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# THE EFFECT OF THE PULSE CURRENT IN WIRE ELECTRIC DISCHARGE MACHINE ON MEASUREMENT ERROR TOWARD ALUMINUM ALLOY: AN EXPERIMENTAL STUDY

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**Abstract**

This research investigates the measurement error on Wire EDM cutting products to find the pulse current's problem-solving. One of the machining parameters that affect the precision of Wire EDM is the magnitude of the current. The experimental study carried out by using the pulse current started from 4-Ampere up to 8-Ampere as the research parameters. A chamfer dimension on 6061 Aluminum alloy was investigated with the gd&t method with ISO 5459 and ISO 1101 standard. Statistic method applied and processed on Minitab with Shapiro-Wilk parameter for normal distribution. These experimental studies have a normal distribution that finds the phenomena of 8-Ampere of pulse current generate a large measurement error. Furthermore, in these experimental studies, the usage of a Profile Projector generates a massive measurement error, up to 64.5% compared with CMM. A strong commitment to calibrate the Profile Projector up to date to maintain the machining quality.

**Keywords:** WEDM, Pulse Current, Aluminum 6061 Alloy, GD&T.

## 1. Introduction

Wire Electric Discharge Machine (WEDM) is a non-conventional cutting machine. Using wire supplied with an electric current in, it can do the cutting process with various metal types. This machine usually uses to obtain high precision and highly complicated products [1].

Wire Electric Discharge Machines have different parameters in terms of pulse current, feed rate, and pulse frequency. The Parameters that are influencing the dimensional results are current or pulse current [2]. The more significant of the current flowing, the dimensional precision of a product decreases. It must choose the right type of current and pay attention to the type of material used [3].

This study explained the effects of various kinds of electric currents on the dimensions of an aluminum part and determining the right parameters in working on the product on the Wire Electric Discharge Machine. Furthermore, a comparison of each product's dimensions has been processed with current magnitude 4-Ampere, 6-Ampere, and 8-Ampere. A heat generated by low pulse current with a diameter of 0.2 mm brass wire, with a 2 mm/min feed-rate on 6061 Aluminum Alloy produced the smooth cutting surface and minimum of MRR [4].

According to Geng, a corner-cutting system for an aluminum product with the radius corner-profile is used to vary the finished product's shape. An optimizing method is applied to get the corner-angle cutting quality with the product [5]. Kandpal, investigate the surface quality of 6061 on SEM and

EDX that MRR, tool wear rate, surface roughness, and overcut increase in pulse-on time and peak current [6]. Furthermore, according to Wilujeng, an aluminum 6061 alloy have a ductile and lightweight that has a strong correlation of surface roughness with geometric tolerance [7].

This study aims to investigate the measurement error caused by the pulse current variations on Wire Electric Discharge Machine on the dimensional accuracy of aluminum products using references with ISO 5459 and ISO 1101 standards as a geometric and dimensioning tolerance (GD&T) method with CMM (Coordinate Measuring Machine) [8] and TMS (Topography Measuring System) [9]. It indicates that the higher the pulse current, the higher the value of cutting edge on the aluminum part dimension, which means that the precision level is getting out of tolerance.

## 2. Research Method

The Wire EDM used in this study is a Sodick Wire Electric Discharge Machine (LN1W), with wire diameters of 0.2 mm. The wire electrode used is Brass with a diameter of 0.2 mm, with a 2 mm/min [4].

An Aluminum 6061 Alloy with 10mm thickness used to investigate the corner shape, chamfer, dimension. The measurement error on the chamfer dimension represents the Wire EDM axis's maintenance issues.

The measuring device with the touching method is CMM (Coordinate Measuring Machine), Mitutoyo Crysta-Plus M443. That metrology measuring machines can produce coordinates with ±3µm accuracy in three-dimensional structures with mutually perpendicular axes to each other [10].

Furthermore, TMS (Topography Measuring System) or well known as a Profile Projector, Nikon DP-303 Data Processor, used to be investigated by using the visual method. This visual measuring method can generate the dimension with ±25µm accuracy in a two-dimensional layout [11].

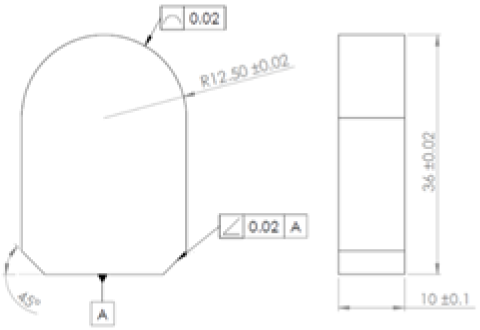



**Figure 1. Detail Drawing of a 6061 Aluminum Part**

The drawing prepared (Fig. 1) according to ISO 5459 standards and ISO 1101. ISO 5459 is geometrical tolerancing that describes the datum system [12]. ISO 1101 is Geometrical tolerancing describes tolerance of form and orientation [13]. The geometrical tolerance was applied to detail-drawing about 20µm.

The design of the experiment generated from two-level of measuring devices and three-level of pulse current parameters. The measurement data took eight times for a single form of the specimen.

A normality test established to get the data distribution on the normal shape or not. The Shapiro-Wilk test is the most popular normality test with a total population of less than 50. This experimental study uses the alpha significance level of 5%, which means data is declared to be normally distributed if the significance value is more than 5% (Sig.>0.05). One of the formulae that can use to measure the validity of them is the Shapiro-Wilk's equation.

## 3. Result and Discussion

The normality test carried out using the Shapiro-Wilk test found in the Minitab program. $H_0$ rejected if the p-value is smaller than $\alpha = 0,05$.

Figure 2 shows that the data spread around the diagram and follows a regression model to conclude that the processed data normally distributed data so that the normality test.

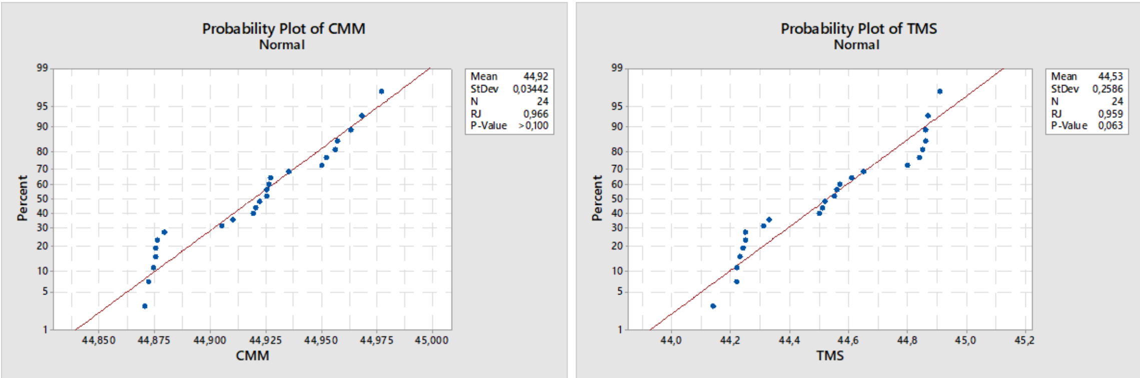
Figure 2 (a) shows that the measurement results using CMM, then carried out the Shapiro-Wilk test, obtained P-Value larger than 0,1, which means higher than $\alpha = 0,05$. Therefore, it can be concluded that $H_0$ is accepted.

Figure 2 (b) shows that the Profile Projector's measurement results then carried out the Shapiro-Wilk test and obtained a P-Value of 0,063, which means higher than α 0,05. Then, it can be concluded that $H_0$ is accepted.

Figure 3 shows that the data spread using the box plot. The measurement results on the pulse current parameter of 4 Amperes, using CMM, has a standard dev value of 0.0153-deg and a mean value of 44.956-deg. While the measurement results using Profile Projector have a value of std dev 0.0789-deg and a mean value of 44.830-deg. Using both CMM and Profile Projector measurement methods, the chamfer dimension is accepted, and the minimum dimension level is 44.800-deg.

The measurement results on the pulse current parameter of 6 Amperes, using CMM, have a standard dev value of 0.00725-deg and a mean value of 44.923-deg. While the measurement results using Profile Projector have a value of std dev 0.0298-deg and a mean value of 44.519-deg. Using CMM measurement methods, the chamfer dimension is

accepted, and the minimum dimension level is 44.800-deg. However, the chamfer dimension from Profile Projector measurement methods is rejected, and the result is lower than 44.800-deg.




**(a)** **(b)**

**Figure 2. Normality test of (a) CMM data, (b) TMS data**

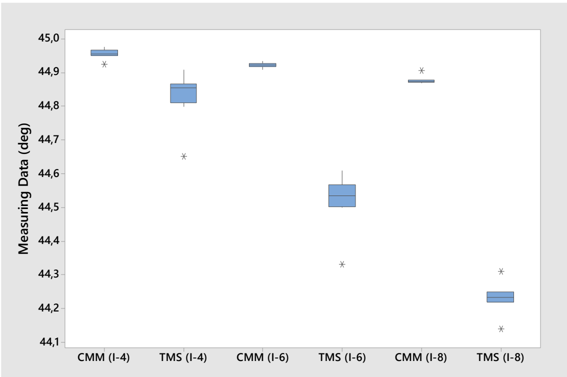



**Figure 3. Box plot data of CMM data and TMS data**

Furthermore, the measurement results on the pulse current parameter of 8 Amperes, using CMM, has a standard dev value of 0.00394-deg and a mean value of 44.878-deg. While the measurement results using Profile Projector have a value of std dev 0.0167-deg and a mean value of 44.233-deg. Using CMM measurement methods, the chamfer dimension is accepted, and the minimum dimension level is 44.800-deg. However, the chamfer dimension from Profile Projector measurement methods is rejected, and the result is lower than 44.800-deg.

The difference in measurement results between CMM and Profile Projector at 4 Ampere variable pulse current is 12.6%. For a pulse current of 6 Amperes, the difference in measurement results is 40.4%. Whereas for a pulse current of 8 Amperes, the difference in measurement results is 64.5%. It happens as an outcome, the pulse current value increases. The heat source then produced a high value of MRR, and it has rough surface quality [6].

Afterward, ISO 5459 and ISO 1101 standards ultimately passed. Consequently, the center's angularity with the corner edge reached the minimum level of the chamfer dimension 0.020-deg while using CMM. On the other hand, Profile Projector has a large measurement error and increases the pulse current. It arises as an outcome of Profile Projector using a visual method that has less accuracy than the touching method by the CMM probe. Simultaneously, measure a rough surface due to a large pulse current—furthermore, the last calibration of Profile Projector since 2016.

The pulse current effect based on the CMM and Profile Projector data shows there is no correlation between the measurement data and the WEDM axis. As an outcome of those three-pulse current setting parameters, it has been accepted on the CMM method. On top of that, the maintenance activity should be done along their timeline period; it can preserve the WEDM machining quality.

## 4. Conclusions

The measurement result on 4 Ampere of pulse current has the best result of the machining process that generates a 44.956-deg as mean value with CMM. It has a 12.6% measurement error with Profile Projector. For the next plan, the Profile Projector should re-calibrate to meet the industrial requirement.

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