Design and Optimization of CNC Milling Process Based on Vibration System Detector Using Particle Swarm Optimization Algorithm Method

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Abstract. Machine maintenance in industry requires speed and convenience, one method is vibration analysis. Engine vibrations cause a pattern of sound emitted by the engine, where the sound of one engine mixes with the sound of another engine. Excessive vibration levels in the engine indicate damage to engine components. If this excessive vibration is not acted upon, the machine will experience more serious damage.In order for it to work optimally, the machine requires maintenance or maintenance. Machine maintenance systems are very important in industry to extend machine life. One maintenance method that is often used is predictive maintenance based on vibration signals. Predictive maintenance is a type of maintenance that can be carried out by monitoring the vibration conditions caused by the machine. One way that can be done to overcome damage to the machine is to analyze the vibration level in the machine in the form of the amplitude value of the vibration speed. This method can predict machine damage based on the vibration signals that arise, so that serious damage can be avoided. The research designed

M. U. H. Al Rasyid and M. R. Mufid (eds.), *Proceedings of the International Conference on Applied Science and Technology on Engineering Science 2023 (iCAST-ES 2023)*, Advances in Engineering Research 230,
https://doi.org/10.2991/978-94-6463-364-1_95

and made a CNC Milling machine prototype which is a combination of two outputs of vibration detection and process optimization. The aim of this research is to find out and determine parameter settings that are able to produce an optimum response. The experimental design used is full factorial, orthogonal array, and response surface methodology, with the optimization methods being back propagation neural network (BP ANN) and particle swarm optimization (PSO) algorithm.

Keywords. CNC Milling; vibration detector; PSO ; BPANN-GA.

1. INTRODUCTION

Machines in industry that have a rotational function often experience vibrations. Engine vibrations cause a pattern of sound emitted by the engine, where the sound of one engine mixes with the sound of another engine (1). Changes in engine vibration will result in changes in the sound patternemitted by the engine

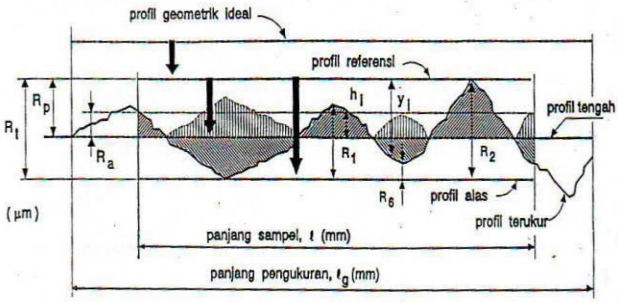
Excessive vibration levels in the engine indicate damage to engine components. If this excessive vibration is not acted upon, the machine will experience more serious damage (2). In order to work optimally, the machine requires maintenance. The machine maintenance system is very importantin industry to extend the life of the machine. One maintenance method that is often used is predictive maintenance based on vibration signals. Predictive maintenance is a type of maintenance that can be carried out by monitoring the vibration conditions caused by the machine (5). One maintenance method that is often used is predictive maintenance based on vibration signals. Predictive maintenance is a type of maintenance that can be carried out by monitoring the vibration conditions caused by the machine. One way that can be done to overcome damage to the machine is to analyze the vibration level in the machine in the form of the amplitude value of the vibration speed.

By measuring the vibration level values, it can be seen whether the bearings on the machine are suitable for use or not (6). Problems or types of machine damage that can be detected based on vibration signals are unbalance, looseness, misalignment and bearing damage. This method can predict machine damage based on the vibration signals that arise, so that serious damage can be avoided.

The CNC operating system uses a program that is controlled directly by a computer. In general, the construction of CNC machine tools and their working system is synchronized between the computer and the mechanic. This CNC milling machine is a machine tool that works on 3 axes X, Y and Z. This CNC milling machine will work according to the pattern of the workpiece drawing that is made and is equipped with a system Control. The control system on this CNC milling machine is a combination of several components that are connected using cables to one another. Several important components contained in the CNC milling machine control system include the computer, breakout board, motor driver, stepper motor and power supply. faster wear rate with applied load.

2. THEORETICAL ANALYSIS

Surface roughness is defined as the irregularity of the surface configuration on an object or plane. This occurs because various deviations occur during the machining process, so that a surface that has a perfect shape cannot be created. The position of Ra, profile shape, sample length and measurement length read by the surface roughness measuring instrument can be seen in Figure



Figur 1. Parameter in Profil roughness (Rochim,2001)

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All mechanical systems have a certain mass and elasticity that is capable of moving relatively, so that almost all machine tool structures will experience vibration. Vibration is a back and forth movement within a certain time interval. Back and forth movement within a certain time interval is called periodic movement. This periodic movement can always be expressed in a sine or cosine function, therefore periodic movement is alsocalled harmonic

An illustration of harmonic periodic motion in the time domain is shown in Figure 1. Displacement is depicted in the vertical direction while time is depicted in the horizontal direction

3. EXPERIMENTAL METHOD ANDPROCEDURE

The experimental equipment used is a CNC Milling machine, accelerometer, power supply, Picotech ADC (analog to digital converter), and computer as well as a surface roughness test. The workpiece used is the SKD 11 tool (300 x 60 x 20) (mm), carbide tool. The process variable is the spindlerotation which is determined: (2000, 3000,4000,5000) (rpm). Depth of cut 0.3 mm, 0.4 mm 0.5 mm. The response variables are vibration level (g.rms) and average surface roughness (Ra) (µm). Vibration measurements are carried out during cutting tests, namely installing two accelerometers (sensors at points A and B) on the workpiece in the x-axis direction (channel A) andin the z-axis direction (channel B) and connecting them to a power supply and ADC (Analog to Digital) Converter), then connected to the computer. Set process variables such as depth ofcut and cross feed speed. Then a cutting test iscarried out on each combination of process variables, until the cutting data is obtained in the form of amplitude which is stored on the computer. The data is processed in mathCAD software to obtain the time domain, then using the formula (fast Fourier transform) the FFT is converted into a frequency domain. The
cutting test scheme to obtain vibration amplitude values can be seen.

Figur 2. experimental scheme

4. RESULTS AND DISCUSSION

The results of the cutting test data arein the form of vibration level amplitude values and surface roughness measurement data. Research experiments were carried out on aluminum material using the CNC process with a Carbide Tool with a diameter of 6 variations in spindle rotation and cutting depth. Results were obtained as shown in Figure 1 forvibration level amplitude data for surfaceroughness data, where for rms (root mean square) vibration calculation data in the time domain the values will be the same as calculations in the frequency domain. For peak and peak to peak vibration calculation data, the time domain is used, where peak amplitude is the maximum value of vibration and peak to peak amplitude is the total amplitude value from the positive point to the negative point of vibration. Examples of vibrations in the time domain and frequency domain in the flat grinding process with cutting depth parameters of 0.3.0.4.0.5 mm and spindle rotation of 2000, 3000, 4000, 5000, 6000 rpm can be seen in the following figure.

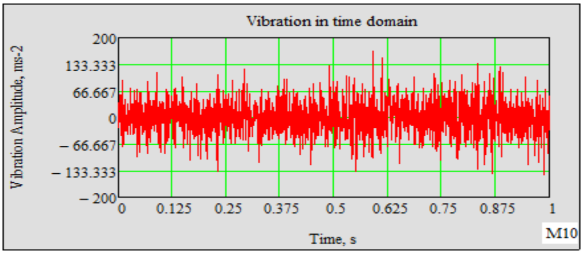

Figure 3. Vibrations in the Time Domai

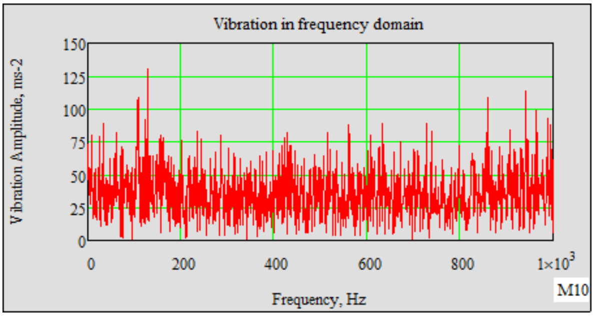

Figure 4. Vibrations in the Frequency Domain

Research experiments were carried out with 4 variations of sp spindle rotation (2000, 3000, 4000, 5000 and 6000) and 3 variations of
cutting depth (0.3, 0.4 and 0.5 mm). From these machining process variables, vibration is then tested and the surface roughness is measured. Data from measurements by the accelerometer are calculated using mathCAD with the formulas for rms, peak and peak to peak on each x-axis and y-axis as follows:

Tabel 1.Data from testing and calculation

Spindel rotation l(rpm)	Dept off cut (a) mm	Amplitudo axis x (A) m/s^2	Amplitudo axis y (B) m/s^2	Ra max. axis x	Ra max. Axis y
2000	a = 0.3	183,7417	188,1417	0,33	0,36
	a = 0.4	286,0418	266,6726	0,43	0,40
	a= 0.5	346,4123	337,6609	0,52	0,48
3000	a = 0.3	242,8280	246,7232	0,55	0,53
	a = 0.4	339,6239	316,7831	0,63	0,64
	a= 0.5	385,3925	403,2435	0,71	0,74
4000	a = 0.3	297,4235	291,2057	0,67	0,69
	a = 0.4	427,7960	360,5500	0,78	0,81
	a= 0.5	459,7460	454,2341	0,89	0,98
5000	a = 0.3	337,6735	325,4557	0,76	0,73
	a = 0.4	492,2763	432,9695	1,05	1,05
	a= 0.5	577,0734	531,1888	1,19	1,16
6000	a = 0.3	422,4194	414,0373	0,96	0,99
	a = 0.4	586,2794	561,3089	1,35	1,22
	a= 0.5	650,0344	592,1781	1,41	1,42

result

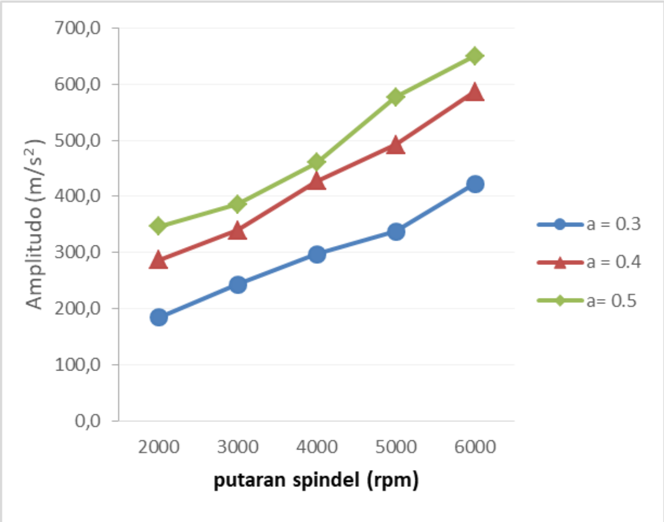

Figure 5. Relationship between amplitude and spindle rotation on peak amplitude in the x axis for cutting depths of 0.3 mm, 0.4mm, 0.5 mm

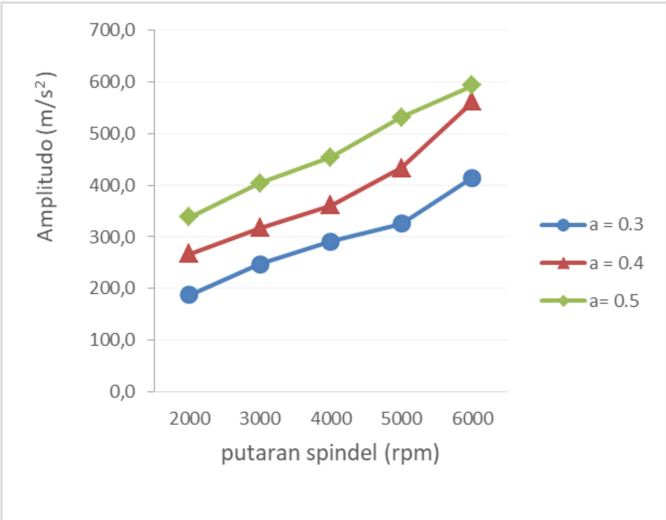

Figure 6. Relationship between amplitude and spindle rotation on peak amplitude in the x axisfor cutting depths of 0.3 mm, 0.4 mm, 0.5 mm

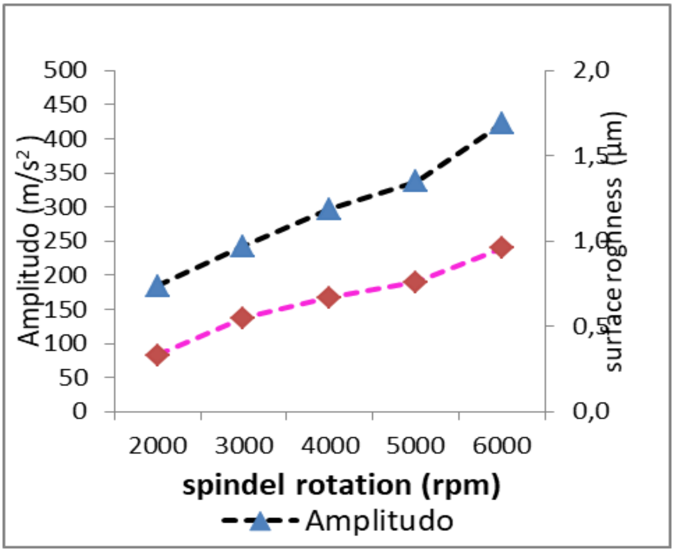

Figure 7. Relationship between amplitude, spindle rotation, and surface roughness on peak amplitude on the x axis for a cutting depth of 0.3mm

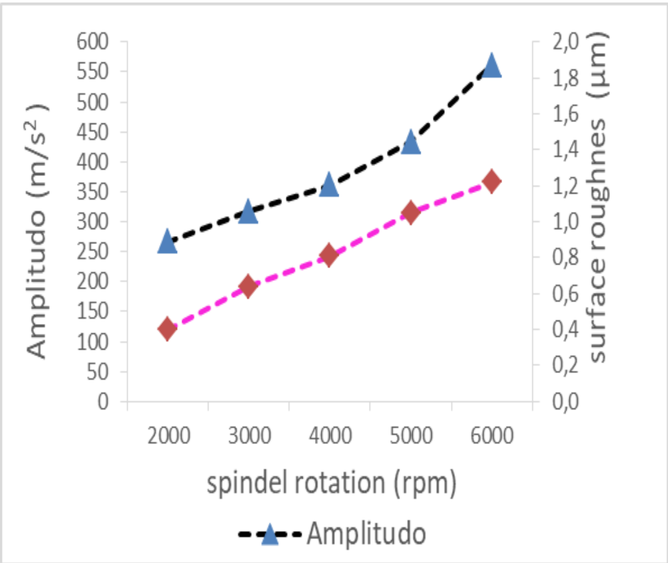

Figure 8. Relationship between amplitude, spindle rotation, and surface roughness on peak

amplitude on the y-axis for a cutting depth of 0.3 mm

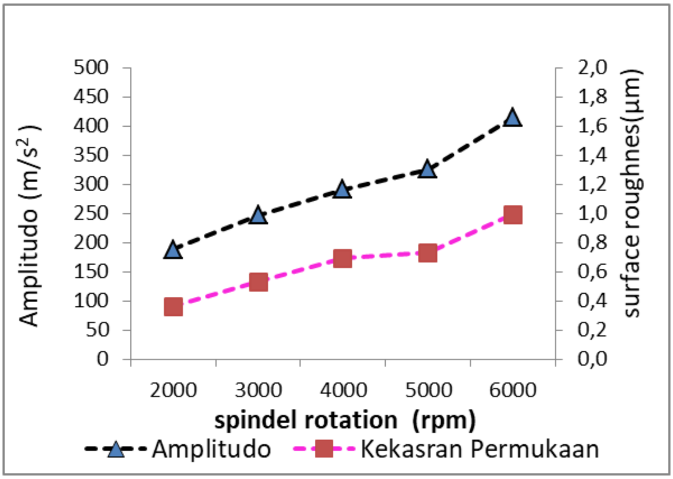

Figure 9. The relationship between amplitude, spindle rotation, and surface roughness on peak amplitude on the y-axis for a cutting depth of 0.4 mm

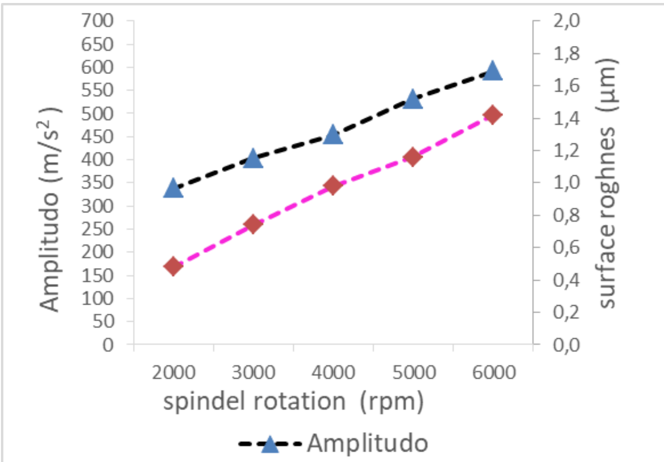

Figure 10. Relationship between amplitude, spindlerotation, and surface roughness on peak amplitude on the y-axis for a cutting depth of 0.5 mm

ACKNOWLEDGMENT

Praise the presence of Allah SWT for all His mercy and grace, so that the author was given the opportunity to complete this research.

The author would like to express his thanks to all parties for all the help, encouragement and dedication that has helped. The author would like to express his thanksto:
Mr.Prof. Dr–Ing. Ir. Suhardjono, M.Sc.who always guides in research
Special to my mother, my wife and mychildren who always pray for me

Friends at the ITS Mechanical Engineering Manufacturing Process Laboratory who study the field of vibration and fellow lecturers at Poliwangi
The author realizes that there are still many shortcomings in writing this research journal.Therefore, the author really hopes for constructive criticism and suggestions. We hope that this journalcan provide benefits and contribute to the advancement of science, especially in the field of engineering and manufacturing systems. Amen

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