International Journal of Advanced Smart Convergence Vol.12 No.1 101-107 (2023)
http://dx.doi.org/10.7236/IJASC.2023.12.1.101

IJASC 23-1-13

Effect Of Cut Depth On Rough Quality And Energy Consumption When Turing Cylindrical With The Pinacho S-90/200 Lathe

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Abstract

Machine tools are widely used in mechanical manufacturing corporations, as well as in engineering courses at universities in Vietnam. The PINACHO S-90/200 lathe is particularly popular. This paper aims to research and select an optimal cutting depth to minimize power costs and ensure surface roughness quality when machining upper plain cylindrical turning products with the PINACHO S-90/200 lathe on C45 steel material.

Keywords: *Pinacho s-90/200 type lathe, Surface roughness, power consumption*

1. Introduction

The equipment, object and scope of the research is PINACHO S - 90/200 lathe, the turning tool used for machining is the external turning tool, the processing material is C45 steel, the turning technology is the outer cylinder turning, the parameters The effect selected for study is the depth of cut (t) on the surface roughness quality and power consumption. Using the method of studying the theory of machining and cutting on lathes. Determine experimental research in machine building to produce the objective function, thereby establishing the correlation between the influence parameter and the objective function. Performing optimization problems to find the reasonable cutting mode of PINACHO S - 90/200 lathe.[1],[2],[3]

The Pinacho S-90/200 lathe is a high performance precision machine tool designed and manufactured by Pinacho, a Spanish company based in Burgos, Spain. The lathe is suitable for a wide range of applications including turning, facing, grooving, threading, and drilling. It is designed with a sturdy construction and equipped with a powerful motor, a precision spindle, and a variety of accessories [4], [5].

The cut depth affects the rough quality and energy consumption when turning cylindrical with the Pinacho S-90/200 lathe in a variety of ways. The deeper the cut depth, the more material that needs to be removed, resulting in more energy being consumed. Additionally, the deeper the cut depth, the more difficult it is to achieve a smooth finish. As a result, the deeper the cut depth, the higher the risk of producing a rough surface finish. Furthermore, the deeper the cut depth, the longer the cutting process will take, resulting in higher energy

Manuscript Received: January. 19, 2023 / Revised: January. 22, 2023 / Accepted: January. 25, 2023
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consumption [6], [7],[8].

Figure 1. Pinacho S-90/200 lathe

Parameters: Motor: 3.7 kW motor; Spindle: 30-2500 RPM; Bed: cast iron; Controls: digital display and control panel; Accessories: a variety of accessories including a 3-jaw chuck, 5-jaw chuck, collet chuck, and a variety of tool holders; Weight: 1,300 kg

Figure 2. Utilized blades and workpieces

The *objectives* of the research are to analyze the effects of the depth of cut (t) on the surface roughness quality and power consumption of C45 steel machined with external turning tool on the PINACHO S - 90/200 lathe. The research method includes studying the theory of machining and cutting on lathes and determining the experimental research in machine building. The research will also cover optimization problems to find the optimal cutting mode of the lathe. The results of the research will provide insights into the optimal cutting modes and parameters for machining C45 steel with external turning tools on the PINACHO S - 90/200 lathe [9], [10], [11].

2. Research parameters

2.1. Factors affecting the objective function

- Group of elements belonging to ingot: The billet used for testing is C45 steel.
- Group of elements belonging to the processing mode:. Is the depth of cut (t)
- Group of elements belonging to the cutting parameters: The cutting speed (Vc)

2.2. Constraints

- The maximum cutting speed (Vc) must not exceed a certain value.
- The depth of cut (t) must not exceed a certain value.

- The feed rate (f) must not exceed a certain value.
- The cutting forces must not exceed a certain value.
- The temperature of the cutting tool must not exceed a certain value

2.3. Calculate and determine the cost of electricity

The *process* of testing and conducting to determine the specific power consumption level through the power change of the cutting process. That is measuring the amperage. To perform the above measurement is as a result of the change of power before and during the cutting process of the blade, from which the power difference is known to convert into non-electrical quantities. [12], [13].

- Before cutting we use capacity

$$N_0=\sqrt{3}\,.I_0.U_0.\mathrm{Cos}\,\varphi_0 \qquad (1)$$

N_0: No-load capacity (W).
I_0: No-load current (A).
U_0: Low voltage network voltage (V).
$\mathrm{Cos}\,\varphi_0$: No-load power factor.

- Power used for cutting process.

$$N_1 = \sqrt{3}\,.I_1.U_1.\,\mathrm{Cos}\,\varphi_1 \qquad (2)$$

N_1: Power Consumption
I_1: The current has the maximum value when cutting.
U_1: Low voltage signal (V).
$\mathrm{Cos}\,\varphi_1$: Power factor under load.

During the experiment, I only conduct the experiment when the voltage is stable. From (1), (2) see.
During the cutting process, the power consumption:

$$N = N_1 - N_0 = U.\sqrt{3}\,.(I_1 - I_0).\mathrm{Cos}\,\varphi \qquad (3)$$

The *cutting* area F is determined with a caliper and micrometer.

Measuring the surface roughness of the product after turning with a MARSURF PS10 roughness meter with computer connection, after machining I use a MARSURF PS10 meter to measure the product surface roughness directly, the roughness value is read on but the LCD screen of the Fluke measuring device, from which we determine the roughness of the product after machining. [14], [15].

3. Experiments and results

The MARSURF PS10 is a user-friendly, portable, computer-connected roughness measuring device that is suitable for measuring the surface roughness of products after machining. It is capable of measuring Ra, Rz, Rq and Rsk values, which are all essential in determining the quality of the finished product. The device features a USB connection for easy data transfer and a large LCD display for easy readings. It also comes with a range of accessories, including a stand and probes

Figure 3. Fluke meter with PC connection

Figure 4. Roughness meter MARSURF PS

3.2. Measurement results

Table 1. Effect of parameters on cutting depth on power cost and roughness; Spindle speed n = 1050 Rounds/min, δ = 75^0, S = 0.3mm/ Rounds

Ordinal number	Depth of cut (t)	Number of times performd	U_t	I_0	I_1	$\cos\varphi_t$	N_t	T (s)	F (m^2)	N_r (Wh/m^2)	Ra
1	0,1	1	227.04	5.71	7.52	0.44	313.18	15	0.002301	567.11	2.96
		2	225.27	5.71	7.53	0.41	291.15	15	0.002301	527.22	2.97
		3	227.29	5.71	7.57	0.41	300.22	15	0.002301	543.64	2.98
2	0,2	1	226.44	5.71	7.47	0.42	289.92	15	0.00234	516.24	1.91
		2	224.49	5.71	7.42	0.43	285.91	15	0.00234	509.09	1.92
		3	226.60	5.71	7.41	0.46	306.92	15	0.00234	542.57	1.88
3	0.3	1	227.71	5.71	7.35	0.44	284.28	15	0.002357	502.54	1.99
		2	226.26	5.71	7.31	0.42	262.66	15	0.002357	464.33	1.98
		3	227.66	5.71	7.32	0.44	277.59	15	0.002357	490.72	2.01
4	0.4	1	224.74	5.71	7.56	0.44	316.86	15	0.002192	602.30	2.15
		2	224.15	5.71	7.62	0.42	311.45	15	0.002192	592.01	2.15
		3	226.02	5.71	7.67	0.46	352.96	15	0.002192	670.92	2.18
5	0.5	1	225.50	5.71	7.74	0.45	356.79	15	0.002192	678.21	2.27
		2	228.92	5.71	7.79	0.44	362.88	15	0.002192	689.78	2.28
		3	227.83	5.71	7.75	0.46	370.30	15	0.002192	703.89	2.29

3.4. Experiment results

After the preparation was completed, we carried out exploratory experiments and replaced the number in formula determined that the Person criterion χ^2_{tt} = 5,34 was smaller than criterion (χ^2_b = 9,49), the data of the experiment obey the normal distribution, replace the number in formula and determine the repeat times for each experiment m = 2.54 taking m = 3.

3.4.1. Evaluation of the power charge due to the influence of the depth of cut parameter (t)

The *experiment* was carried out as follows: Change the t values: t_1= 0.5mm; t_2=1mm; t_3= 1.5mm; t_4= 2mm; t_5= 2.5mm, cutting speed corresponding to the value n = 1050 Rounds/min, cutting angle fixed δ = 75^0, feed rate fixed S = 0.3 mm/round. Experimental results and data processing are recorded in Table 1, using software and data processing program for experimental planning, the following results are obtained:

- *Regressive* mathematical model of electricity:

$$Nr = 548 - 123,12t + 72,951t^2 \quad (4)$$

The *Kokhren* standard calculated value is G_{tt} = 0.283

The *calculated* value of Fisher's criterion is F_{tt} = 3.17

We *check* the uniformity of the variance G_{tt} = 0.283 < G_b = 0.615. with the experimental variance is considered to be the same. Check the compatibility of the model $F_{tt} < F_b$, the model (4) is considered compatible. [4]. According to the results, we draw the correlation graph of the specific power cost and the cutting depth of the figure 5.

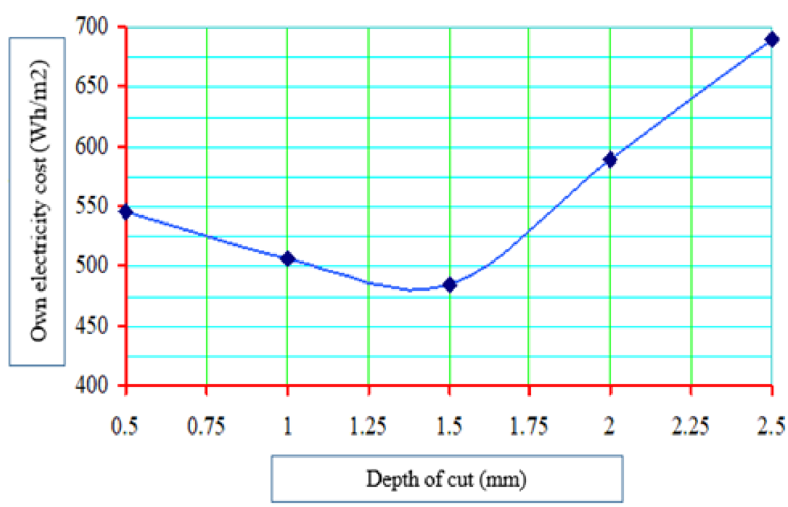

Figure 5. Correlation graph of cutting depth and power cost

3.4.2. Effect on surface roughness due to depth of cut (t)

The *experiment* was conducted as described above, and the experimental results and data processing using software, data processing program yielded the following results:

- *Regression* mathematical model of roughness:

$$Ra = 2,933 - 1,328t + 0,439t^2 \quad (5)$$

The *Kokhren* standard calculated value is G_{tt} = 0,523

The *calculated* value of Fisher's criterion is F_{tt} = 4,69

We check the uniformity of the variance G_{tt} = 0.523 < G_b = 0.615. with the experimental variance is considered to be the same. Check the compatibility of the model $F_{tt} < F_b$, the model (4) is considered compatible. [4]. According to the results, we plot the correlation graph of cutting depth and surface roughness as shown in Figure 6. For cutting depth (t): from regression equations (4), (5) and graphs of Figures 5 and 6, it is found that cutting depth t = 1.3 mm, the specific power costs and roughness are the smallest.

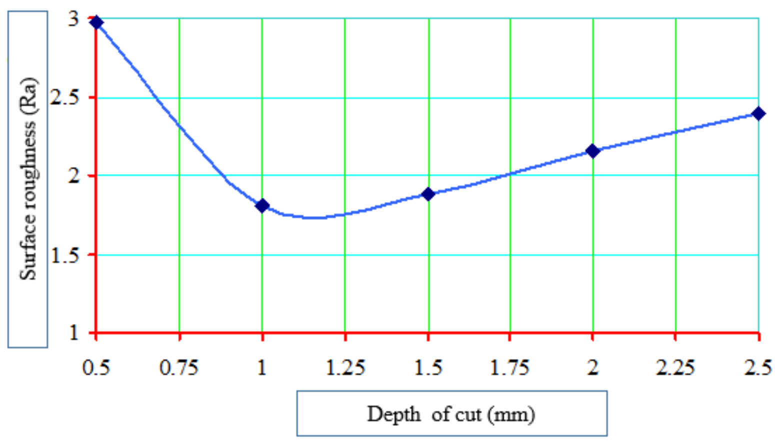

Figure 6. Correlation graph of roughness quality with depth of cut

3.4.3. Experimental convenience according to the optimal mode

After *determining* the optimal usage mode of the lathe, I re-tested the optimal lathe mode calculated in the previous section. The post-processing test results are recorded in the table below. Comparing the error between the experimental value of the power cost of the lathe in the optimal mode with the theoretically calculated value of 4.832%, it can be concluded that the optimal value found is reliable. Comparing the error of experimental value with theoretical calculation of machined surface roughness is 6

Table 2 Test results of shaft turning according to the optimal mode of cutting depth

Numerical order	The goal function	The optimal value is calculated according to the theory	Experimental value according to the optimal mode	Error
1	Nr_{min} (Wh/m^2)	172,094	180,41	4,832%
2	Ra_{min} (μm)	0,816	0,871	6,74%

4. Conclusion

Through *the* analysis and findings of the article, I have drawn some conclusions. Firstly, the focus of this research is on the power cost and surface roughness of the workpiece, and the selection of the cutting depth parameter that affects these objectives. A method has been developed to determine the target functions. Secondly, by utilizing a multi-objective approach to solve the optimization problem, this study has determined the optimal parameters for the Pinacho S-90/200 lathe when turning a smooth shaft with a C45 billet, with a cutting depth of t = 1.3 mm. With the specified turning modes, the processing power cost is as low as N_{rmin}= 172,094 Wh/m^2. Finally, by utilizing a multi-objective approach to solve the optimization problem, this study has determined the optimal parameters for the Pinacho S-90/200 lathe when turning a smooth shaft with a C45 billet, with a cutting depth of t = 1.3 mm. With the specified turning modes, it is possible to confirm that the machined surface roughness is at least R_{amin} = 0,816 μm.

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