Figure-2.1. Flow chart.

Experiment set up

a) The experiment using a vertical milling machine at JTKP laboratory as shown in Figure-2.2.

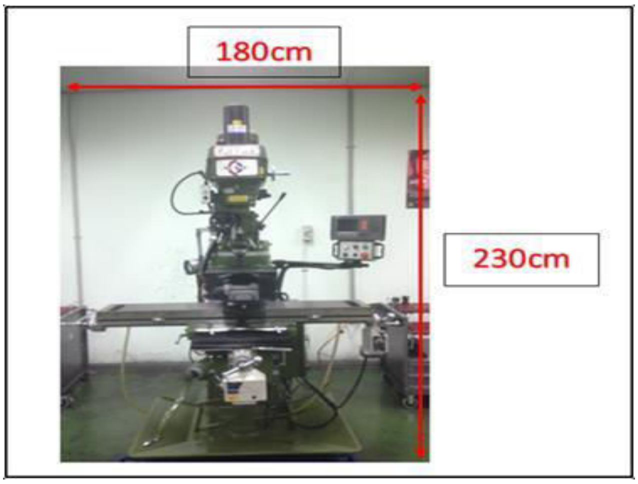

Figure-2.2. Vertical milling machine.

b) Figure-2.3 illustrated that the vacuum clamping will be attached to the milling machine table using bolts and nuts.

c) The sealing cord will be placed on the vacuum clamping based on the size of the material uses.

Figure-2.3. The vacuum clamping on a milling machine.

Figure-2.4. The O-ring sealing cord on the vacuum clamping.

d) The material is mild steel and the dimension is 100mm x 100mm x 1.5mm.

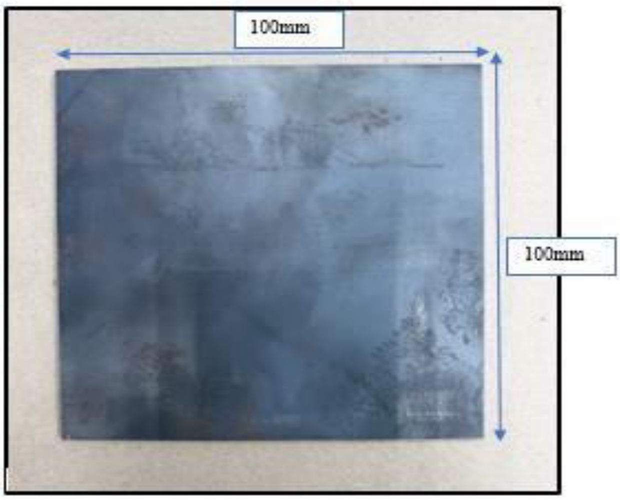

Figure-2.5. The workpiece of the experiment.

e) The end mill cutter as per Figure-2.6 was used for this experiment is an 8mm dimension and 4 flutes. All experiment used the same tooling cutter.

VOL. 15, NO. 5, MARCH 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

To optimize the effects of different cutting parameters on surface roughness and set up time

Two evaluations will be conducted to test the product. There are surface roughness testing and time setting for clamping. The surface roughness, arithmetic mean surface roughness will be analysed using surface roughness machine at JTKP laboratory. The time setting will be compared between vacuum clamping and vice clamping on a milling machine using the stopwatch in the Figure-2.7.

Figure-2.6. End mill cutter.

Figure-2.7. Stopwatch.

METHOD

After machining the workpiece using a milling machine, all the output from the experiments will be analysed using Portable Surface Roughness Tester, Mitutoyo SJ-401 at JTKP laboratory as shown in Figure-2.8.

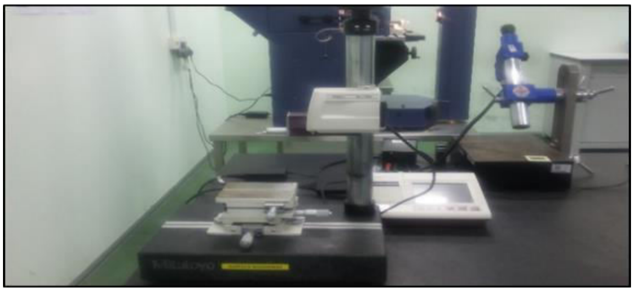

Figure-2.8. Portable Surface Roughness Tester, Mitutoyo SJ-401.

To find out whether the surface is suitable for a certain purpose, roughness is an important parameter. This surface roughness machine will show the measured roughness depth (Rz) and mean roughness value (Ra) in micron (µm). Each experiment will be conducting ten times of measurement of the data. The setting of the machine is 8mm travel length and 0.5mm/s travel speed. All the data obtained from the surface roughness machine tester will be recorded.

For a setup time, two clamping devices will be put on a milling machine for the experiment. The stopwatch will be used to take setup time to compare between two clamping devices. Three times data will be collected for each experiment will be taken.

RESULTS AND DISCUSSIONS

Experimental result of surface roughness

Spindle speed, feed rate and depth of cut are the main parameters affecting the surface roughness. The portable surface roughness tester is required to analyse the arithmetic mean value of this experiment.

Table-3.1. Average of all spindle speed of arithmetic mean value (Ra).

Spindle speed (RPM)	Average of all spindle speed of arithmetic mean value, (µm)
410	**2.311**
500	**2.148**
580	**2.089**
660	**2.038**
750	**1.773**
830	**1.744**
910	**1.627**
1000	**1.816**
1160	**1.839**
1330	**1.888**

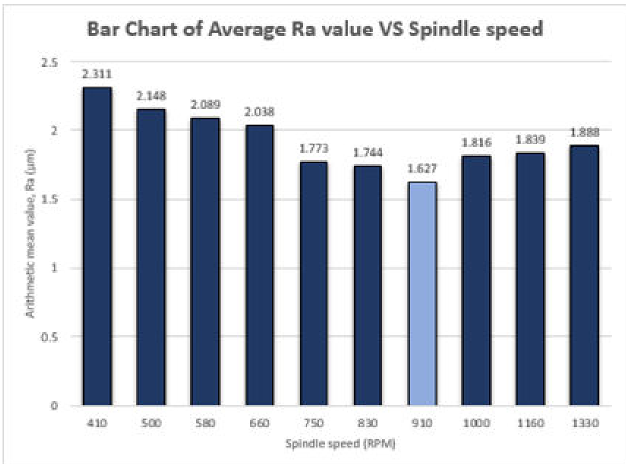

Figure-3.1. Bar chart of comparison between the arithmetic means value and spindle speed.

Table-3.2. The comparison of setup time between conventional vise and portable round shape vacuum clamping.

Reading number	Setup time, sec	
	Conventional vise	Vacuum clamping
1	59.4	12.2
2	50.7	12.6
3	54.7	11.4
4	55.2	13.0
5	51.9	12.3
6	51.6	12.9
7	58.2	11.6
8	54.2	13.2
9	57.8	12.1
10	52.4	12.7
Average	**54.7**	**13.6**

CONCLUSIONS

This research was developed to optimize the round shape portable vacuum clamping and analyse the machining parameter on a milling machine. The objective of this research is to study the effects of a different cutting parameter, optimize and analyse the result of surface roughness. In this investigation of the research, the process was carried out to cut the workpiece of mild steel using the facing operation of the conventional milling machine. The facing operation used end mill cutter of 8mm diameter to cut ten slots of the workpiece with different spindle speed which is 410, 500, 580, 660, 750, 830, 910, 1000, 1160 and 1330. The depth of cut is 0.5mm and feed rate is 85mm/min was the machining parameter that fixes the entire experiment. Next, the ten slots will evaluate the surface roughness using portable surface roughness tester, Mitutoyo SJ-401. This experiment will show that which spindle speed is suitable for machining the workpiece using portable round shape vacuum clamping at 0.5mm depth of cut and 85mm/min feed rate.

Generally, the result of surface roughness proves that the suitable spindle speed for machining is 910 RPM because it has the lowest arithmetic mean value which is 1.627 µm. Over than 910 RPM will increase the arithmetic mean value because of vibration and vacuum pump suction does not support higher spindle speed.

In addition, another experiment was carried to find out which clamping device (conventional vise and vacuum clamping) is faster in term of setup time. The result proved that the portable round shape vacuum clamping is the fastest 13.6 seconds compare with conventional vise which is 54.7.

Based on the finding of this research, the portable round shape vacuum clamping is functional and can be used for one of the clamping devices. It has the fastest setup time compared with the conventional vise. A good clamping system will reduce setup time; improve machining performance and precision on the workpiece.

ACKNOWLEDGEMENTS

The authors would like to thank Faculty of Manufacturing Engineering, Faculty of Mechanical, Mechanical and Manufacturing Engineering Technology and Universiti Teknikal Malaysia Melaka (UTeM) for their support that enabled this work to be carried out through the grant of FRGS/2018/FTKMP-AMC/F00387.

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