***JEMMME,*** *Vol.3, No. 2, November 2018*
ISSN 2541-6332
e-ISSN 2548-4281

# Effect of Pipe Cutting Gap using CNC toward Surface Hardness

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***Abstract***

*This research concerned the standard value of surface roughness on Computer Numerical Control (CNC) to obtain fine pipe cutting result and is more useful for company to simply recognize the appropriate standard gap in designing. Standard design used is 30 mm with 3 specimen variations and variation gap value of 42 mm, 44 mm, and 46 mm. In recognizing fine refinement, standard on Roughness Average (RA) is used with surface roughness scale tool. Based on the experiment, it shows that gap design for pipe with Computer Numeric Control (CNC) in 30 mm has less optimum result because its cutting result still has crust, the gap is still considered too close. Therefore, re-grinding was conducted to result smoother result in achieving surface roughness value of 32RA. Fine pipe result without crust is 46 mm with roughness value of 4 RA. The smaller value obtained from measuring surface roughness, the more optimum result obtained.*

***Keywords****: Gap; CNC; pipe cutting*

## 1. INTRODUCTION

One of material processing in industry is cutting. Conventionally, cutting process could be conducted with lathe, milling machine, grinding machine, and so forth.[1] Besides, non-conventional process also could be conducted by utilizing technologies such as Computer Numeric Control (CNC), Laser Beam Machining (LBM), Plasma Arc Machining (PAM), Abrasive Jet Machining (AJM), Ultrasonic Machining, Chemical Machining, Electro Chemical Machining, Electro Discharge Machining, Ion Beam Machining, and more. [2]

Recently, piping has rapidly growth as it is one of important material for hotel roof, dwelling, airport, and tower. In this modern era, heavy equipment construction builds infrastructure or tower using pipe profile. Yet, cutting uses CNC pipe is still minimum as in CNC pipe system there are complicated steps from design to NC/CNC that furthermore is applied to cut pipe profile.

In construction company or fabrication, most of the labors are more choosing coping/notching pipe by using manual pipe cutting machine and it is indirectly needs longer time and cutting result still has rough surface. Therefore, it needs further treatment to smoothen the surface. Meanwhile, using Computer Numeric Control (CNC) pipe is saving time and obtained result is satisfying and efficient.[3]

There are different forms in chamfer program of CNC cutting pipe such as minimum cutting angle and maximum cutting angle. Contour (form) of specimen is in variance depending on the requirement and design adjustment.

Gap is the term for distance on Computer Numeric Control (CNC) design where workpiece converge in the same standard distance within all angles. It is as differentiator between material and waste material and is as displacement of pipe torch cutting axis on Computer Numeric Control (CNC). The gap, eventually, has important role for pipe cutting result, gap standard is 30 mm for minimum measurement and 50 mm for maximum. [4]

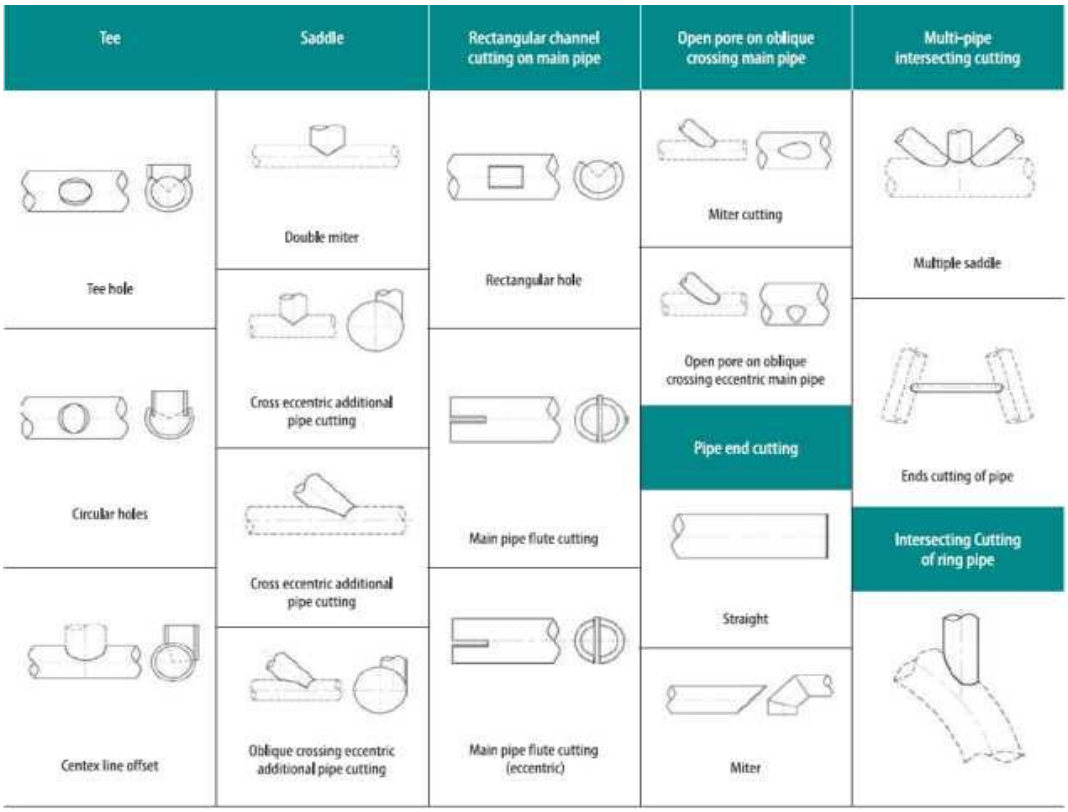



*Figure 1.1 Specimen design & program CNC cutting pipe*

An ideal geometric characteristic presented in fine surface. [5] Practically, it is almost impossible to obtain fine cutting result on object surface. As there are factors to result crust on cutting result, for instance, human factor (operator) and machine used to conduct the process.[6] [7]

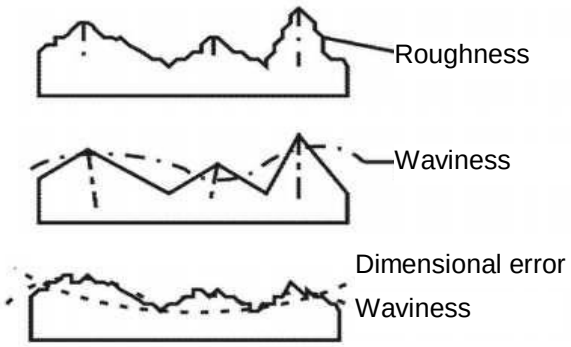



*Figure 1.2 Roughness, waviness, and dimensional error of surface*

## 2. METHODS

Initial process of CNC cutting pipe is determining graphics for pipe contour to be processed. As graphical user interface facilitates the engineer to operate machine easily. Operators, subsequently, set up the parameters of the pipe and select the desired profile with the aid of graphic displays. This allows the operator controlling the machine for cutting process based on programmed NC code.

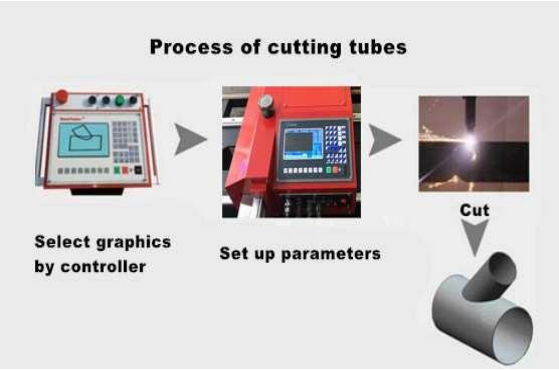



*Figure 2.1 Process of cutting pipe*

*Figure 2.2 CNC pipe cutting process with torch*

Independent variable used in this research is gap variation (material gap) on CNC design and for dependent variable is measurement on surface roughness. It is determined by using surface roughness tester. Each component surface has different form and variation in terms of structure or result of its production process. Roughness is defined as irregular surface form as a result of production process by machine. Roughness value stated in Roughness Average (RA). RA is roughness parameter mostly used in testing roughness surface.


*Figure 2.3 Surface Roughness Scale*

**Calculation for process time (Facing)**

$$t_h = \frac{\pi \cdot d_e \cdot L \cdot i}{v_c \cdot f} \quad (1)$$

th = Machining time [s]
de = Cutting diameter [mm]
L = Length of cut [mm]
i = Number of cutting
f = Feed rate [mm]

$$L = \frac{d - d_1}{2} + l_a \quad (2)$$

$d_1$ = Inner diameter [mm]
la = length before cut [mm]

## 3. RESULT AND DISCUSSION

Subsequent to the result of conversion from NC to CAD, design built as the reference for program with the dimension and material length determined by engineer. The existing gap design of 30 mm for cutting pipe is modified into 3 variations of gap design i.e. 42 mm, 44 mm, and 46 mm. Those gaps determined to obtain standard value in adjusting gap position in CNC (computer numerical control) design layout.

Further test is measurement to find out the fineness of surface. Result of fine surface after cutting tried to be achieved with minimum standard of gap design in 30 mm. Furthermore, variation of 42 mm, 44 mm, and 46 mm gap used to find out the influence of different gap design on cutting result.

Cutting result on Figure 3.1 used 30 mm gap. Countour of cutting result shows defficiency on surface cutting. It has more rough result and tends to require re-grinding to have fine flat surface with roughness value of 32 RA.

*Figure 3.1 Cutting result with 30 mm gap*

### 3.1 Cutting result with 42 mm gap variation

First variation design is 42 mm gap for 12 meter pipe length with 141 mm diameter and 6.5 mm thickness. It is as depicted on Figure 3.2.

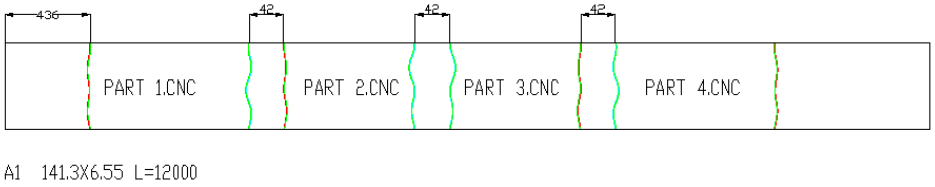



*Figure 3.2 Variation gap design of 42 mm*

As ilustrated in Figure 3.3, it is the cutting result used 42 mm gap. It shows smoother contour than standard gap. The roughness value of surface shows the number of 8 RA.

*Figure 3.3 Cutting result with 42 mm gap*

### 3.2 Cutting result with 44 mm gap variation

The second gap design variation is 44 mm with 12 meter pipe length. Pipe diameter is 141 mm with thinkness plumbing pipe is 6.5 mm. Figure 3.4 shows the design with 44 mm gap.

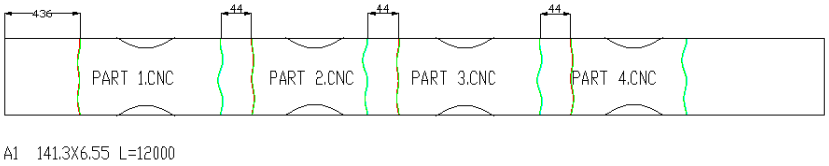



*Figure 3.4 Variation gap design of 44 mm*

Cutting result on Figure 3.5 shows contour surface of 44 mm gap. It is smoother than using standard gap. Roughness value of the surface is 16 RA.

*Figure 3.5 Cutting result with 44 mm gap*

### 3.3 Cutting result with 46 mm gap variation

Design modification on the third variation is 46 mm gap for 12 meter pipe length with 141 mm diameter and 6.5 mm plumbing pipe thickness. Figure 3.6 shows the design with 46 gap.

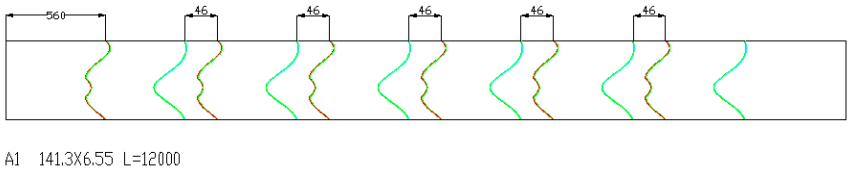



*Figure 3.6 Variation gap design of 46 mm*

Cutting result on Figure 3.7 shows the contour surface on 44 mm gap. It is smoother than using standard gap. Its roughness value shows 4 RA.

*Figure 3.7 Cutting result with 46 mm gap*

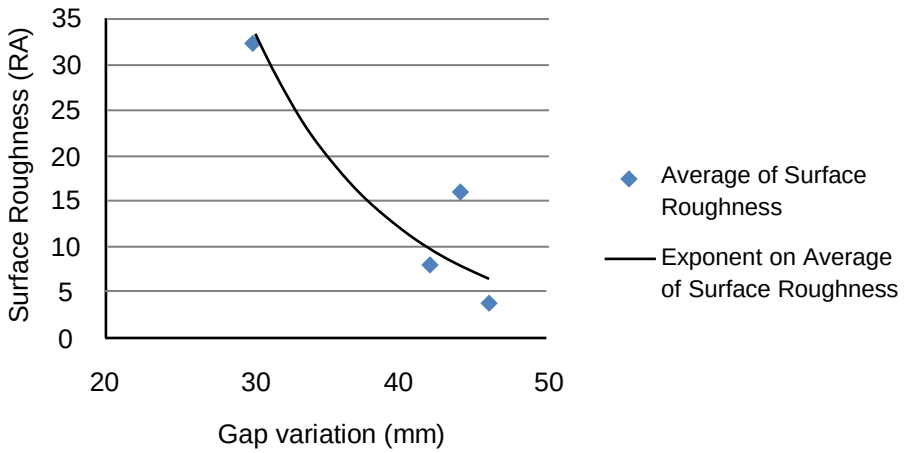
### 3.4 Comparison on cutting result with gap variation

Table 3.1 shows the result of all comparisons between variations.

*Table 3.1 Comparison on roughness with gap variations*

| Gap variation (mm) | Surface Roughness (RA) First angle | Second angle | Third angle | Average of Roughness |
|---|---|---|---|---|
| 30 | 32 | 32 | 32 | 32 |
| 42 | 8 | 8 | 8 | 8 |
| 44 | 16 | 16 | 16 | 16 |
| 46 | 4 | 4 | 4 | 4 |

Based on the above table, the following is graphic of the comparison of all variations. It is as depicted by Graphic 3.1.




*Graphic 3.1 Surface roughness value with gap variation*

Graphic 3.1 shows that surface roughness would be decrease by the wider gap between torch and pipe surface cut. It is caused by the wider gap, the more optimum of torch heat to cut and to damage the surface.

## 4. CONCLUSION

The result of CNC design analysis shows that the wider gap, the smaller surface roughness value. It explains that obtained value will be better for the average of surface roughness.

The obtained result of CNC cutting with 30 mm gap shows less fine contour and need re-grinding process on the surface to have smoother result. Furthermore, 46 mm gap for pipe cutting is to obtain good result on surface roughness. This gap gives lower roughness value than 30 mm, 42 mm, and 44 mm gap.

Gap tolerance in 42 mm for minimum is appropriate as by less than this gap, result of cutting contour has melt crust because of torch heat during cutting and it would need re-grinding to smoothen the surface.

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