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Determination of Reasonable Value Range of Some Parameters When Cleaning Steel with Ultrasonic Assistance

N. Hong Son[1,*], H. Van Nam[1], T. Trung Hieu[1], V. Van Khiem[1], H. Nhu Tan[1], D. Duc Trung[2]
[1]Center for Mechanical Engineering, Hanoi University of Industry, Hanoi, Vietnam
[2]Faculty of Mechanical Engineering, Hanoi University of Industry, Hanoi, Vietnam
* E-mail: nguyenhongson@haui.edu.vn

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ABSTRACT

There are many parameters affecting the amount of removed rust on the steel surface during ultrasonic cleaning. This article presents the experimental study results to determine the value range of some paratmeters of machining process to ensure the amount of removed rust on the steel surface with great value. Tests were performed in two different detergent solution media of without using acid and using acid. The reasonable value ranges of machine power, machining time, distance from steel plate to ultrasonic transducer (called machining distance) and detergent solution concentration have been determined. From the results achieved in this paper, the development direction for the next studies has also been proposed.

Keywords : Steel Surface Cleaning, Ultrasonic Machining, Machining Productivity, Reasonable Value Range

I. INTRODUCTION

For mechanical parts after machining, parts of internal combustion engines and mechanical equipment disassembled for inspection and repair, they will not avoid substances such as oil, grease, dirt adhering to their surface. In these cases, the cleaning step is extremely important, deciding their use quality as well as aesthetics. For complex details in appearance and structure (with many small holes, grooves ...), the cleaning is extremely difficult if using traditional cleaning methods. However, when using an ultrasonic cleaning method, it will not only ensure the required cleanliness but also ensure the safety of parts [1].

Ultrasonic cleaners are highly regarded for its superior cleaning ability thanks to the application of ultrasonic technology. The operating principle of this device is quite simple, mainly thanks to the elasticity of the solvent creating thousands of microscopic air bubbles (bubbles) penetrating deeply into each corner. When these microscopic bubbles burst, they will create a huge energy source that helps to remove all stubborn stains. Another advantage of the ultrasonic surface cleaning method is that there is almost no harm to the quality of object [2]. Besides, this method is also known as the only method that can clean extremely complex or very small surfaces, which are difficult or impossible to do by other methods. The ultrasonic-cleaned product also enables less drying time than other cleaning methods. This technology

can remove most types of materials adhering on the surface of objects such as oil, dirt, rust, fungus, calcification, blood and biological contaminants, etc. [3-5]. A simple example than can be easily seen when the ultrasonic cleaning is more dominant than the cleaning with a scrubbing tool is in necessary case of cleaning uneven surfaces [6].

The process of surface cleaning with ultrasonic assistance consists of the following stage (figure 1) [7]:

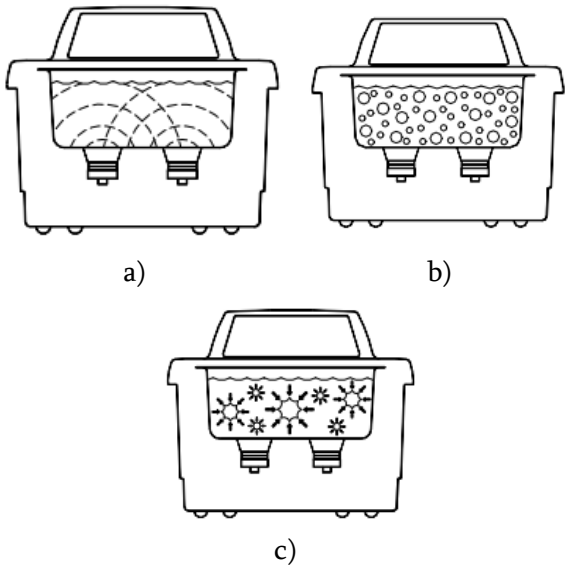

Figure 1. The stages of surface cleaning process [7]

Stage 1: When the ultrasonic waves from the tranducer radiate through the solution in the tank, they cause alternating high and low pressures (Figure 1a).

Stage 2: During the low pressure phase, millions of microscopic bubbles form and develop. This process is called Cavitation, which means “Formation of bubbles” (Figure 1b).

Stage 3: During the high pressure phase, the bubbles deflate or “explode”, releasing a large amount of energy. These explosions behave like a huge number of tiny air jets at very high speeds and energies. They work in all directions, attacking all surfaces to remove the rust on the surface of objects (Figure 1c).

There are many parameters affecting the cleaning effect of ultrasonic cleaning process such as ultrasonic frequency, size and shape of the object to be cleaned; size and shape of tank; type of used ultrasound transducer, solution cleanliness, solution temperature, solution concentration, etc. [8, 9].

In this paper, we will conduct the tests to determine the value range of some parameters of machining process to ensure the amount of removed rust with great value.

II. TESTING PROCESS

The cleaning equipment used in this study is the cleaning tank as shown in Figure 2. The internal length, width and height of the tank are 700 mm, 400 mm and 400 mm respectively. Materials of the tank (pot) are made of stainless steel to ensure that it is not affected by chemicals in cleaning solution [10], [11]. The power source with ultrasonic frequncy is provided by an ultrasonic generator with a frequency of 40 KHz, which has the notation of AC220V50Hz +/- 10%. The ultrasonic transducer cluster used in this study is the transducer cluster with 32 IBL-type transducers.

Figure 2. Testing process

The testing process was performed on steel samples with their length, width and thickness of 96 mm, 96 mm and 2.5 mm respectively. The acid used in this study is H_3PO_4 type.

Micro-electronic balance, type AJ203 with number 140211043 (by Shinko Denshi Company – Japan) is used to determine the amout of removed rust. This balance is capable of weighing a maximum of 200 (g), with an accuracy of 1/1000 (Figure 3). The solution temperature is determined with a thermomerter called TP 101 (also known as thermometer TP 101). This device is capable of measuring temperatures in the range of $50^o \div 300^o$ with an error of $\pm 1^o$.

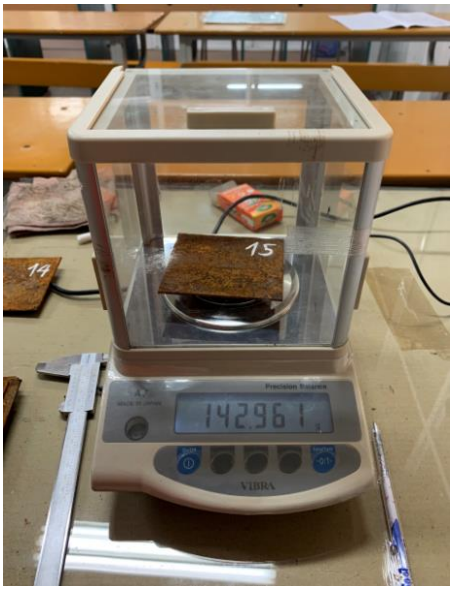

Figure 3. Micro balance AJ203, No. 140211043

The testing process is as follows:

- Step 1: Weigh the mass m_1 of steel sample before testing.
- Step 2: Conduct the Test in accordance with the value of input parameters.
- Step 3: Weight the mass m_2 of the sample after the test (the testing sample is weighed after it is dry).
- Step 4: Determine the amount of removed rust by the formula $m = m_1 - m_2$.

III. TESTING RESULTS AND DISCUSSION

A. Without using acid

Conduct the test of steel surface cleaning process when changing the value to determine the influence of machining time (T) to the amount of removed must (m). During the test, the values of other parameters were fixed as follows: Temperature t = 70^o C, machining power Q = 50%, distance from ultrasonic transducer to the parts L = 250 mm. In Figure 4, it shows the graph of the influence of T on m. From this figure, it shows that:

- When the machining time increases from 5 minutes to 30 minutes, the amount of removed rust will also increase but very slowly.
- When the machining time increases from 5 minutes to 30 minutes, the amount of removed rust will also increase and a slightly faster rate.
- When the machining time increases from 50 minutes and above, the amount of removed is almost unchanged.
- The amount of removed rust is of great value when machining over the period of 30 to 50 minutes.

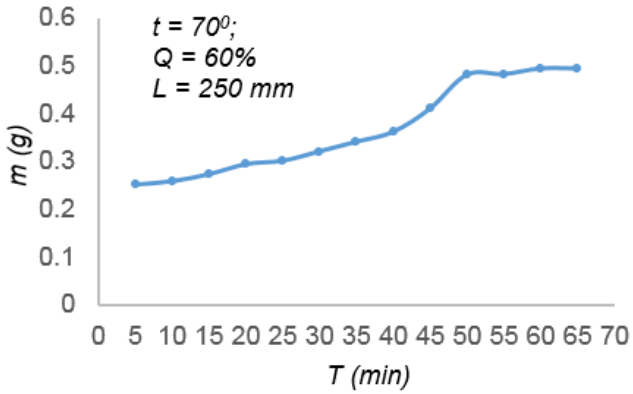

Figure 4. The influence of the machining time on the amount of removed rust without using acid

Conduct the test to determine the influence of machine power (Q) on cleaning performance. During the test, the values of parameters were fixed as follows: Temperature t = 70^o C, time T = 50 minutes, distance L = 250 mm. In Figure 5, it shows the graph

of the influence of machine power Q on cleaning mass m. From the graph in this figure, it shows that:

- When the machine power Q increases, the amount of removed rust *m* also increases. Whereas, when Q increases from 25 to 30%, *m* increases rapidly, when Q incrases from 30% to 60%, *m* also increases, with at a slower rate, when Q incrases from 60 to 70%, *m* increases rapidly. When the power Q > 70 %, increasing Q will make *m* increase at very slow rate.
- In order for the amount of removed rút to have a great value, the machine power should be selected in the range of 60 to 70%.

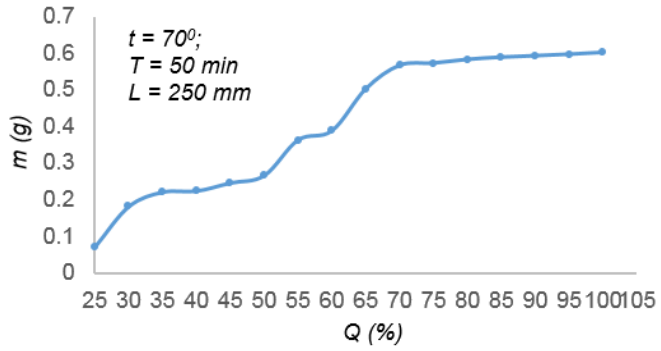

Figure 5. The influence of the machine power on the amount of removed rust without using acid

Conduct the test to determine the influence of distance from ultrasonic transducer to machining parts on cleaning performance. During the test, the values of parameters were fixed as follows: Temperature: 70° C, time: 50 minuts, machine power: 70%. In Figure 6, it shows the graph of the influence of machining distance on cleaning mass. Observing this figure, it shows that when the machining distance L increases from 50 mm to 300 cm, the amount of removed rust will increase at a slow rate; when L increases from 300 mm to 350 mm, the amount of removed rust will decrease slowly. The m value has a great value corresponding to L = 250 ÷ 350 mm.

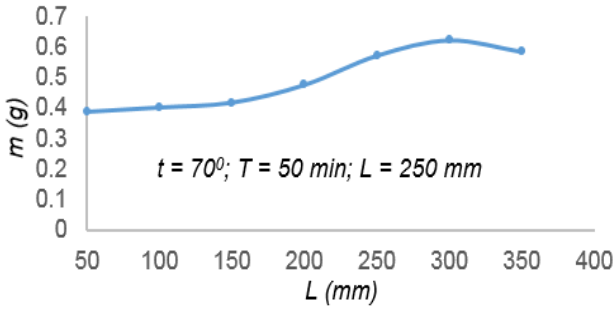

Figure 6. The influence of the machining distance on the amount of removed rust without using acid

B. Using acid

Conduct the test to determine the influence of machining time on the amount of removed rust. During the test, the values of parameters were fixed as follows: Temperature: t = 70° C, machine power Q = 50%, distance from ultrasonic transducer to parts L = 250 mm; acid solution concentration C = 0.4%. In Figure 7, it shows the graph of the influence of T on *m*. Observing this figure, it shows that:

- When the machining time increases from 0.5 minutes to 1.5 minutes, the amount of removed rust will also increase but quite slowly.
- When machining with the time from 1.5 minutes to 2 minutes or more, the amout of removed rust will increase rapidly
- When machining with the increased time from 2 minutes to 3 minutes, the amount of removed rust will also increase slowly.
- When the machining time increases from 3 minutes or more, the amount of removed rust is almost unchanged.
- In a period of 3 to 5 minutes, the amount of removed rust has a relatively large value.

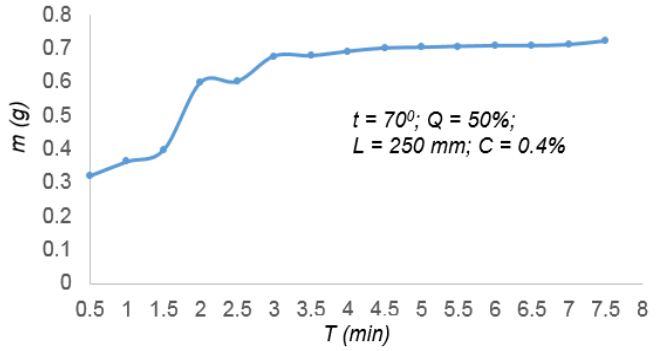

Figure 7. The influence of the machining time to the amount of removed rust using acid

Conduct the test to determine the influence of machine power on cleaning performance. During the test, the values of parameters were fixed as follows: Temperature: t = 60° C, time: T = 3 minutes, distance: L = 250 mm. In Figure 8, it shows the graph of the influence of machine power Q on cleaning mass m. From the graph in Figure 8, it shows that

- When the machine power Q increases from 25% to 30%, m will increase quite rapidly.
- When the machine power Q increases from 30% to 50%, m is almost unchanged.
- When Q increases from 50% to 55%, m increases very quickly.
- When Q exceeds 55%, m is almost unchanged.
- In order for the amount of removed rút to have a great value, the machine power should be selected in the range of 60 to 70%.

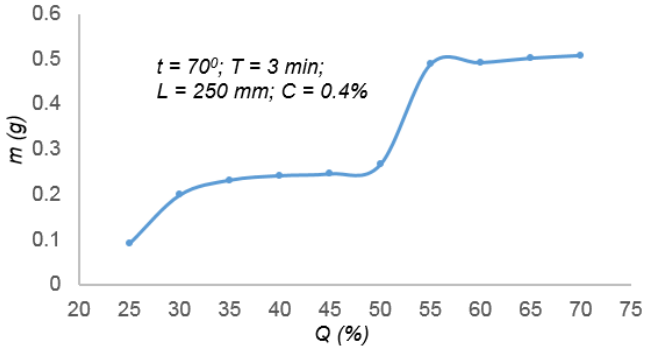

Figure 8. The influence of the machine power on the amount of removed rust using acid

Conduct the test to determine the influence of machining distance on cleaning performance. During the test, the values of parameters were fixed as follows: Temperature: t = 60° C, time T = 50 minutes, machine power: Q = 70%. In Figure 9, it shows the graph of the influence of machining distance on cleaning mass. Observing this figure, it shows that:

- When the machining distance increases from 50 mm to 150 cm, the amount of removed rust is almost unchanged.
- When the machining distance increases from 150 mm to 300 cm, m will increase. However, if L continues to increase, m will decrease. Correspoding to L equal to 250 – 350 mm, m has a great value.

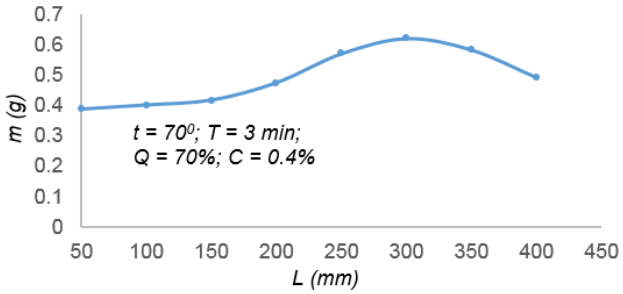

Figure 9. The influence of the machining distance on the amount of removed rust using acid

Conduct the test to determine the influence of solution concentration on cleaning performance During the test, the values of parameters were fixed as follows: Temperature: t = 60° C, time T = 4 minutes, machine power: Q = 70%. In Figure 10, it shows the graph of the influence of solution concentration on cleaning mass. From the results in Figure 10, it shows that: When the solution concentration increases from 0.5% to 0.4%, *m* will increase rapidly. However, if the solution concentration continues to increase, *m* tends to decrease. In the range of C = 0.3% ÷ 0.5%, *m* has a relatively large value.

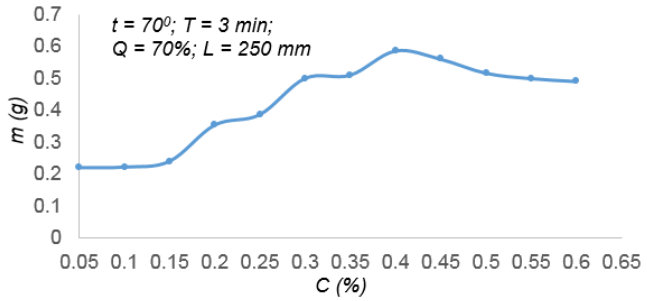

Figure 10. The influence of t he solution concentration on the amount of removed rust using acid

IV. CONCLUSION

Ultrasonic steel surface cleaning process was performed in this study. Tests were performed when changing some parameters of machining process to investigate the change of the amount of removed rust on the steel surface. The tests were performed in two different solution types of without using acid and using acid. From the testing results, it is determined that:

- When not using acid in the detergent solution, if you want to have a great value of rust removal productivity on the steel surface, you should select the machining time of 30 to 50 minutes, the machine power of 60 to 70% and the machining distance from 250 to 350 mm. If using acid in the detergent solution, it is necessary to machine within 3 to 5 mintues, the machine power of 60 to 70%, the machining distance of 250 to 350 mm and the solution concentration from 0.3 to 0.5%

- This study only conducted the testing process when changing each input parameter. Machining productity is only subject to the change of each parameter, but also subject to the simultaneous influence of parameters as well as the interaction between input parameters. We will address in the next study to clarify the limitations that this study has not yet carried out.

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