Development of Computer Controlled Oxy Estelline Cutting Machine

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Abstract

Occasionally, the state organizations and many private companies in Thi Qar Governorate request some spare parts that must be manufactured locally because they are unavailable in Iraq .Since these parts have complex shapes, and the Engineering College Workshop's machines are unable to cut them, thus it was necessary to develop the existing Oxy Estelline cutting machine to control its motion by computer.

The main idea of this research is to make the machine cutter movement in two dimensions according to a path drawn by (Autodesk Land Desktop) program which necessitates addition of an electric circuit (Interface) between the machine and the computer to convert the path into two dimensional motions .This requires replacement of some unnecessary parts from the machine by others. The major added parts are:

1. Servo Motors.
2. Controller.
3. Drive.
4. Power Supply.
5. Power Cables.
6. Data Cables.
7. Lead Screws.
8. Brackets.
9. Bases to fix the motors and brackets.

After welding processes of the bases and mounting the motors, brackets, and electric circuits, the machine was tested by fixing a pen instead of the cutter and drawing many graphs such as circle, rose, gear, and gasket on a paper .The drawings are completed successfully and accurately, then the machine was used to cut rose and gasket by the flame .Satisfactory results are obtained .Now, the user can use the machine easily to cut any complex shape.

Keywords: CNC machine tool accuracy; Geometric error; Machining error; Error compensation.

المستخلص

في الكثير من الأحيان تقوم الشركات الحكومية وبعض الشركات الأهلية في محافظة ذي قار بطلب تصنيع بعض قطع الغيار غير المتوفرة في الأسواق المحلية. ولما كانت هذه القطع ذات أشكال معقدة يصعب قطعها داخل ورش الكلية لذا دعت الحاجة إلى تطوير ماكنة قطع بالشعلة الأوكسي إستيلينية الموجودة في داخل الورش وجعل حركتها آلية ومن ثم السيطرة عليها بواسطة الحاسوب.

إن الفكرة الرئيسة للبحث هي جعل أداة القطع في الماكنة تتحرك في بعدين وفقاً لشكل مرسوم بالحاسبة بواسطة برنامج الرسم (Autodesk Land Desktop) وهذا يستلزم وضع مجموعة دوائر الكترونية (Interface) بين الحاسبة وماكنة القطع لتحويل الرسم الموجود في الحاسبة الى حركات في بعدين. هذا الامر تطلب رفع بعض القطع غير الضرورية من الماكنة وإضافة قطع أخرى.

ومن أهم القطع التي تمت إضافتها الى الماكنة هي:

1. ماطورات (Servo Motors)
2. مسيطر (Controller)
3. قائد (Drive)
4. مجهز قدرة (Power Supply)
5. كيبلات قدرة(Power Cables)
6. كيبلات نقل البيانات (Data Cables)
7. براغي (Lead Screws)
8. محامل (Brackets)
9. قواعد تثبيت للماطورات والمحامل

بعد إجراء عمليات اللحام لقواعد التثبيت وتركيب الماطورات والدوائر الالكترونية تم اختبار الماكنة عن طريق تثبيت قلم بدل أداة القطع والرسم على ورق سميك وقد تم بنجاح رسم دائرة ووردة رباعية الاوراق ومسنن وكازكت وكانت الرسوم دقيقة جداً ومطابقة للواقع. بعد ذلك تم استخدام أداة القطع لقطع وردة خماسية الاوراق وكازكت وكانت النتائج مرضية جداً.

1. Introduction

CNC machines are used extensively in industries to reduce costs, improve productivity, obtain better product quality, and avoid humans faults and working in hazardous environments.

Chana Raksiri et al [1] proposes a new off line error compensation model by taking into account the geometric and cutting force induced errors in a 3-axis CNC milling machine . Geometric error estimation determined by back-propagation neural network is proposed and used separately in the geometric error compensation model .Likewise, cutting force induced error estimation by back-propagation neural network determined based on a flat end mill behavior observation is proposed and used separately in the cutting force induced error compensation model .Various experiments over a wide range of cutting conditions are carried out to investigate cutting force and machine error relation .Finally, the combination of geometric and cutting force induced errors is modeled by the combined back-propagation neural network .This unique model is used to compensate both geometric and cutting force induced errors simultaneously by a single model .Experimental tests have been carried out in order to validate the performance of geometric and cutting force induced errors compensation model.

Tae-Yong Kim et al[2] present the indirect cutting force measurement method in contour NC milling processes by using current signals of servomotors .A Kalman filter disturbance observer and an artificial neural network (ANN) system are suggested.A Kalman filter disturbance observer is implemented by using the dynamic model of the feed drive servo system, and each of the external load torques to the *x* and *y*-axis servo motors of a horizontal machining center is estimated .An ANN system is also implemented with a training set of experimental cutting data to measure cutting force indirectly .The input variables of the ANN system are the motor currents and the feed rates of *x* and *y*-axis servo motors, and output variable is the cutting force of each axis .A series of experimental works on the circular interpolated contour milling process with the path of a complete circle have been performed . It is concluded that by comparing the Kalman filter disturbance observer and the ANN system with a dynamometer measuring cutting force directly, the ANN system has a better performance.

Mahbubur Rahman[3] presents a theoretical and practical relations which have been established between static and dynamic measuring systems .These relations are important when we are measuring machine tools with different measuring devices to validate the measurement results.The traces obtained by one measuring system have been compared and simulated with the traces obtained by other methods.Several methods for improving the positioning accuracy of machine tools which have been studied .One of the methods is NC code modification .This method has been applied to develop an NC program processor based on the error found by the measurements.

Hui Wang and Qiang Huang[4] use the concept of an Equivalent Fixture Error (EFE) embedded into a modeling methodology to obtain insights into this fundamental phenomenon and to achieve an improved process control. They developed a sequential root-cause identification procedure and EFE compensation methodology .A case study was presented to demonstrate the proposed diagnostic procedure .A simulation study was also performed to illustrate the error compensation procedure.

Abdul –Baki Khalaf [5] performed a 3-axes CNC plasma-cutting machine designed, manufactured and controlled .Mechanical design included material selection, frame design, guideways design, driving mechanism and bearings mounting .Hardware elimination of errors such as backlash, clearance and squareness are strongly considered in each step of the procedure of mechanical design .Also he develop a new motion controller model called Error Model Reference Adaptive Control(EMRAC) .The model was built in the form of (C++) language .The model has been validated through several tests and proved to have advantages over other standard control techniques.

2. Design and analysis

The cutting machine before development is shown in Figure (1) .From this machine some of the unimportant parts are removed, then all remaining parts are maintained and lubricated.

Figure (1). Cutting machine before development.

Two servo motors with the following specifications are used :

- Stall current continuous 7.2 A

- Voltage 230 V
- Rated speed 5000 RPM
- Rated output power 1.6 kW
- Continuous stall torque 4 N.m
- Peak torque 12.8 N.m

The dimensions of the motors are illustrated in Figure (2).

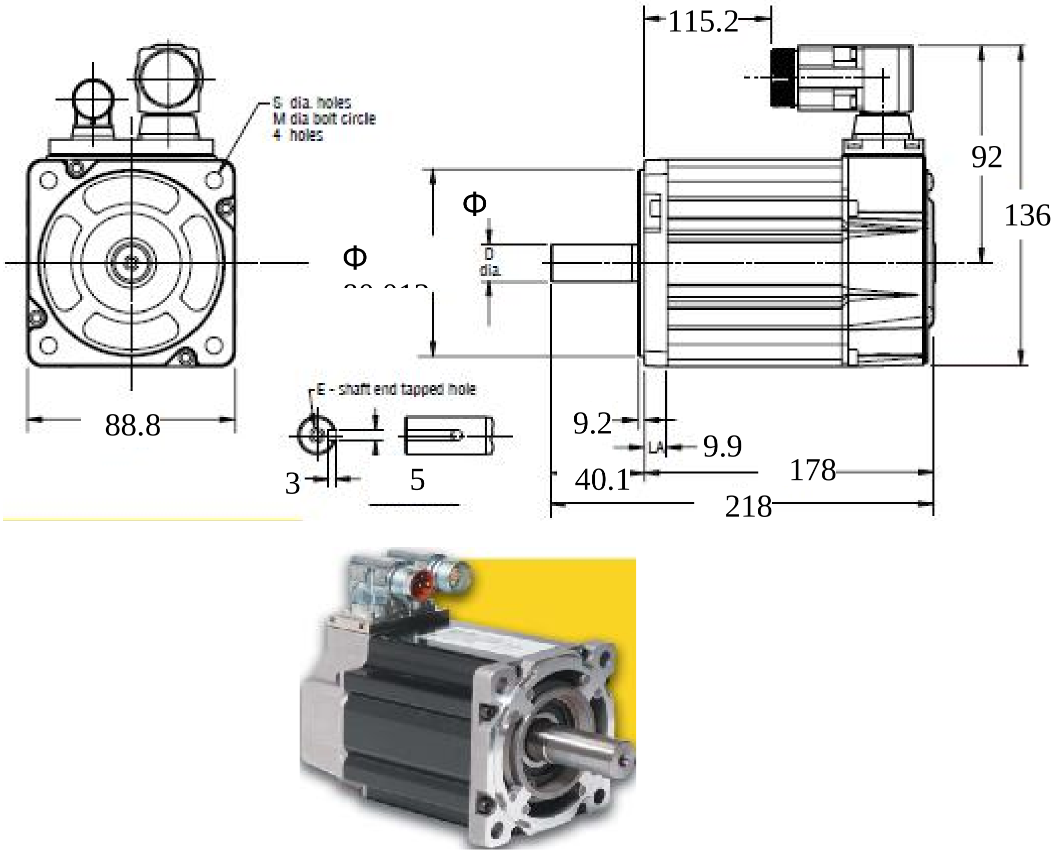

Figure (2) .Dimensions in (mm) of the servo motors.

Two Aries drives are used to control the torque, velocity, and position of servo motors . The drive dimensions are shown in Figure (3).

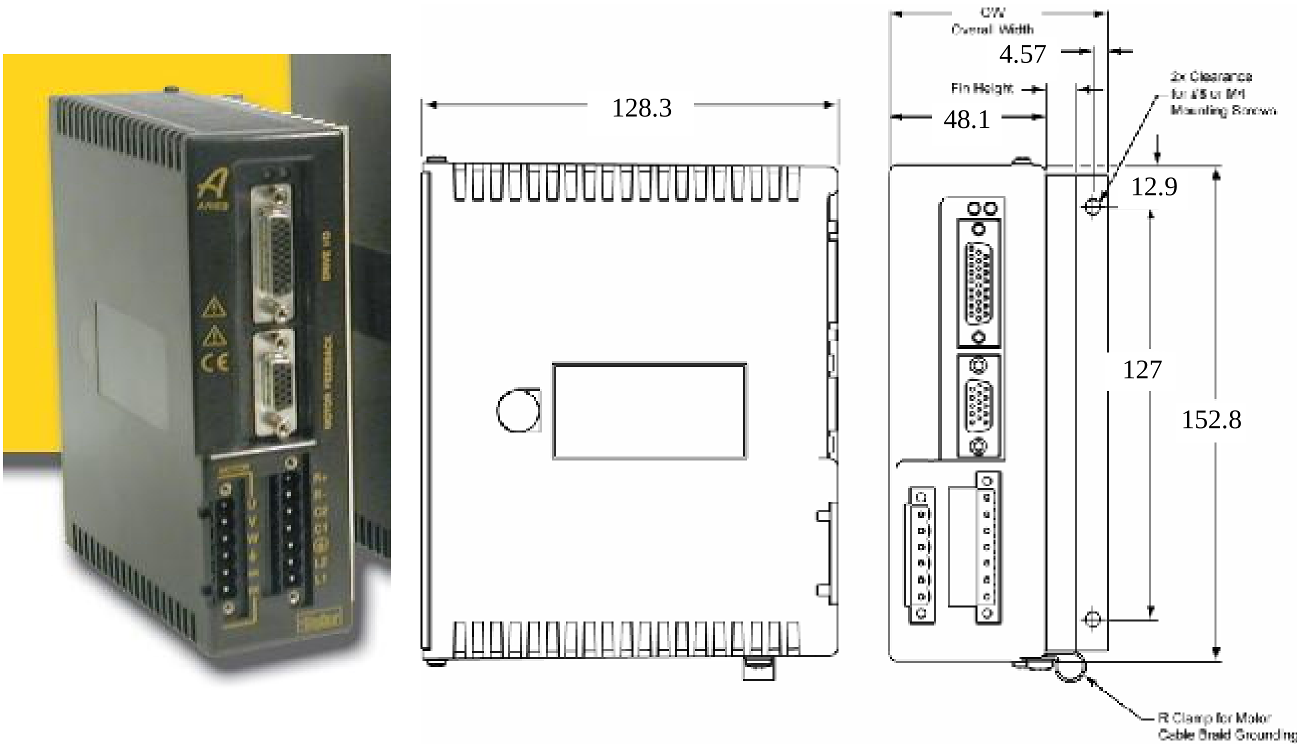

Figure (3).Drive dimensions in (mm).

Among the most important elements of automated manufacturing machines is the controller . The controller provides the facility of proper placement of the cutting tool relative to work piece. The most common controller in industry is the PID (Proportional-Integral-Derivative) controller. Such controllers are widely used in NC and CNC machines. This because of their general applicability to most control systems, and they can be implemented easily either in analog form or in digital form. ACR9000 controller is used to controlling servo drives. There are eight axis connectors on the front panel .They are labeled AXIS0 through AXIS7, the dimensions of the controller are illustrated in Figure (4).

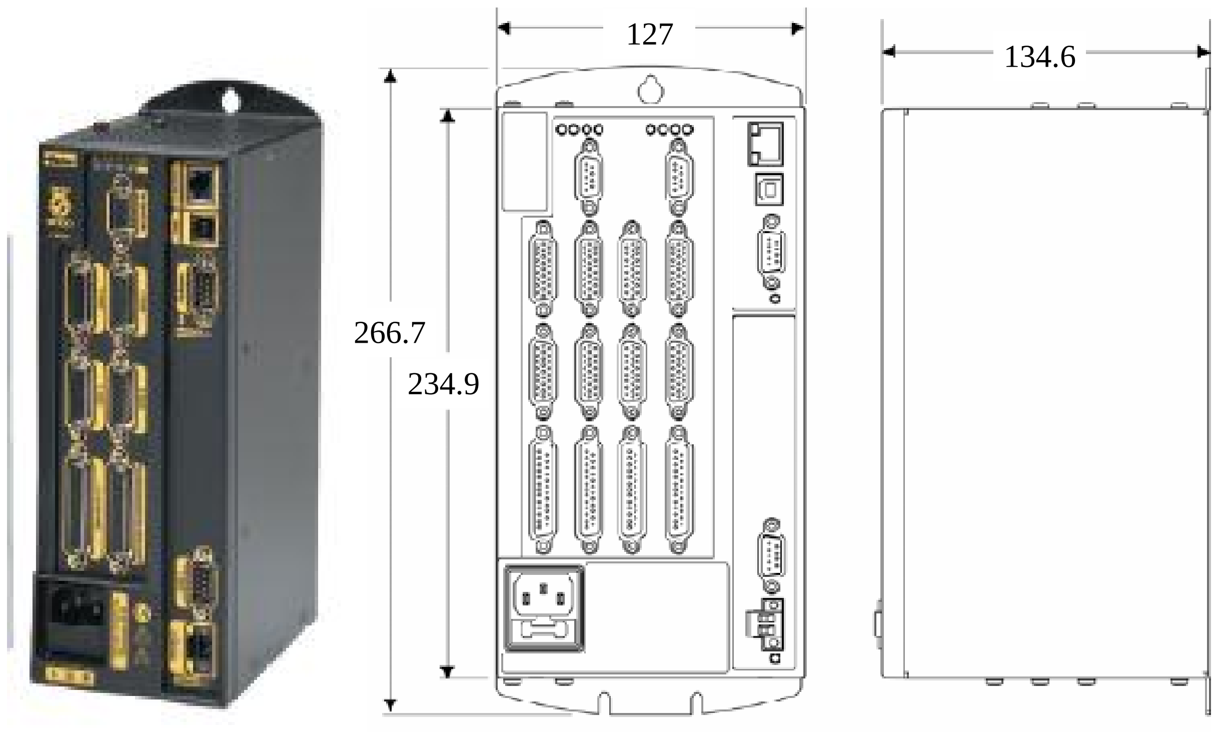

Figure (4). Controller dimensions in(mm).

The motion in two dimensions is transmitted by two lead screws each of them have diameter of (22 mm), pitch of (2.5 mm), and length of (2 m) .Each of the lead screw mounted by two brackets, the brackets and motors are mounted on bases made from cast iron material of dimensions (330×130×10 mm) for motors and (60 ×130 ×10 mm) for brackets as shown in Figure (5).

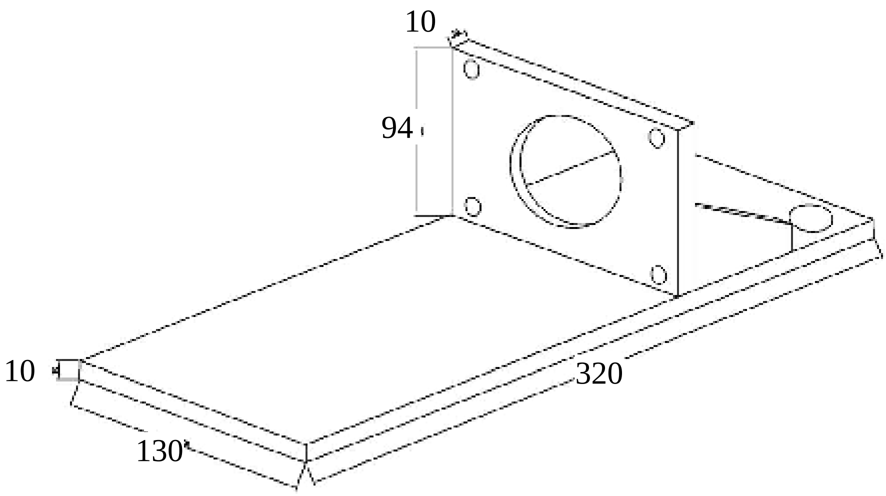

Figure (5) .The base used to support the servo motors.

The motors are connected to the lead screw by a muff coupling as illustrated in Figure (6).

Figure (6). The connection between the motor and the lead screw.

The x-axis guide way consists of lead screw and nut , two brackets are mounted on the lead screw .Each bracket consists of ball bearing assembled inside a cap bracket .All brackets are mounted on bases are welded to the machine body .

The above procedure for installing guide way for x-axis is repeated for y-axis .The cutting machine with all added parts is shown in Figure (7) and Figure (8).

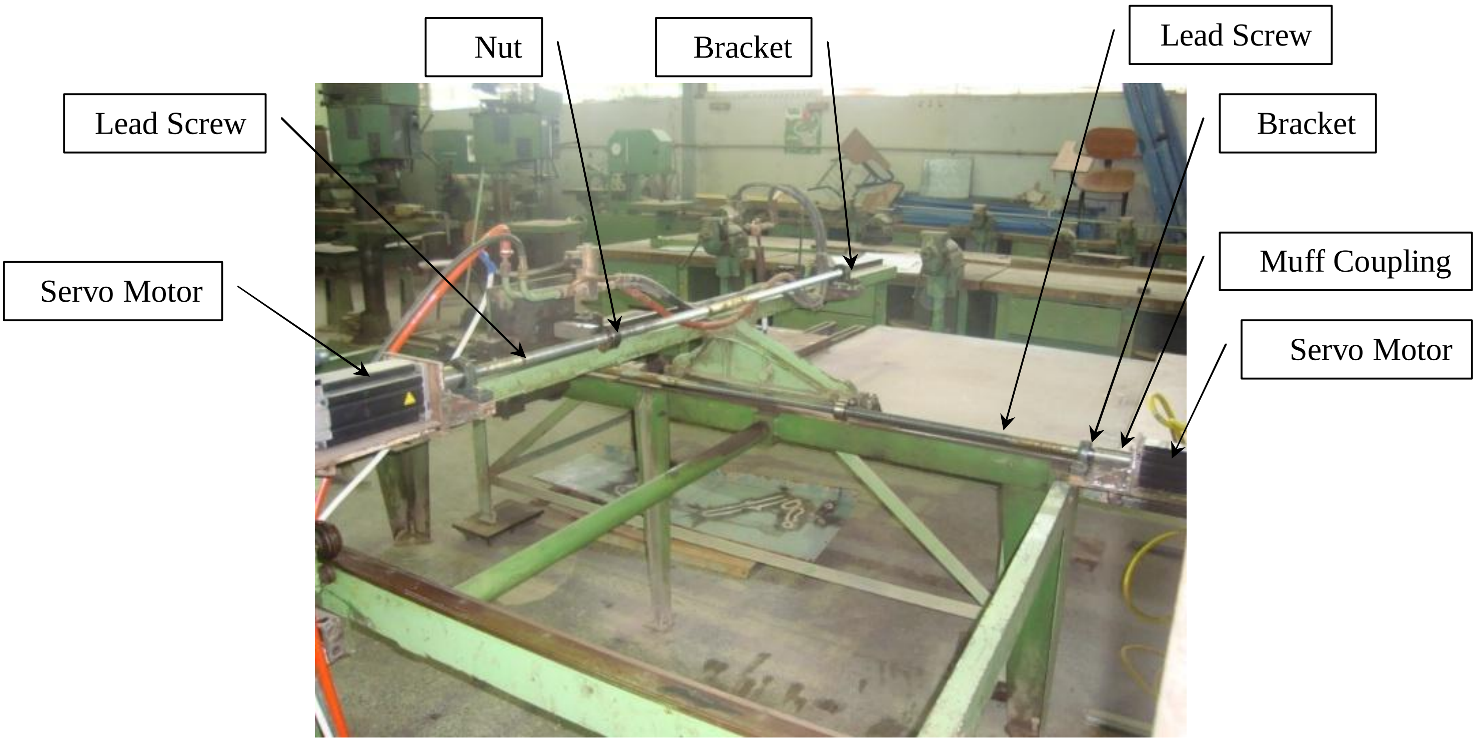

Figure (7). Cutting machine with mechanical added parts.

Figure (8) . Interface circuit for cutting machine.

3. Graphical User Interface (GUI)

A Graphical User Interface (GUI) is a graphical display that contains devices or components , that enable a user to perform interactive tasks .To perform these tasks, the user of the GUI does not have to create a script or type commands at the command line .Often, the user does not have to know the details of the task at hand.

The GUI components can be menus, toolbars, push buttons, radio buttons, list boxes, and sliders—just to name a few .In MATLAB software, a GUI can also display data in a tabular form or as plots, and can group related components.

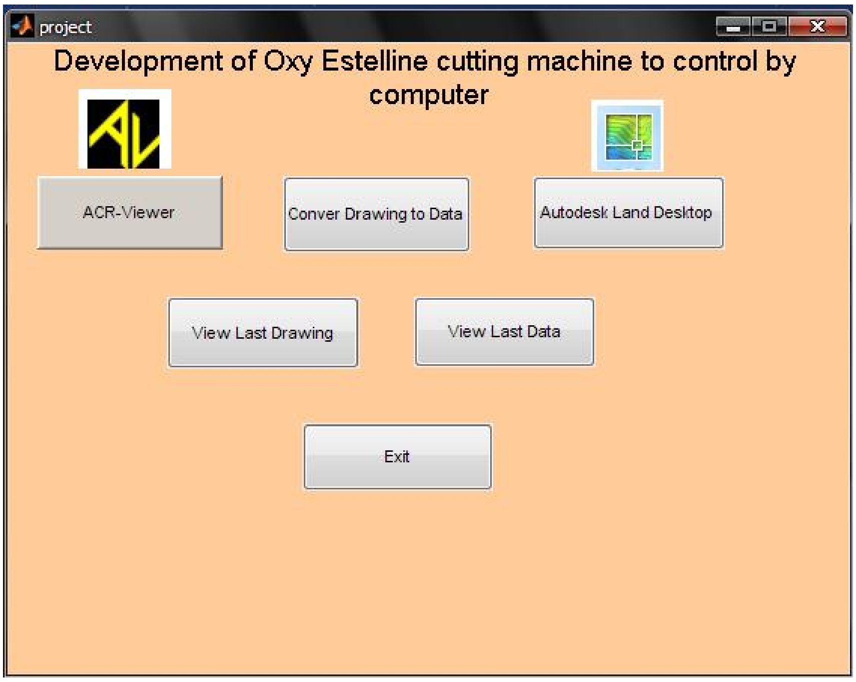

Figure (9) . Graphical User Interface (GUI) menu.

Each component, and the GUI itself, is associated with one or more user-written routines known as callbacks .The execution of each callback is triggered by a particular user action such as a button push, mouse click, selection of a menu item, or the cursor passing over a component.

Using MATLAB 7.6.0(R2008a) creates GUI to connect two programs, namely, Autodesk Land Desktop and ACR -Viewer to easy control the path drawn in Autodesk Land Desktop program and convert this path to data to be exported to ACR -Viewer program to make the motion in two dimensions.

4. Results and discussion

After welding processes of the bases and mounting the motors, brackets, and electric circuits, the machine was tested by fixing a pen instead of the cutter and drawing many graphs such as circle, rose, gear, and gasket on a paper.

- By using Autodesk Land Desktop program the planned tool path shown in Figure (10) for the cutting experiment is drawn.

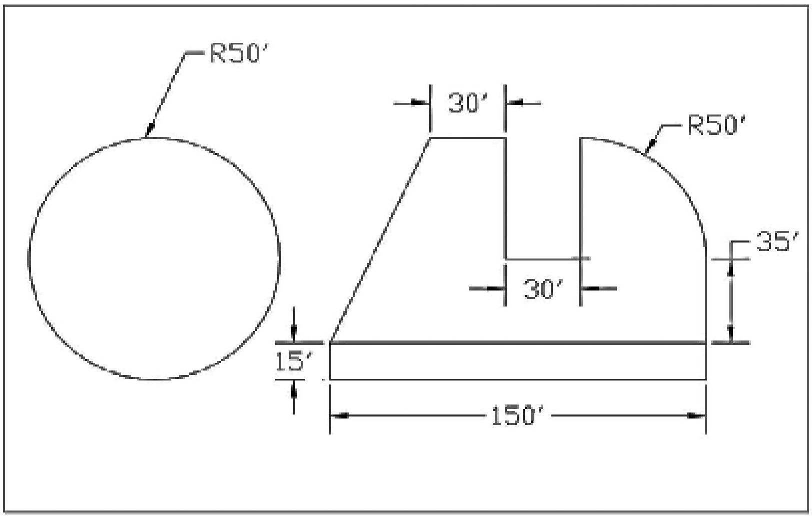

Figure (10) .Planned tool path for the cutting test all dimensions in (mm).

Then by using GUI menu this drawing is converted into data then exported to ACR-Viewer to make the cutter of the machine to move according to this data .The true scale of the drawing by the machine is shown in Figure (16).

- By using the same procedure as above the planned tool path shown in Figure (11) for the cutting experiment is drawn.

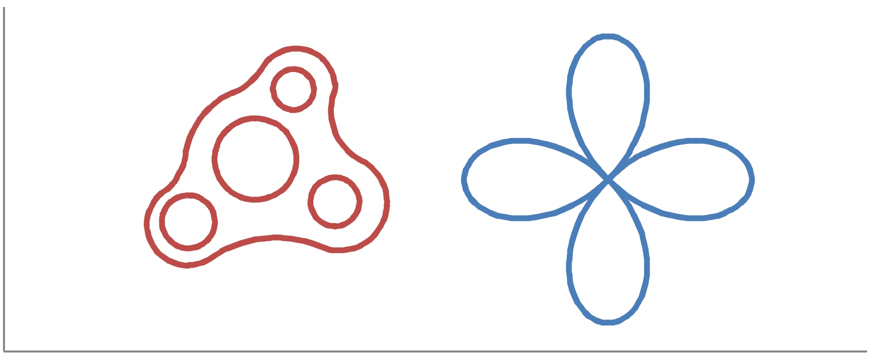

Figure (11). Planned tool path for the cutting test .

Figure (17) shows the true scale drawn by the machine, the dimensions of the true scale are measured. The result was accurate and acceptable. Then the machine was used to cut circle and gasket by the flame as shown in Figures (12) and (13).

Figure (12). Cutting a circle.

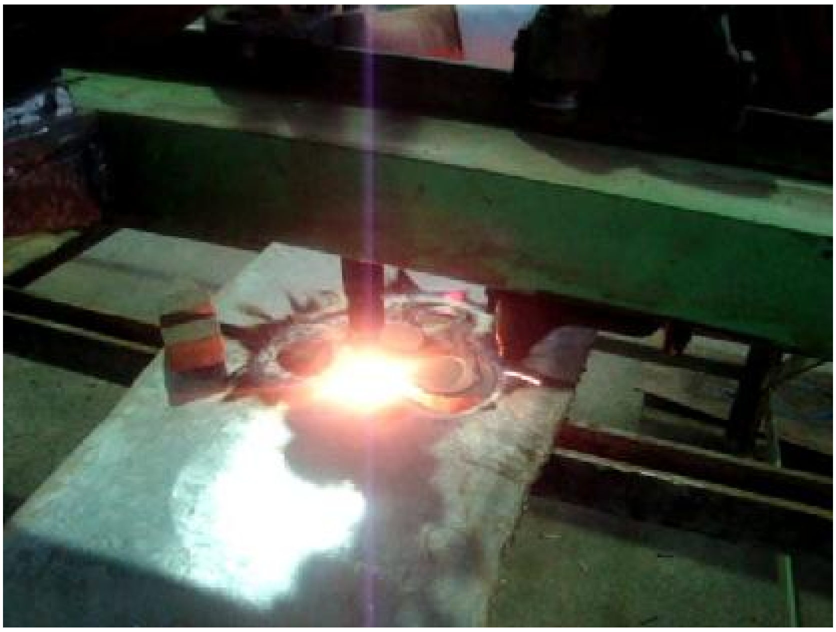

Figure (13). Cutting a gasket .

Figure (18) show the true scale for gear drawn by the machine. Figure (14) and figure (15) represents the final shape of the gasket and rose cut by the machine. Now, the user can use the machine easily to cut any complex shape.

Figure (14) . Final shape of gasket that was cut by the machine.

Figure (15). Final shape of rose that was cut by the machine.

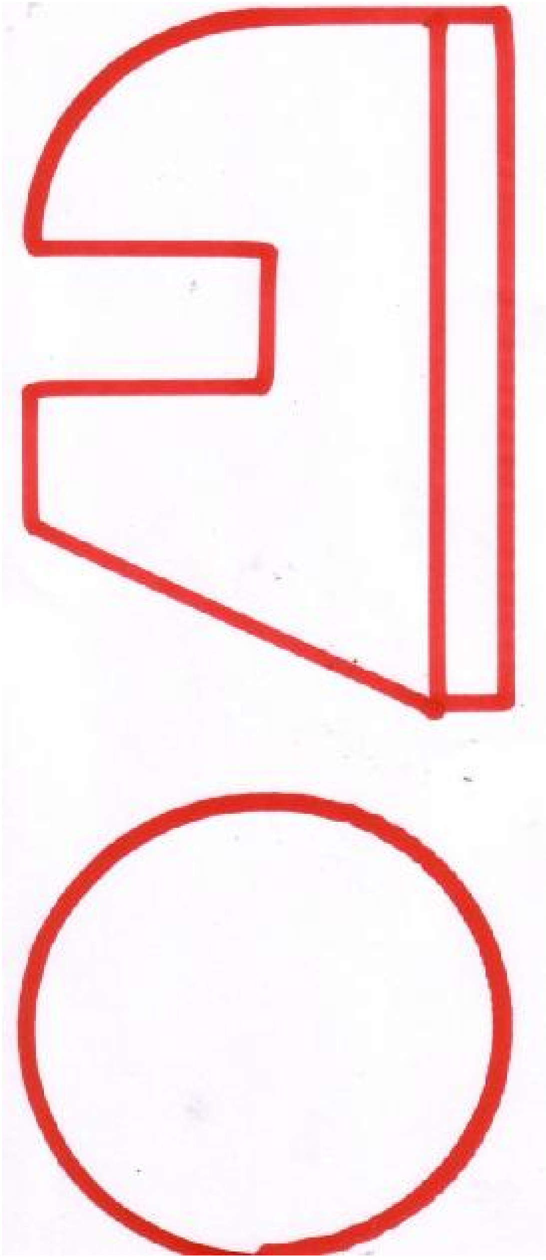

Figure (16). The true scale drawing by the machine.

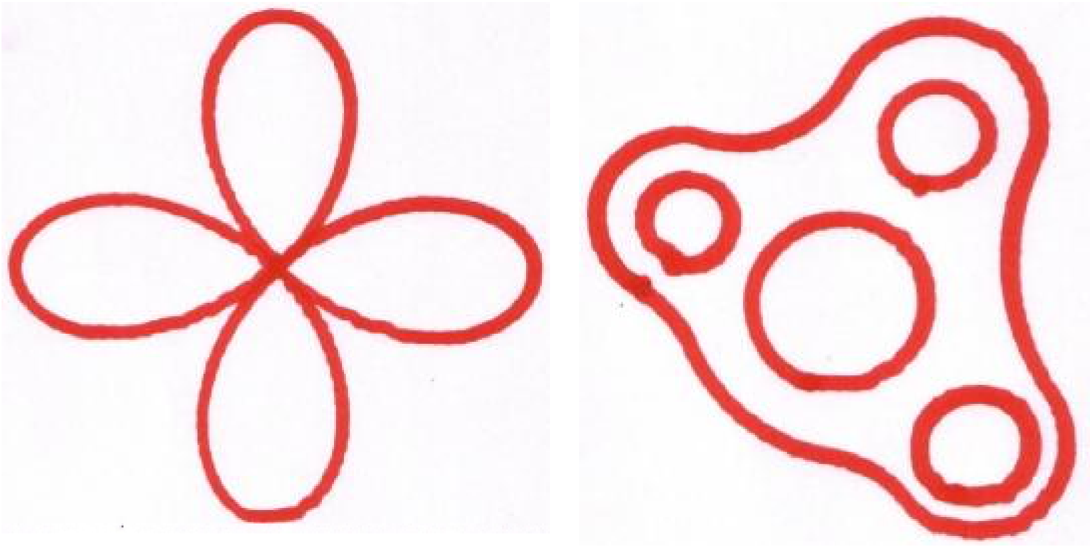

Figure (17) . The true scale of rose and gasket drawn by the machine.

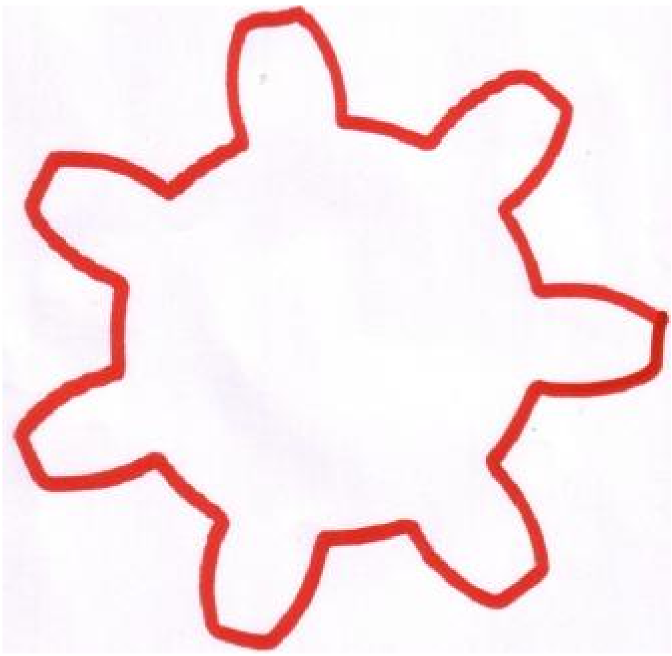

Figure (18) . The true scale of gear drawn by the machine.

5. Conclusions

- PC interface provides powerful control tool for CNC machines. The address and data buses allow for high rate of data transfer between the PC and the machine.
- Servo motors are good motion drives for CNC machines. This is because of their wide range of control of speed.
- User can use the machine easily to cut any complex shape.

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6. References

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