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INTEGRATION SYSTEM OF CAD/CAM IN MACHINERY PROCESS USING WIRE-EDM

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Abstract

Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) are usually used to draw sketches and model manufacturing work processes on machines that operate using computer numerical control (CNC). To communicate with each other CAD and CAM must have the same format, the drawings produced by CAD must the same format to be run on the CAM. In this study, product images will be created using Autocad software and it will run on the Fikus VisualCAM 19 software to visualize the tool pathway. The program is created to run a CNC machine and the resulting product will check the conformity of its dimensions and geometry. The results obtained are that the images generated from the AutoCAD software can run well on the Fikus VisualCAM 19 software. The program in the form of NC code generated by AutoCAD and Fikus VisualCAM19 software can be run properly by a CNC wire-cutting EDM machine, this can be seen from the product results that match the dimensions and geometry.

Keywords: EDM Wire-Cutting, CAD, CAM, CNC

Abstrak

Computer Aided Design (CAD) dan Computer-Aided Manufacturing (CAM) biasanya digunakan untuk menggambar sketsa dan memodelkan proses pekerjaan pabrikasi pada mesin yang pengoperasiannya menggunakan computer numerical control (CNC). Agar CAD dan CAM saling berkomunikasi maka memiliki format yang sama sehingga amar yang dihasilkan oleh CAD dapat dijalankan pada CAM. Pada studi ini gambar produk akan dibuat menggunakan software Autocad setelah itu hasil gambar akan dijalankan pada software Fikus VisualCAM19 untuk visualisasi tool pathway. Program dibuat untuk menjalankan mesin CNC wire-cutting EDM dan produk yang dihasilkan akan periksa kesesuaian dimensi dan geometrinya. Hasil yang didapat bahwa gambar yang dihasilkan dari software AutoCAD dapat dijalankan dengan baik pada software Fikus VisualCAM19 untuk visualisasi tool pathway. Program berupa NC code yang dihasilkan software AutoCAD dan Fikus VisualCAM19 dapat dijalankan dengan baik oleh mesin CNC wire-cutting EDM hal ini terlihat dari hasil produk yang sesuai baik dimensi dan geometri.

Kata Kunci: WEDM, CAD, CAM, CNC

1.0 INTRODUCTION

Making complex products sometimes cannot be carried out by conventional machines, so that a machine with CNC features is needed. Before carrying out making a product, an image of a product has to perform first. The usage of product images to analyze designs and product simulation needs to see if they are functioning correctly and see potential problems that may occur [1]. Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) are usually used to draw sketches and model manufacturing work processes on machines that operate using computer numerical control (CNC) [2]. A product to be made is drawn in 2D or 3D using CAD. Then, through CAD, solid modeling gives a realistic view of the part and installed [3]. After solid modeling generates, the next step is to enter it into the CAM system (some CAM software features have been integrated with CAD) to virtually run the CNC program. Computer-Aided Manufacturing (CAM) is software that uses a computer system to plan, manage, and regulate manufacturing operations. Through CAM, visualization governs how the movement path of the tool to remove

parts of the object does. Furthermore, it is carrying into G-code or CNC programming language.

G-code (or RS-274) is a computer numerical control (CNC) programming language widely used by automated machines. Numerical control (NC) programs are a series of lists of commands that describe the steps in the machine's order. When the program is done, the machine controller interprets each instruction, which causes actions on the machine such as starting or stopping the spindle or coolant, changing the spindle speed, moving the table or slide in a particular direction, distance, and speed [4].

Machine operations that use computer numerical control (CNC) make machines more productive than conventional machines to decrease the cost of producing a product. The manufacturing process using NC equipment can simulate making a product where each trajectory of the equipment is visualized. It is possible to make program corrections from the machine to reduce cutting errors that can waste material or save machine usage [5].

The use of CNC in the manufacturing process also has advantages in terms of machine accuracy in terms of accuracy, precision, flexibility, and production capacity. So that in the modern generation like today, many industries are starting to leave conventional machine tools and switch to using CNC machine tools [6].

Wire-Cutting Electrical discharge machining (EDM) is usually for the manufacture of products with complex shapes. The Electrical discharge machining (EDM) process is utilized because it has several advantages: it can be used on complex workpieces. There is no direct contact between the workpiece and the electrode, so thin workpieces or very hard workpieces can be processed [7]. Almost all types of work done on conventional machines can be completed through this process. The working principle of the EDM machine is to use an electrode to cut the workpiece by producing an electric jump between two conductor surfaces. Wire-cutting EDM machines are widely used to make complex shapes on polycrystalline diamond cutting equipment and form carbide tools such as form tools, thread shakers, dies, and crushing rolls.

The optimal manufacturing process of wire EDM is highly dependent on several parameters. One of the essential parameters in the cutting process is the peak current, which is the amount of power used in the EDM measured in amperes. The amount of peak current is adjusted according to the surface area to be cut, and the Material Remove Rate (MRR) increases with the increase in peak current. Although current significantly affects the cutting speed, experiments were carried out on cutting SS 304 material where the increase in current increased the cutting rate [8].

Meanwhile, operating a WEDM machine is usually recommended to use a low current setting; otherwise, the workpiece may overheat or be challenging to clean the cutting residue. Although current strength also affects the rate of cutting the workpiece, the increase in current strength during cutting impacts the increase in material removal rate (MRR) [9].

Sometimes, CAD software cannot be read by CAM or CNC machines because they have the same programming language. The limit of software usage often happens because each manufacturer develops programs with their file formats, making it challenging to communicate with each other. Several CNC machine manufacturers work closely with CAM providers to produce good system controls. This study aims to see whether the drawings generated from AutoCAD software run on VisualCAM19 as a visualization toolpath way and the program run on a CNC wire-cutting EDM machine. Through this study, foreseen to provide input in the process of making CNC programs for use in wire-cut EDM [10].

2.0 METHOD

In this study, we have manufactured products using Wire-Cutting Electrical Discharge Machining (EDM). The material used for the product's manufacture is NAK80 steel, where the material data sheet in table 1.

Table 1: *Material Data Sheet* NAK80 *Steel*

Mechanical Properties	
Tensile strength	183,400 psi
Yield Strength (.2% offset, 41 HRc)	147,600 psi
Reduction of Area	41.9%
Elongation in 2" (longitudinal)	16.1%
Modulus of Elasticity (room temp.)	30.0 x 10^{-6} psi
Physical Properties	
Coefficient of Thermal Expansion 68°F to 212°F 68°F to 392°F 68°F to 572°F	(x 10-6 in/in/F°) 6.3 7.0 7.5
Coefficient of Thermal Conductivity *At* 200°F *At* 400°F	(BTU/ft hr F°) 23.9 24.4
Magnetic Properties	
Maximum Magnetic Permeability	380
Saturated Magnetism (Gauss)	16,360
Residual Magnetism (Gauss)	8,500
Coercive Force (Oersted)	14.0
Typical Chemistry	
Carbon	0.15%
Manganese	1.50%
Silicon	0.30%
Copper	1.00%
Nickel	3.00%
Aluminum	1.00%

The material preparation process was conducted so that the surface and material become angled using a milling machine and grinder.

Figure 1 shows how this study of integration system of CAD/CAM in machinery process using wire-EDM was conducted. The product design is made with CAD, after which moving the tool pathway on the CAM is visualized. The visualization results on the CAM will be analyzed whether the visualization produces effective and efficient

tool movements and then proceeds with the creation of a numerical control (NC) program.

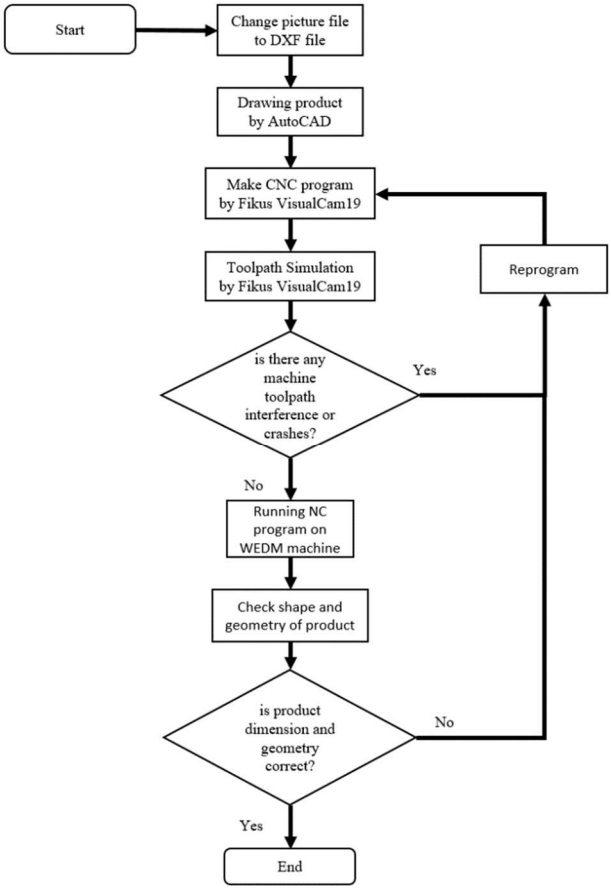

Figure 1: Research Methodology Flowchart

Furthermore, the AgieCharmilles Cut P350 wire-cut CNC wire-cut machine runs the program and the resulting product order quality inspection for geometrical and dimensional conformity. The specifications of the tool in Table 2.

Table 2. Specifications of AgieCharmilles Cut P350

Specification	
Machine type	*Submerged wire cutting*
Dimension	80.70 x 87.95 x 84.80 in
Total weight	5401.27 lb
Machining Area	
Vertical sliding door	Automatic
Max. workpiece dimensions (Top load)	39.37 x 5.906 x 8.661 in
Max. workpiece dimensions (Frontload)	31.496 x 21.654 x 8.661 in
Max. workpiece weight	1653.45 lb
Dimensions of table	26.772 x 17.716 in
Floor-to-table distance	39.37 in
Travel	
X, Y, Z travel	13.78 x 8.661 x 8.661 in
U, V travel	13.78 x 8.661 in
Axes	
Max. speed (X, Y, and U, V axes)	3 m / min
Integrated Collision Protection (ICP)	*Standard on 5 axes*

Table 3 describes the application and software that are used for making drawing and simulation the tool paths.

Table 3: Software and application

Software	Function
Autodesk AutoCAD	Computer-aided design (CAD) for drawing of products
Fikus VisualCam19	CAM for simulation cutting process, control cutting parameter, and programming Wire EDM machine
Vectorizer.io	Online application to convert images like PNGs, BMPs, and JPEG to a scalable vector graphics (SVG, EPS, DXF)

3.0 RESULT AND DISCUSSION

The workpiece made is in the form of the Batam State Polytechnic logo, which is shown in Figure 2 and it's converted to DXF format see figure 3.

Figure 2. Politeknik Negeri Batam Logo

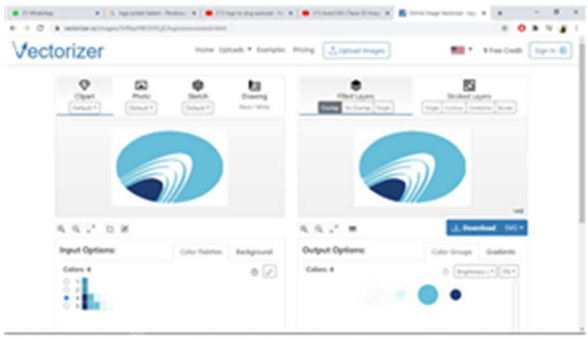

Figure 3: The Process of Changing the Politeknik Negeri Batam Logo Format

The Batam State Polytechnic logo is converted by online application vectorizer.io from image (JPEG) to scalable vector graphic like DXF format so that it has the shape and size in AutoCAD software, the resulting image as in Figure 4.

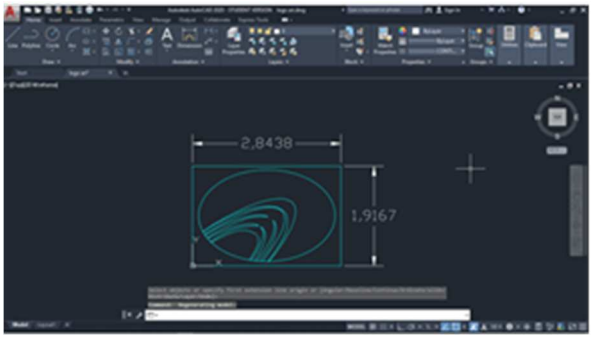

Figure 4: Sketching Process of Workpiece Drawing Using AutoCAD

The AutoCAD software's image results address the CAM software, which uses the Fikus VisualCAM19 software. There are no significant obstacles, and the data generated by AutoCAD software is read well with Fikus VisualCAM19 with a length of 60 mm and a width of 40 mm. The image results as in Figure 5.

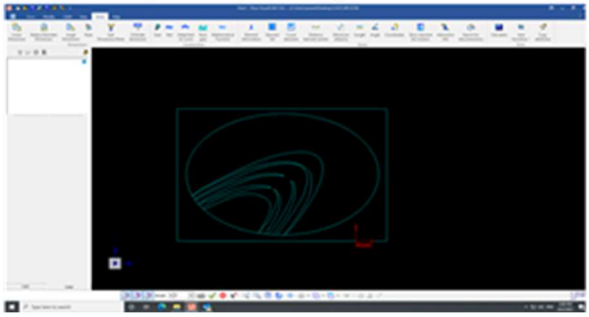
Figure 5: The results of the Polibatam logo on the Fikus VisualCAM19 software

3.1. NC Program Development

The AgieCharmilles Cut P 350 CNC machine run a program generated by the Fikus VisualCam19 software is needed. Concerning the cutting visualization to run well, it is necessary to input the parameters, as shown in Figure 6.

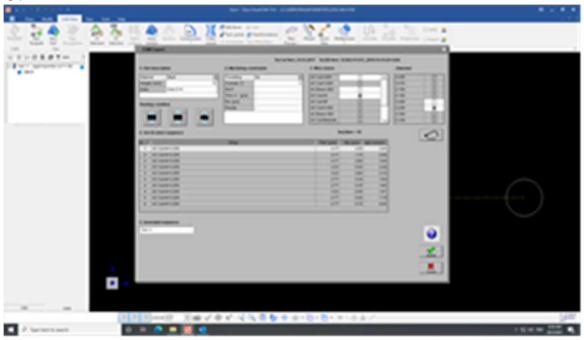
Figure 6: Parameters of the pathway tool

Later the parameters have begun. Furthermore, the visualization of the movement path of the wire-cutting EDM electrode on the CAM is obtained. The following information is in Figure 7.

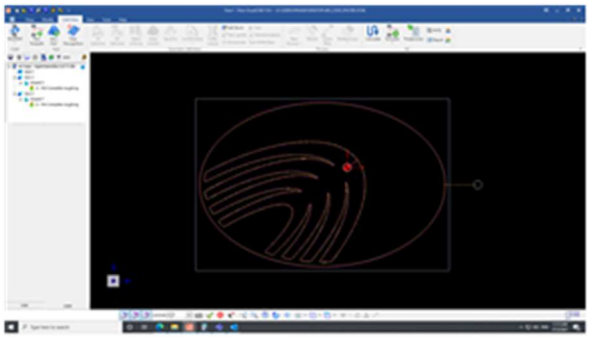
Figure 7: Visualization of the WEDM Pathway Tool

3.2. Running the WEDM CNC Machining Program

The CNC AgieCharmilles Cut P350 engine runs the program produced by the Fikus VisualCAM19 software. When running a machine, require to enter a pre-made file and check the programming code. Subsequently is necessary to set the starting point or zero-point for the cutting wire. To match the starting point of cutting in the program that has been made. The wire used is 0.25 mm in diameter, and the gap that occurs during the cutting process is 0.38mm.

Workpiece cutting sets with two steps. The first step, the feeding process, is carried out three times using different settings. The first cutting, which sets 1.70Ra toolset parameter with a 3 mm/min cutting speed, takes an hour. The second and third cuts using the 0.60Ra toolset parameter at a 3 mm/min cutting speed took 2 hours 40 minutes. The result of cutting the first parameter is in Figure 8.


Figure 8: The Results of The First Step

The second step is the outer part of the logo with two cutting processes with a 1.7Ra toolset parameter and a cutting speed of 4 mm/min taking 1 hour 10 minutes. The results of cutting the two parameters are in Figure 9. Finally, the following is the result of cutting parameters one and two shown in Figure 10.

Figure 9: The Results of Working on The Second Parameter

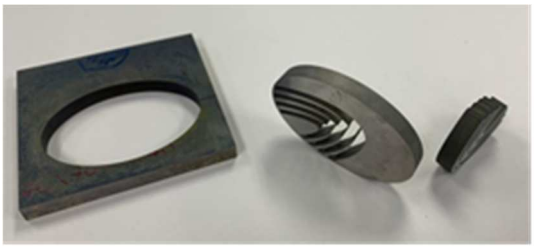

Figure 10: Overall Results of Cutting the Workpiece

4.0 CONCLUSION

Based on the results of the studies conducted, the images generated from the AutoCAD software can be run well on the Fikus VisualCAM19 software to visualize the tool pathway. In addition, the Fikus VisualCAM19 software can simulate the roughing process (initial feeding) to the finishing process to help evaluate the final product to avoid wasting material. The program in the form of NC code produced by AutoCAD and Fikus VisualCAM19 software can be run properly by the AgieCharmilles Cut P 350 CNC machine. It can be seen from the product results that match both dimensions and geometry.

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