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14. ABSTRACT
The specific aims of this project were: 1) to plan a manufacturing laboratory to educate next generation engineers. 2) to acquire appropriate manufacturing equipment to meet this educational goal. 3) to install the equipment and implement the laboratory into the instructional and research programs of the College in collaboration with our industry constituents. All major equipment has been acquired and installed and is now operational. Training in the use of the equipment has been completed for all items and they have been incorporated into several engineering

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Report Title

Manufacturing Laboratory for Next Generation Engineers

ABSTRACT

The specific aims of this project were: 1) to plan a manufacturing laboratory to educate next generation engineers. 2) to acquire appropriate manufacturing equipment to meet this educational goal. 3) to install the equipment and implement the laboratory into the instructional and research programs of the College in collaboration with our industry constituents. All major equipment has been acquired and installed and is now operational. Training in the use of the equipment has been completed for all items and they have been incorporated into several engineering courses and are being considered for others as we develop more experience in their use. Students have been involved in developing student friendly user manuals for several of the more complex pieces of equipment and this process continues as the facility is further integrated into courses. Interactions with industry constituents using the facility have begun and are expected to grow as our capabilities expand. The facility is a major asset to the College, its students and our industry constituents.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Paper

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED	Discipline
Liang, Yan	0.50	
Thota, Chaitanya	0.25	
FTE Equivalent:	**0.75**	
Total Number:	**2**	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Johnson, Richard	0.10	
Morris, Martin	0.10	
Reyer, Julie	0.10	
FTE Equivalent:	**0.30**	
Total Number:	**3**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED	Discipline
Winn, Christopher	0.10	Manufacturing Engineering
Burke, Alexandra	0.10	Mechanical Engineering
FTE Equivalent:	**0.20**	
Total Number:	**2**	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:...... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):...... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME	
Thota, Chaitanya	
Liang, Yan	
Total Number:	**2**

Names of personnel receiving PHDs

NAME
Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

All equipment acquisition, installation, and facility modifications for the Manufacturing Laboratory for Next Generation Engineers have been completed. As noted in earlier progress reports, the equipment purchases were guided with the educational plan that was developed in conjunction with the planning for a new building for the Colleges of Engineering and Business to support the convergence of activities between these two colleges. One of the major features of this planning is the incorporation of the Manufacturing Laboratory for Next Generation Engineers into the larger study of Product Realization. This enhancement of the original educational objective involved changes in the original equipment planned for acquisition and in how it will be used in our educational programs. Instructional use began during the 2012 spring semester and has continued through the fall of 2012, spring of 2013 and into the current fall 2013 semester. A copy of the overall educational plan is attached with comments indicating the equipment acquired to support each item in the plan. The approved budget re-allocations and project extension to September 30, 2013 were critical to completing the installation and startup operation of all equipment. The flexibility provided with these extensions has enhanced the laboratory and provided more training of faculty and staff and increasing student involvement. Faculty and students have been involved in the development of instruction and operation manuals for several of the machine systems to make them more user friendly for student use. The Manufacturing Laboratory for Next Generation Engineers is becoming a major asset to the hands-on practical education of Bradley Engineering students. It is also developing as a resource for collaboration with many of our industry constituents.

Technology Transfer

Manufacturing Laboratory for Next Generation Engineers

Final Report

Department of the Army Grant W911NF-10-1-0508

Due December 30, 2013

Prepared by:

Richard T. Johnson. Principal Investigator
Professor of Mechanical Engineering
Bradley University
Peoria, Illinois 61625

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Appendices

Abstract

The specific aims of this project were: 1) to plan a manufacturing laboratory to educate next generation engineers. 2) to acquire appropriate manufacturing equipment to meet this educational goal. 3) to install the equipment and implement the laboratory into the instructional and research programs of the College in collaboration with our industry constituents. All major equipment has been acquired and installed and is now operational. Training in the use of the equipment has been completed for all items and they have been incorporated into several engineering courses and are being considered for others as we develop more experience in their use. Students have been involved in developing student friendly user manuals for several of the more complex pieces of equipment and this process continues as the facility is further integrated into courses. Interactions with industry constituents using the facility have begun and are expected to grow as our capabilities expand. The facility is a major asset to the College, its students and our industry constituents.

Problem Statement - The Educational Plan

The educational planning for the Manufacturing Laboratory for Next Generation Engineers has been developed between Industrial and Manufacturing Engineering and Mechanical Engineering in conjunction with preliminary space planning for a new Convergence Center facility shared by the Colleges of Engineering and Business. This planning involved trips to other educational institutions with manufacturing laboratory facilities as well as correspondence with faculty and laboratory managers at other educational institutions. Based upon these activities and discussions with involved faculty members, industry constituents and students, the following basic plan was developed.

In the new facility, Mechanical Engineering and Industrial and Manufacturing Engineering and Technology will share the primary responsibility for the College shop and manufacturing facility. That facility will be configured with four distinct functional areas:

1. **Basic machining processes** - using classical manual machines, students will learn the fundamentals of machining processes in a supervised laboratory environment.

2. **Introductory Computer Controlled machining processes** - with CNC machines that can be either operated manually or in an automated mode. This area will also be supervised, but will allow for independent operation by trained students, typically for their project work.

3. **Advanced Manufacturing Processes** - containing a broad array of manufacturing processes including fully automated CNC machines, rapid prototype systems, robotic assembly systems, metrology, and non-traditional systems such as a waterjet cutter, EDM machine, plasma cutter, and plastic injection molder. This area will be capable of commercial grade manufacturing and available for trained students and personnel. It will be an important facility for educational projects and faculty research, as well as funded projects from industry.

4. **Wood Shop** - There will be an adjacent wood shop area in that many of the activities and projects involve wood mockups, wooden support structures, forming for fiberglass or composite lay-up, etc. This area will also be supervised by the technical staff located in this facility.

As part of the long term plan, there will be a number of Product Realization Laboratories that will be a part of the space responsibilities of Mechanical Engineering. These laboratories will include: ideation, design, prototyping and validation, finishing, and project work and assembly areas. Related laboratory space responsibilities for Industrial and Manufacturing Engineering will include: Computer Integrated Manufacturing, foundry technology, forming and fabrication, heat treatment, welding, and non-metallic processes.

Summary Results - Implementation of the Educational Plan

With these plans formed, equipment was acquired that will be included in these laboratories. The major focus of the grant for the Manufacturing Laboratory for Next Generation Engineers was on major areas where we currently do not have particular equipment, where we need to update equipment, and where we need to provide additional equipment to meet instructional needs. Here are the results for these four categories and an explanation of where and how grant funds have been used to create a significant educational and project facility:

1. **Basic machining processes -** using classical manual machines, students will learn the fundamentals of machining processes in a supervised laboratory environment.

   Current Status - Between the Mechanical Engineering Department and the Industrial and Manufacturing Engineering Department we are well equipped to teach and use basic manual machining processes and are currently doing so.

2. **Introductory Computer Controlled machining processes -** with CNC machines that can be either operated manually or in an automated mode. This area will also be supervised, but will allow for independent operation by trained students, typically for their project work. Acquire CNC machines that can be either operated manually or in an automated mode.

   Current Status - Through grant acquisitions, we now have two Tormach three-axis milling machines and two Southwest Industries TRAK lathes installed and operational. These machines can be operated either manually or in simplified CNC mode. There is substantial student project work done on both the Tormach mill and the TRAK lathe. In addition to the project work these machines are being used by students to produce test parts for laboratory classes. Classes that currently use these machines include:

   ME 308 - Thermodynamics of Fluid Flow
   ME 410 - Senior Project I
   ME 411 - Senior Project II
   ME 409 - Mechanical Engineering Projects (Undergraduate)
   ME 681 & 682 - Research (Project Oriented Graduate Research)
   ME 691 - MS Thesis

Tormach three-axis mill

TRAK lathe

Students in Thermodynamics of Fluid Flow are required to design an airplane and machine it from rigid prototype foam using a Tormach mill. The finished prototypes are flight tested on the basket ball court in the Markin Center.

Students Machining Wing

Completed Aircraft

3. **Advanced Manufacturing Processes** - containing a broad array of manufacturing processes including fully automated CNC machines, rapid prototype systems, robotic assembly systems, metrology, and non-traditional systems such as a waterjet cutter, EDM machine, plasma cutter, and plastic injection molder. This area will be capable of commercial grade manufacturing and available for trained students and personnel. It will be an important facility for educational projects and faculty research, as well as funded projects from industry.

   Current Status - Each of the several different advanced manufacturing processes are covered individually in the following points.

   Fully automated CNC turning and CNC 5-axis machining centers. These systems need to be equipped with a separate controller/training unit for use by students in learning how to use the machines to manufacture parts they have designed. Based upon the recommendations by users at Purdue University and California Polytechnic State University - San Louis Obispo, we acquired a Haas VF-2TR 5-axis machining center and a Haas ST-20 turning center. Both systems are well equipped with a reasonable tool allowance. The advantages for us are that these are relatively small machines for our limited space, they use a common controller and each is provided with an additional controller/trainer of which additional units can be purchased. We also have an important advantage in that we have relationships with two other institutions with experience using these systems. In addition, there is a substantial educational users group that shares information and meets annually. They serve as a resource for us in implementation and use in our instructional and project activities.

Both machines have been installed, are operational, and are being implemented into course and project work. We are able to train advanced students with an on-line simulator program provided by Immerse2learn. The machines are currently being used in the following courses in Industrial and Manufacturing Engineering:

- IME 445 - Computer Aided Manufacturing
- IME 670 - Research (Project Oriented Graduate Research)

In the next semester or two they will also be utilized by one or more of the following courses in Mechanical Engineering:

- ME 410 - Senior Project I
- ME 411 - Senior Project II
- ME 409 - Mechanical Engineering Projects (Undergraduate)
- ME 681 & 682 - Research (Project Oriented Graduate Research)

VF-2TR Machining Center

ST-20 Turning Center

Compressor Disc

This compressor disc is an example of 5-axis machining. It is a prototype turbo-charger compressor disc machined from aluminum stock. The complex blade contour can not be machined with the typical 3-axis mill. Five axes are needed to make this part. It was setup and programed and machined by a Manufacturing Engineering graduate student.

The Haas simulators are actual control units for the machines and give very realistic hands-on experience for students learning to program and use the machines.

Haas Machine Simulators

Rapid prototyping machines. We acquired two different types of rapid prototyping machine. Faculty members visited the facilities at Milwaukee School of Engineering, the University of Illinois at Urban/Champaign, and Caterpillar. From these visits we determined that a stereolithography (SLA) machine and one that uses additive technology such as Objet or Stratasys systems would be the most appropriate for our programs. We acquired a ProJet HD6000 3D printer from 3D systems. At the time of purchase this system was the most sophisticated SLA system available both in precision and in materials available for creating parts with different properties. When the machine was installed it was the first machine in a university setting and only the 4th machine installed in the United States. The second machine acquired is a Stratasys Fortus 250mc machine that uses additive technology to build parts from ABS plastic.

The two rapid prototyping machines are installed and in operation and being used in course and project work.

Projet 6000 SLA

Fortus 250 mc

Skull Prototype from CD Scans

One of the more interesting areas now being used in the Mechanical Engineering Biomedical Engineering Emphasis program is the use of rapid prototyping. This is a skull prototype produced on the SLA system. The data used to generate this item was a series of CT scans of an individual's skull. This prototype allows for a detailed 3D study of the missing portion of the skull near the right temporal region. This information is used to design the repair that will be made for this individual.

Non-traditional machining process equipment. Both waterjet and EDM machines have been acquired, installed in the laboratory, and are operational and in use. The waterjet system purchased was an Omax 2626 xp. This system has the highest accuracy of any machine considered and also has the smallest foot print. The EDM machine purchased was a Sodick Model VZ 300L. This machine met all the specifications and provided the best fit into the space available in our current and planned future facilities.

Omax 2626xp Waterjet

Sodick VZ300L EDM

Plasma Cutter. In the final budget revision for the project we were able to reallocate funds to acquire a Plasma CAM CNC cutting system to illustrate this non-traditional method of cutting planar parts. It is installed and operational and now being integrated into our educational programs.

Installed Plasma CAM CNC Cutting System

Robotic Material Handling System (CIM system) - A Bosch Rexroth Modular Mechatronic Training system was acquired for the Computer Intregrated Manufacturing system. It is a small scale flexible system that can be reconfigured to accomplish a number of coordinated material handling and assembly functions. The scale provides students with an easy overview of the entire CIM process in a safe environment. This system has been installed and faculty and staff have been trained in its use. It is currently being used in IMT 446 - *Computer Aided Manufacturing and Automation II* as well as in projects during academic years 2012-2013 and 2013-2014.

Bosch Rexroth CIM system

FARO 3D Coordinate Measuring System

Metrology and Quality Control Equipment - This area already had a CMM and other well known quality control instrumentation. It has been enhanced with the acquisition of a state-of-the-art laser 3D coordinate measuring machine. The machine is a FARO 7 axis Edge system with options and software for both precise coordinate measurements as well as reverse engineering of existing items. In addition, a number of typical quality control instruments were acquired. It is currently being used in IMT 362 - *Metrology and Instrumentation.*

Precision Surface Grinder. In working with our industry constituents and in the project needs we have encountered, the need for a precision surface grinder was established. This machine was acquired and is now installed and operational and is available for projects and course use.

Acer Precision Surface Grinder

Plastic Injection Molder. As we progressed in the development of this laboratory and interacted with our industry constituents it became clear that production of plastic parts is a very important part of manufacturing today and should be addressed in our educational programs. Working with our industry constituents, specifications for a suitable injection molder were developed and an Engel e-victory 80/30 was acquired. The e-victory is a state-of-the art "tie-bar-less" machine with hydraulic clamping, electric drive injection, core pull, and an intuitive 15" touch screen controller. The machine is installed and fully operational. Ancillary equipment includes a mold temperature regulator, a resin dryer, and a ventilation system to remove fumes when molding nylon or other resins that give off chemical vapor when melted and molded. An interested alumnus contributed to having the machine painted in Bradley Red. The machine is currently setup to mold pin and disk friction test samples that are being used in an industry sponsored research program. A Master Unit Die (MUD) unit is installed on the machine to facilitate changing the mold cavity without having to go to the complexity of fabricating an entire new mold and mounting it in the machine.

Engel e-victory Injection Molder System

4. **Wood Shop** - There will be an adjacent wood shop area in that many of the activities and projects involve wood mockups, wooden support structures, forming for fiberglass or composite lay-up, etc. This area will also be supervised by the technical staff located in this facility.

   Current Status - There is an existing wood shop in Jobst Hall. It is well equipped and was recently upgraded with an instant stop table saw to improve the safety in the shop. It is used by all the departments in the College for project and presentation work. The area is supervised by a technical staff member located in the shop area. The equipment in this facility will be moved to the new building when it is completed.

Installation of the larger equipment is in Morgan Hall where the major machining equipment is located. This space has been significantly modified to accommodate the new equipment. The SLA system and one of the TRAK lathes are located in Jobst Hall. Once the engineering component of the new Convergence Center between Engineering and Business is completed, all the equipment will be relocated to this new facility in an area we are calling the Product Realization Laboratory.

Student Involvement

The fact that Bradley University is primarily and undergraduate institution has meant that the undergraduate students will have significant involvement with the facilities that have been put in place through the resources of this grant. Undergraduates have been importantly involved in the development and use of the facility. One of the more important forms of this involvement has been in helping to prepare detailed operating instructions for use by students, faculty, and technical staff for several of the more important pieces of equipment. This is an ongoing process and as students make more use of the facilities, improvements are continuously being made. Two operating instruction manuals that have been developed in this manner have been included in appendices to illustrate some of the effort that has been involved in this project and the influence students have in developing learning aids that are more comprehensible to them. The first appendix is the operating instructions for the Omax 2626 xp waterjet. The second appendix is the operating instructions for the Sodick EDM system.

Publicity

Engel Machinery was particularly pleased to have one of their machines as a part of the Manufacturing Laboratory for Next Generation Engineers. A press release was prepared and released to trade publications in the Plastics Industry. The information was used in two articles and they are included in the third appendix.

Conclusions

This grant has allowed Bradley University to establish a Manufacturing Laboratory for Next Generation Engineers that provides a unique facility for engineering education, manufacturing research, and industry-university collaborations. It is a showplace that illustrates modern manufacturing methods to visitors, constituents, and most importantly to the students who use it. Those students will be better prepared to be rapidly effective as they start their careers in industry. This is a laboratory for the future.

OMAX 2626 XP OPERATING INSTRUCTIONS

BRADLEY
UNIVERSITY

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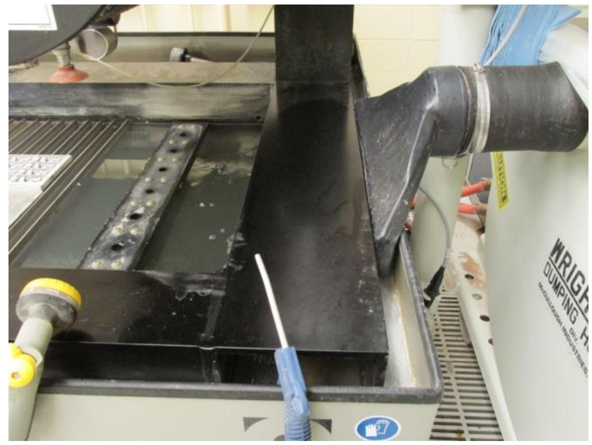
Set Up

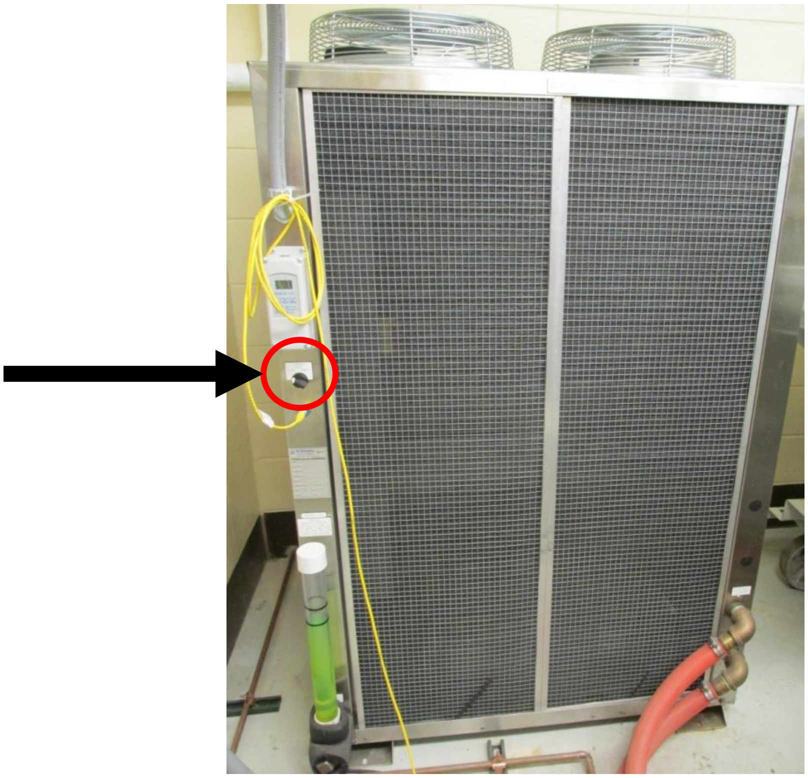
1.) The Reverse Osmosis (RO) system should be plugged into the wall and turned on 24/7.

2.) The Abrasive Removal system should be running continuously to prevent solid abrasive buildup on the bottom of the cutting tank.



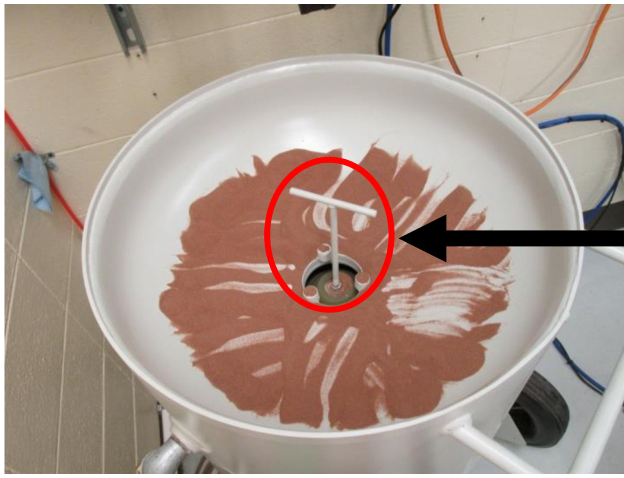
Abrasive Removal System

3.) Turn the cutting tank chiller power switch to local.

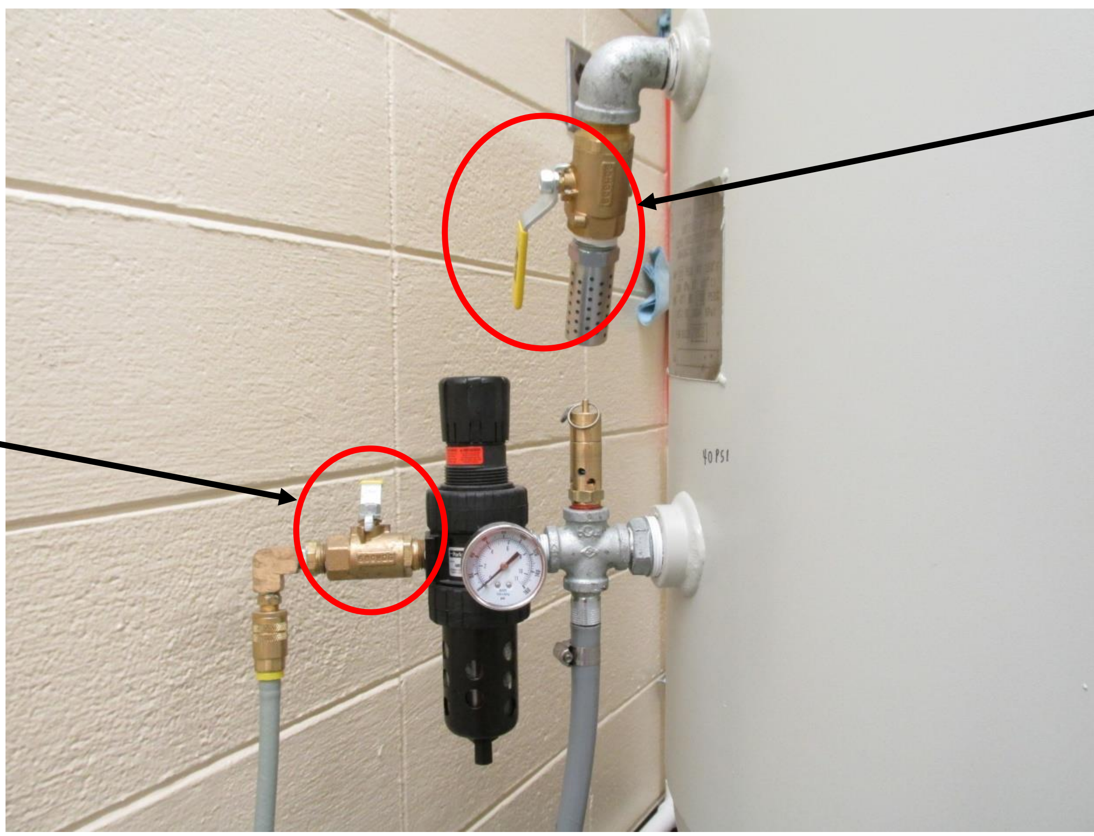


4.) The water to the RO system should be running continuously as well.

5.) **(a)** Open the top of the abrasive storage tank and check the level of material with the gage stick. If needed add abrasive. **(b)** Next, make sure the exhaust valve is closed then lift the fill lid while opening the inlet valve to let air into the tank. Hold the fill lid in the closed position until the air pressure (40 psi) in the tank holds it in place.



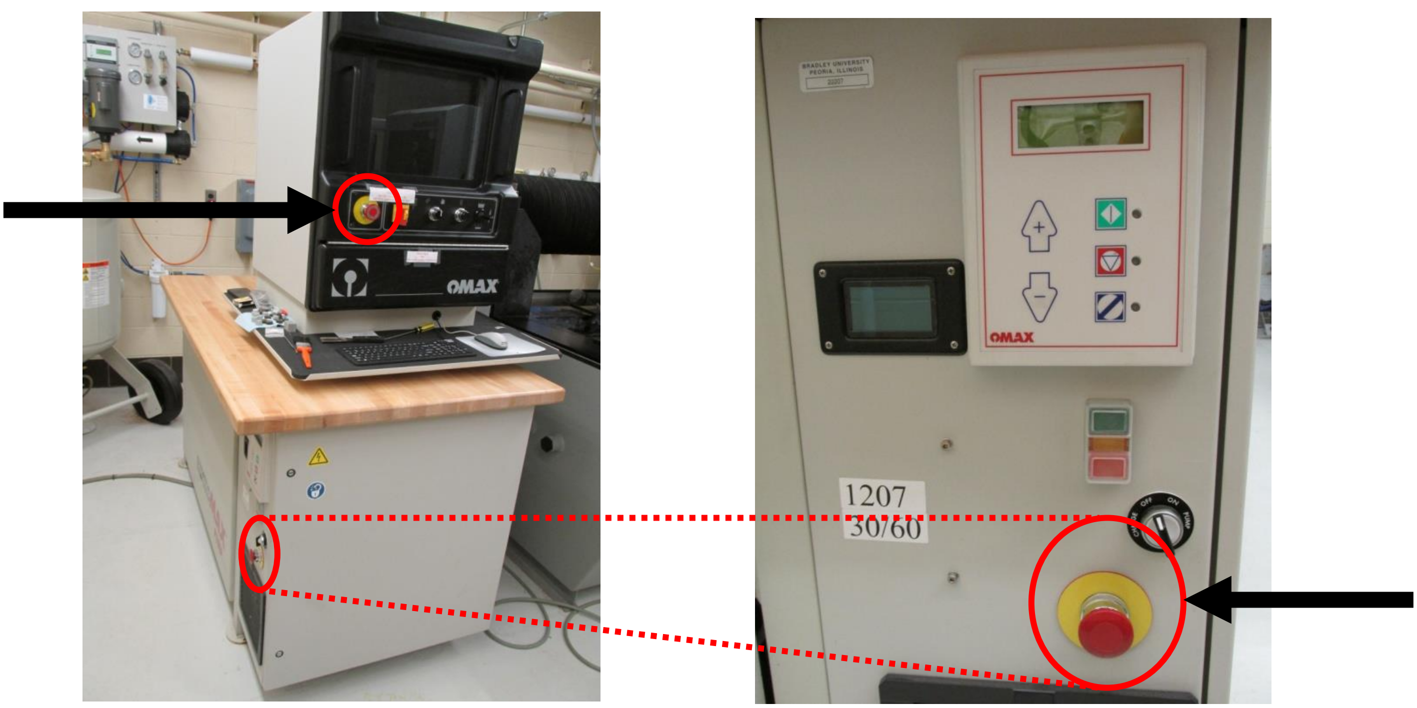
(a)



(b)

6.) Turn on the power to the pump system by moving the lever on the 480 volt disconnect box into the up position.

7.) Check that the Emergency Stop button on the pump and the controller cabinets are in the pulled out position.



8.) Press the power on button on the pump system. It is located on the left side of the pump cabinet as you are facing the front of the waterjet.

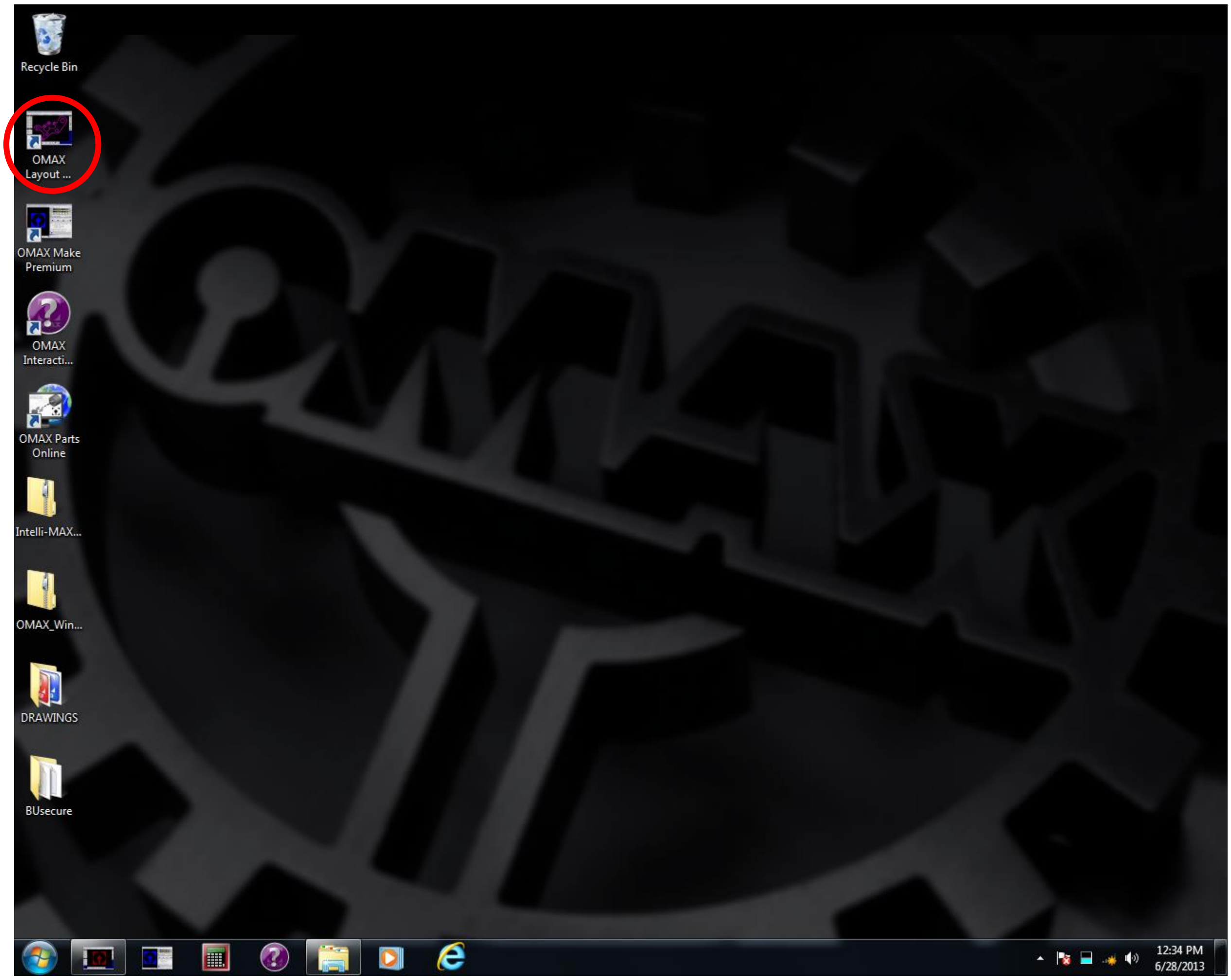
Power Button

9.) Turn on the controller (computer) with the rotary switch on the front of the controller.

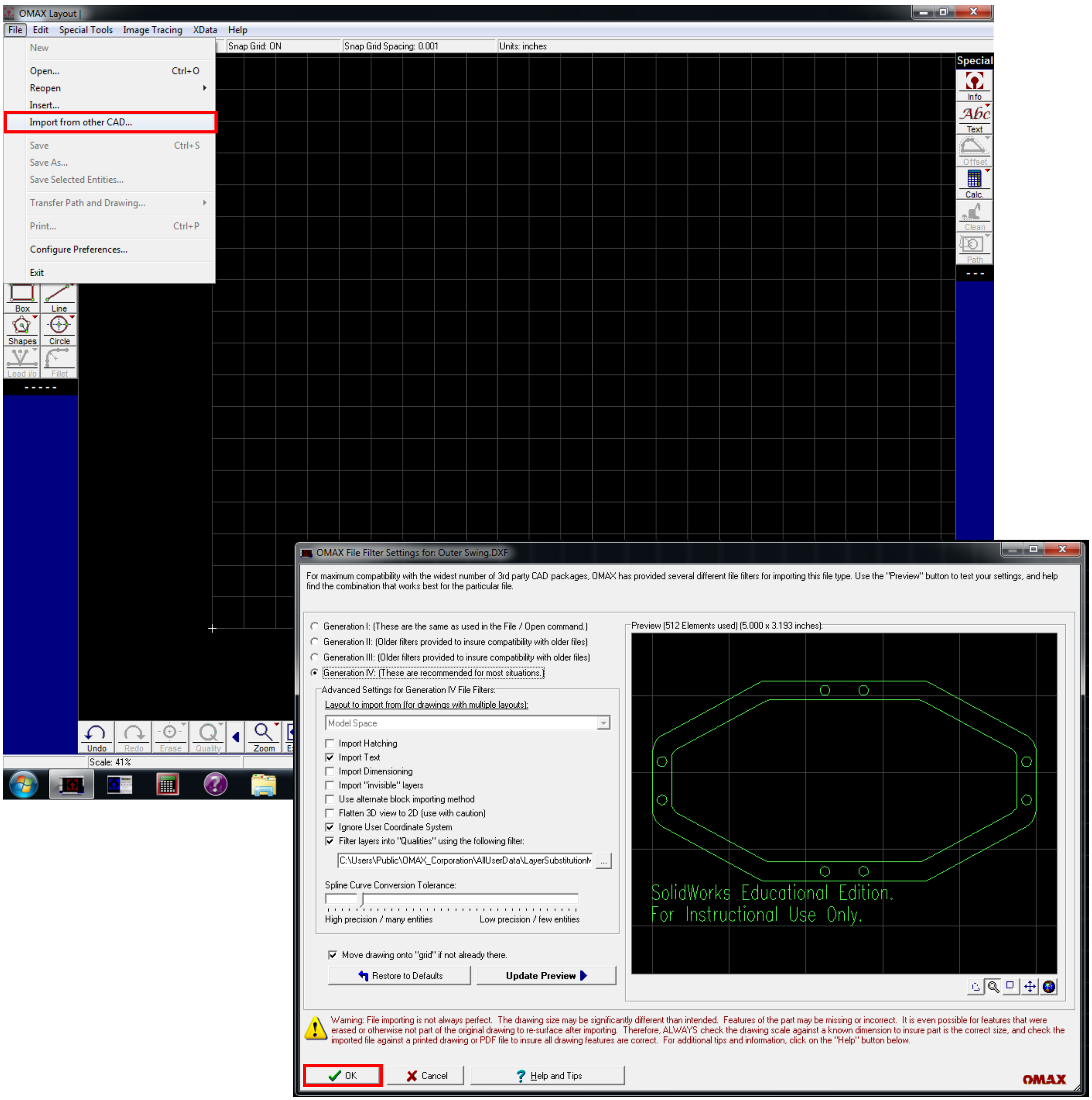
Rotary Switch

Program

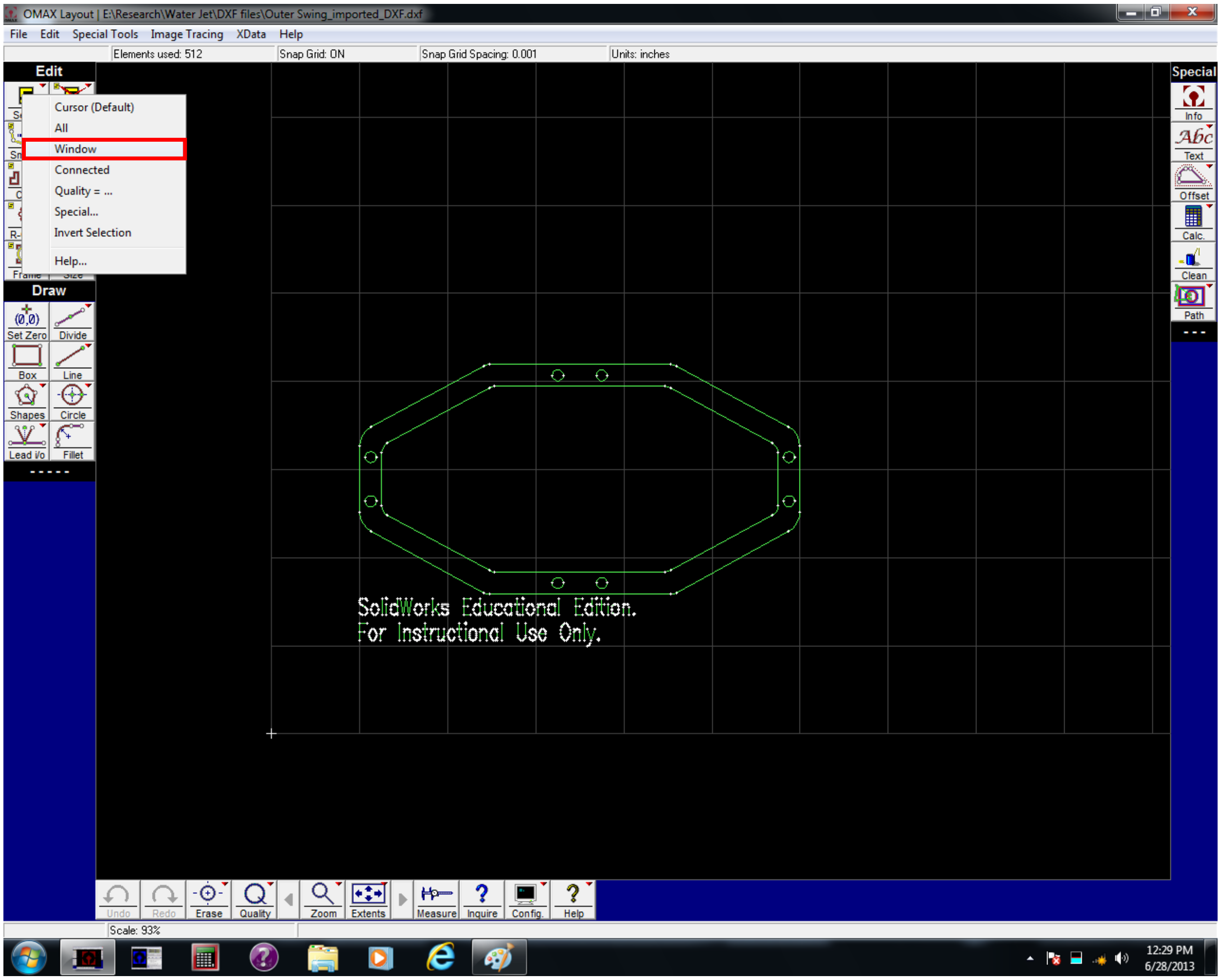
10.) Once the controller (computer) has turned on, double click on the Omax Layout icon to load the controller software.



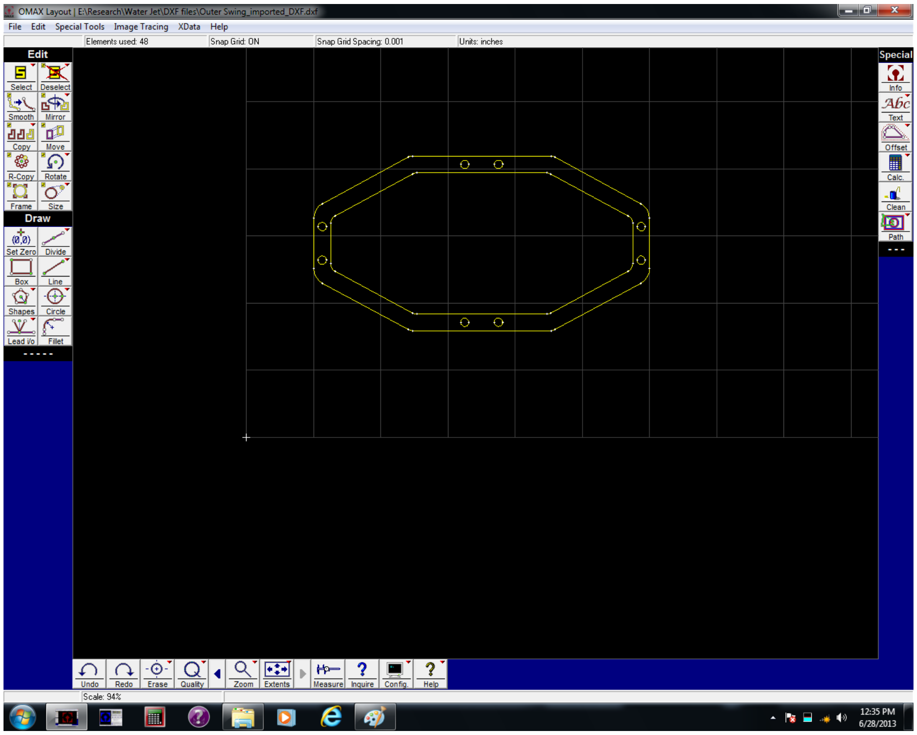
11.) After the program loads, click File and select "Import from other CAD..." on the scroll down menu. A second window will pop up, select the CAD file (usually a DXF file) and click "OPEN." Another window will appear, click "OK."

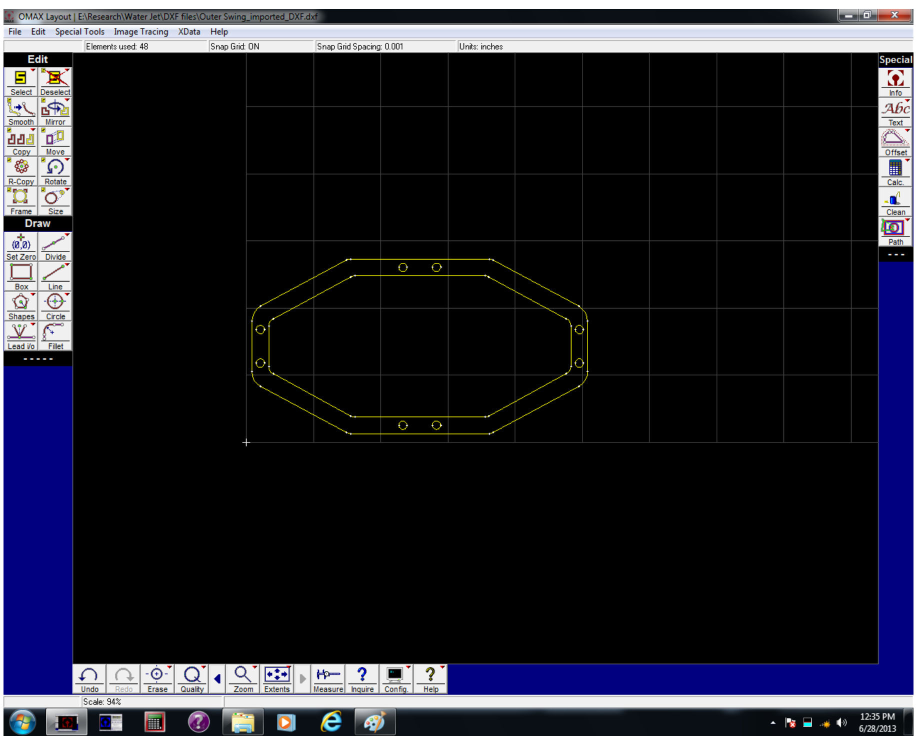


12.) Right click on "Window" in the scroll down menu of the "Select" button. To delete the text "SolidWorks Educational Edition. For Instructional Use Only," select the text by drawing the box over it and release the left mouse button. The selected item will change to a yellow color, Then on the keyboard press "Delete."

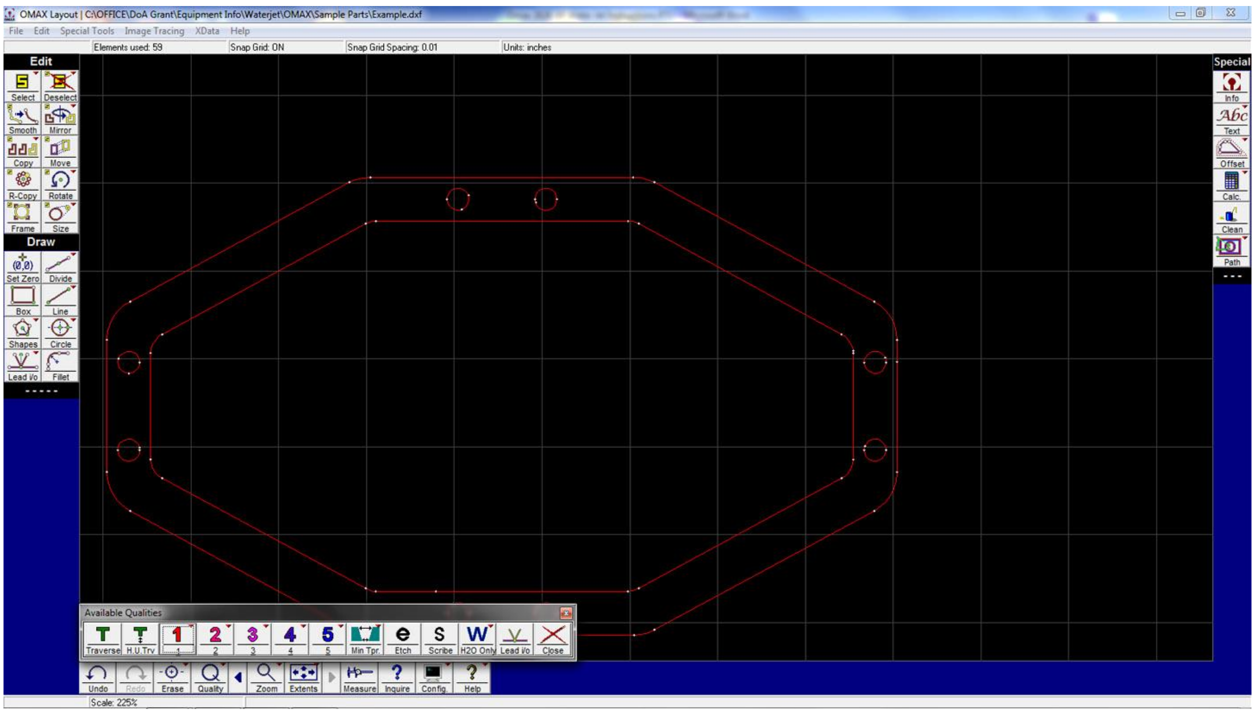


13.) Next, select the entire object using the same method in step 12. Click on the move button and get a cross hair. Left click using the mouse anywhere on or near the object and hold it down while you drag the object close to the corner near the origin (plus sign). Let go of the left click once the object is in the desired position.

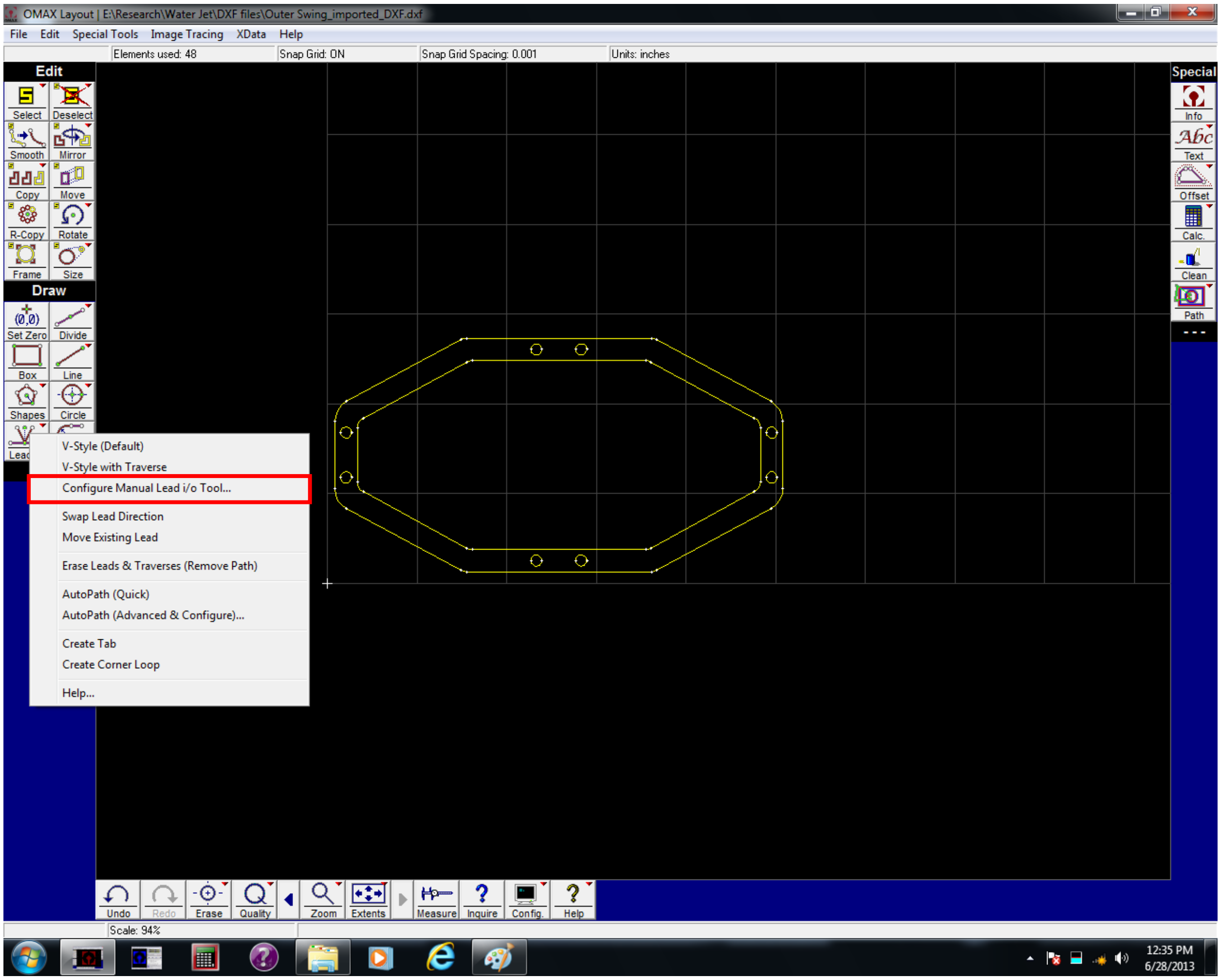




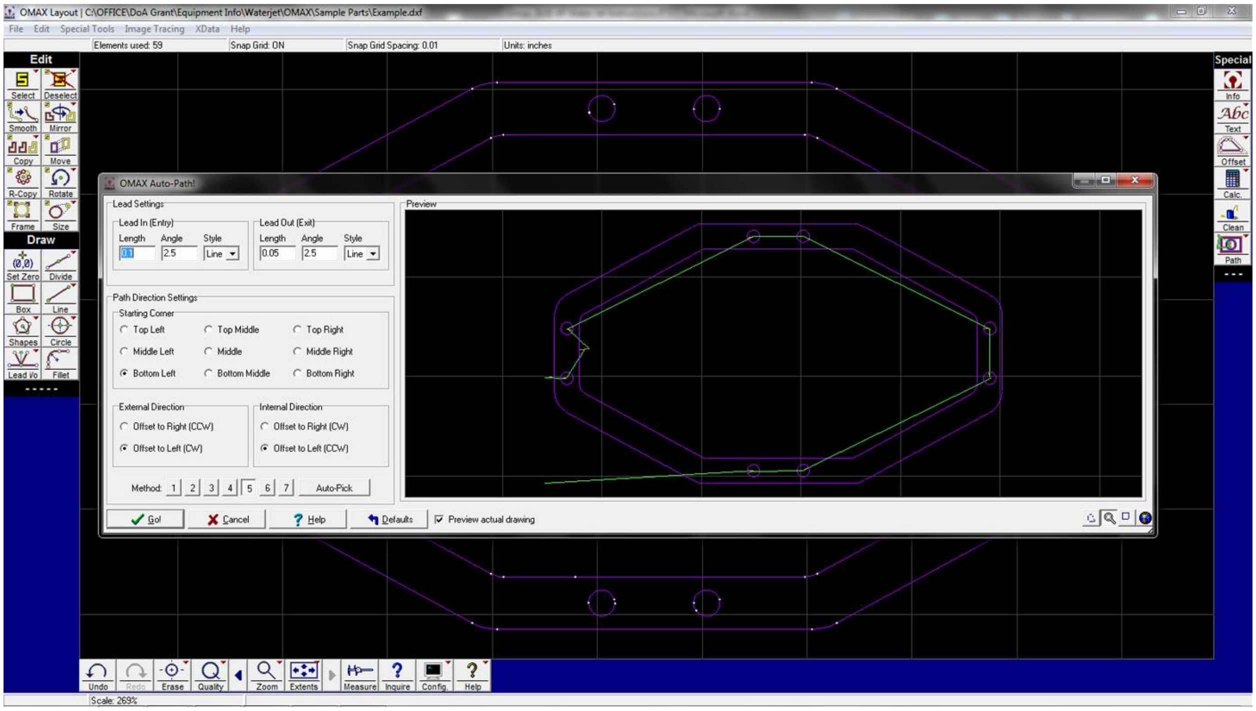
14.) Right click on the quality button and select ALL in the drop down menu. The cut quality selections will appear numbered from 1 to 5. 1 is rough cutting and 5 is fine finish. Cutting speed in inverse to the quality number. 3 or 4 is the normal quality selection. Left click on the number to select a quality. The color of the part outline will change to show the quality. If you want to change the quality, repeat this process and select a different number.



15.) Right click on the Lead i/o scroll down menu, select "Configure Manual Lead i/o Tool..." Another window will pop up from which the offset length of lead in and lead out points can be set. Click "Save" once those parameters are assigned.



16.) Click Lead i/o and select "AutoPath (Advanced and Configure)" on the scroll down menu. The green line is the path the cutting arm takes when it is not cutting. The purple lines that use to be the object dimensional lines are the cutting paths.

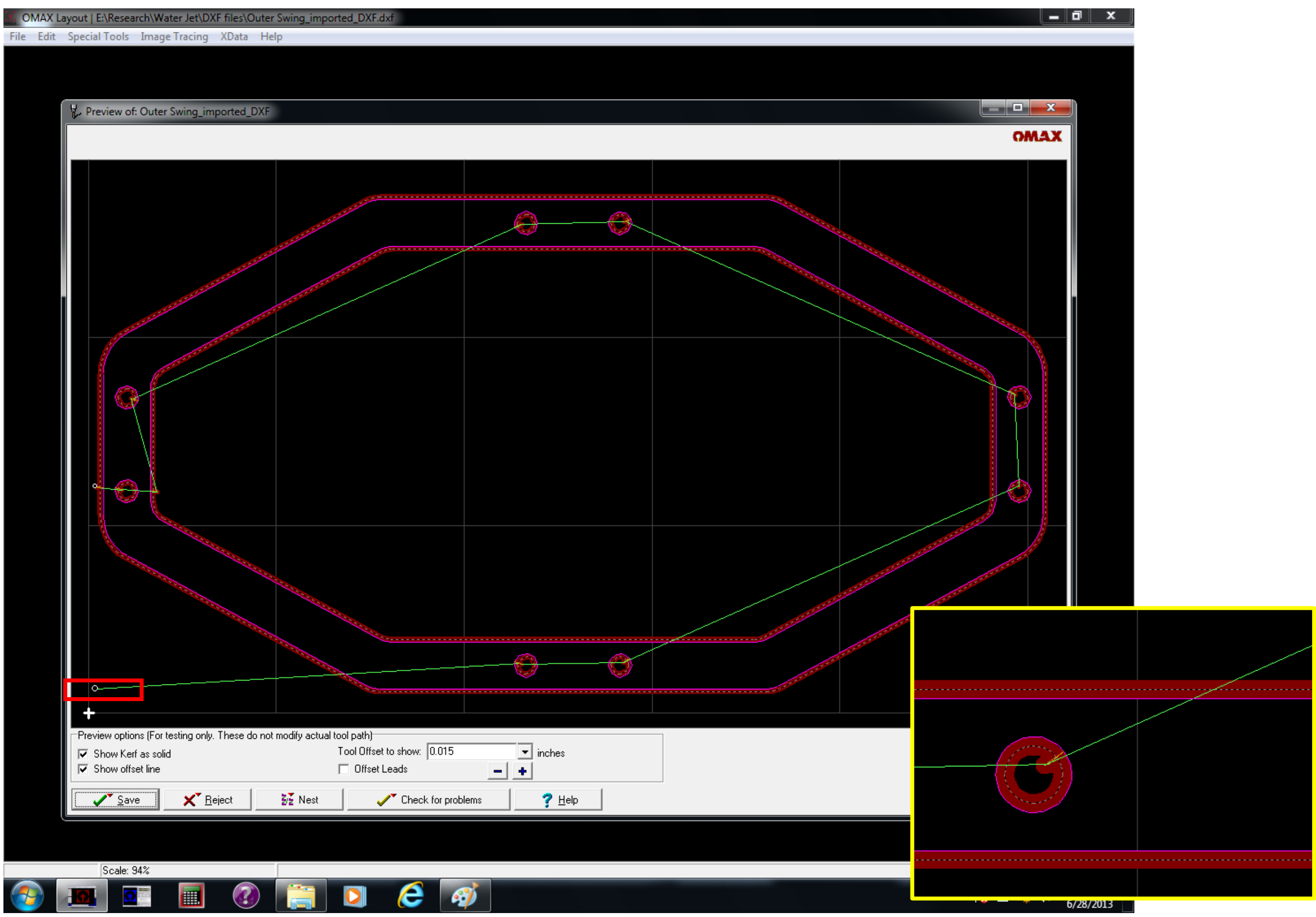


17.) Click on the path button on the right side of the screen. You will be prompted to pick a start point. Move the start point cursor to the end of the lower left green line. Another window will appear, and there are a few things to check for. The cutting path (red dotted line) has to be on the correct side of the dimensional line (purple line). For this example, the external cuts are made on the outside of the dimensional lines and the holes (internal cuts) are made on the inside of the dimensional lines. The lead-in's have to start on the inside of the holes and the cut-out area for the external cuts.

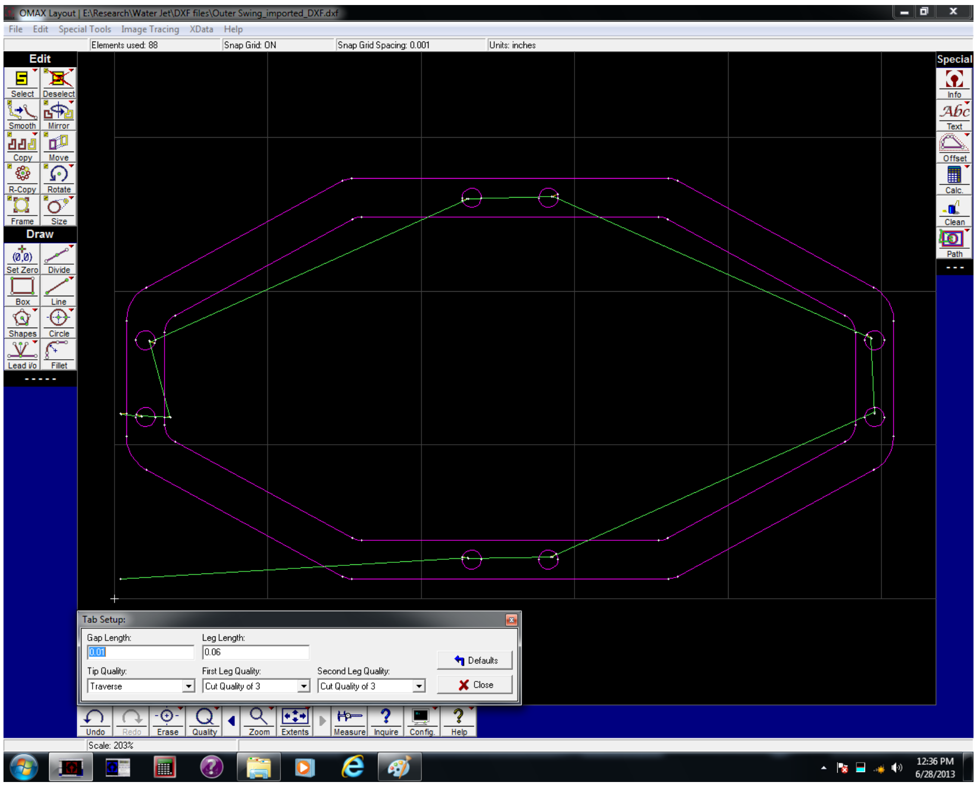
If there is a need to cut several of these objects, click on the "Nest" button and change the number and orientation of the shapes to optimize the space. Click "OK" to save the changes.

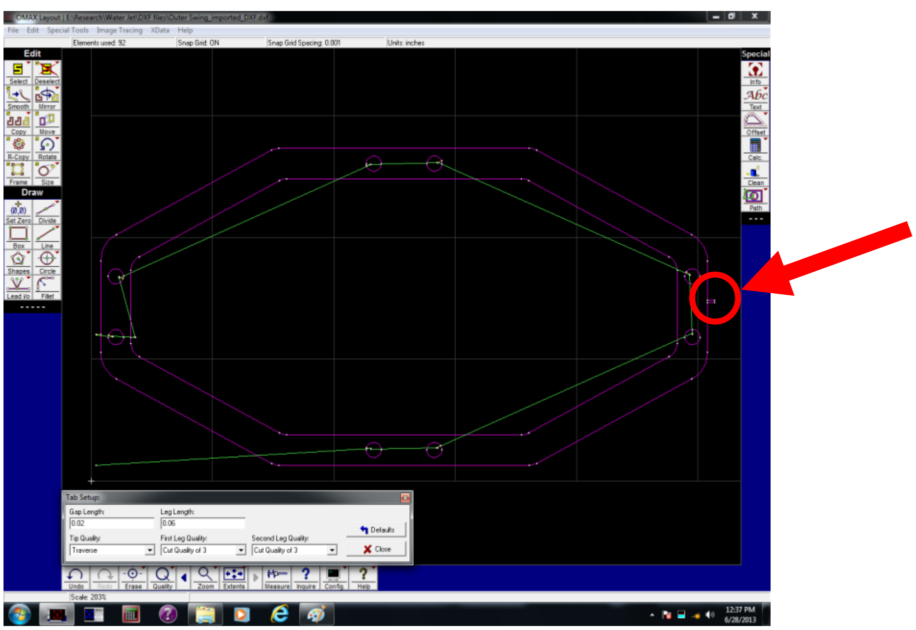
If there is a need to offset the parts, change the offset in the "Tool Offset to show" input box by typing in the number or click the minus or plus buttons.

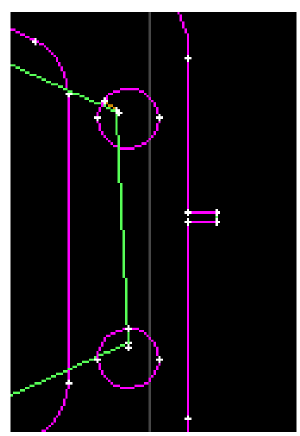
Once finished, click the "Save" button.



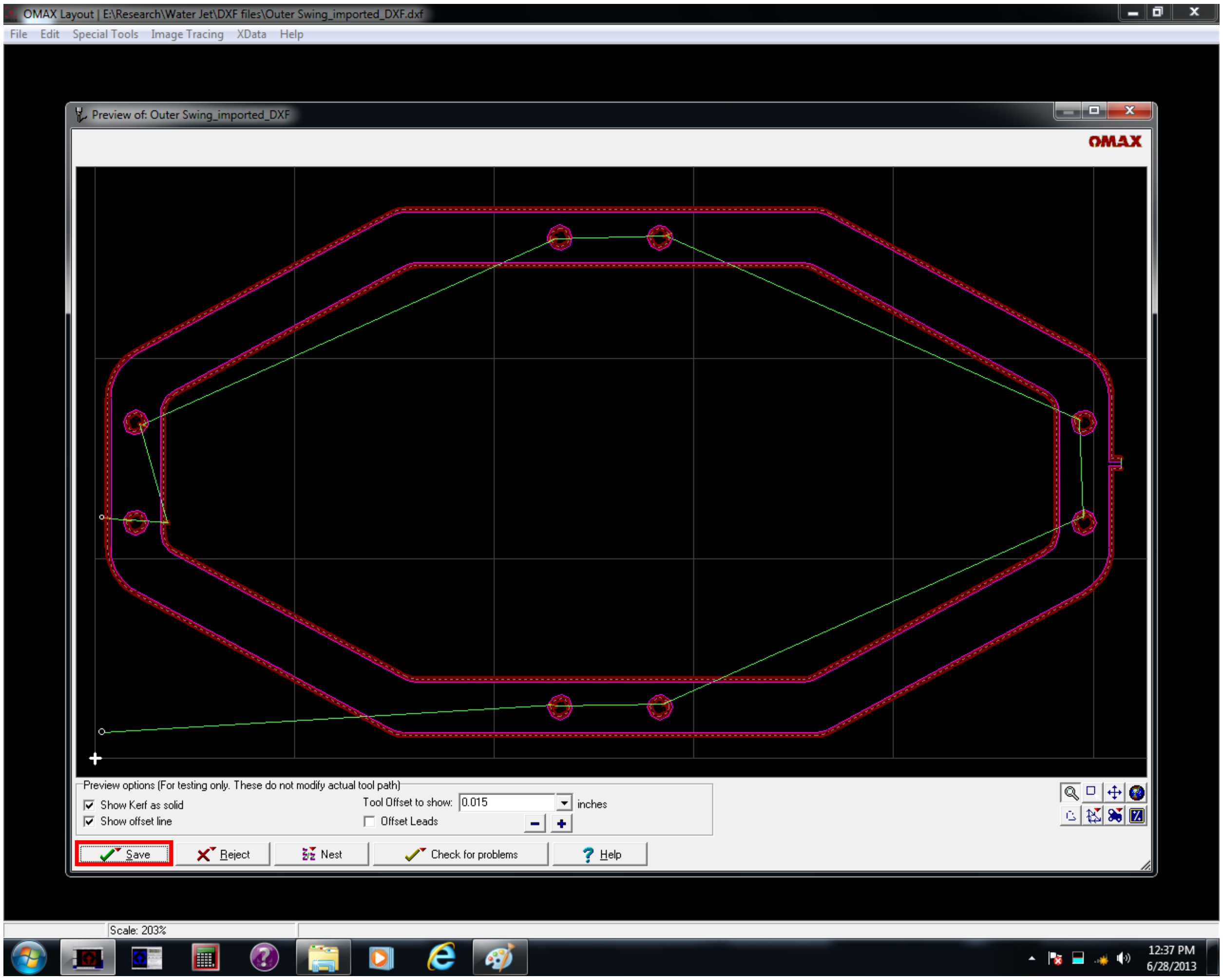
18.) For small parts you may want to add a tab to keep the part from falling off the stock into the tank. First select the edge on which the tab will be created. Right click on "Lead i/o" and select "Create Tab." The dimensions will vary depending on the material, thickness, the location of the part on the work piece. The best method to use is trial and error, but for the 5/16" thick steel the recommended gap length is 0.010" and leg length is 0.032". Click on the left or the right side of the selected line depending on which side you want the tab to jut out or in.



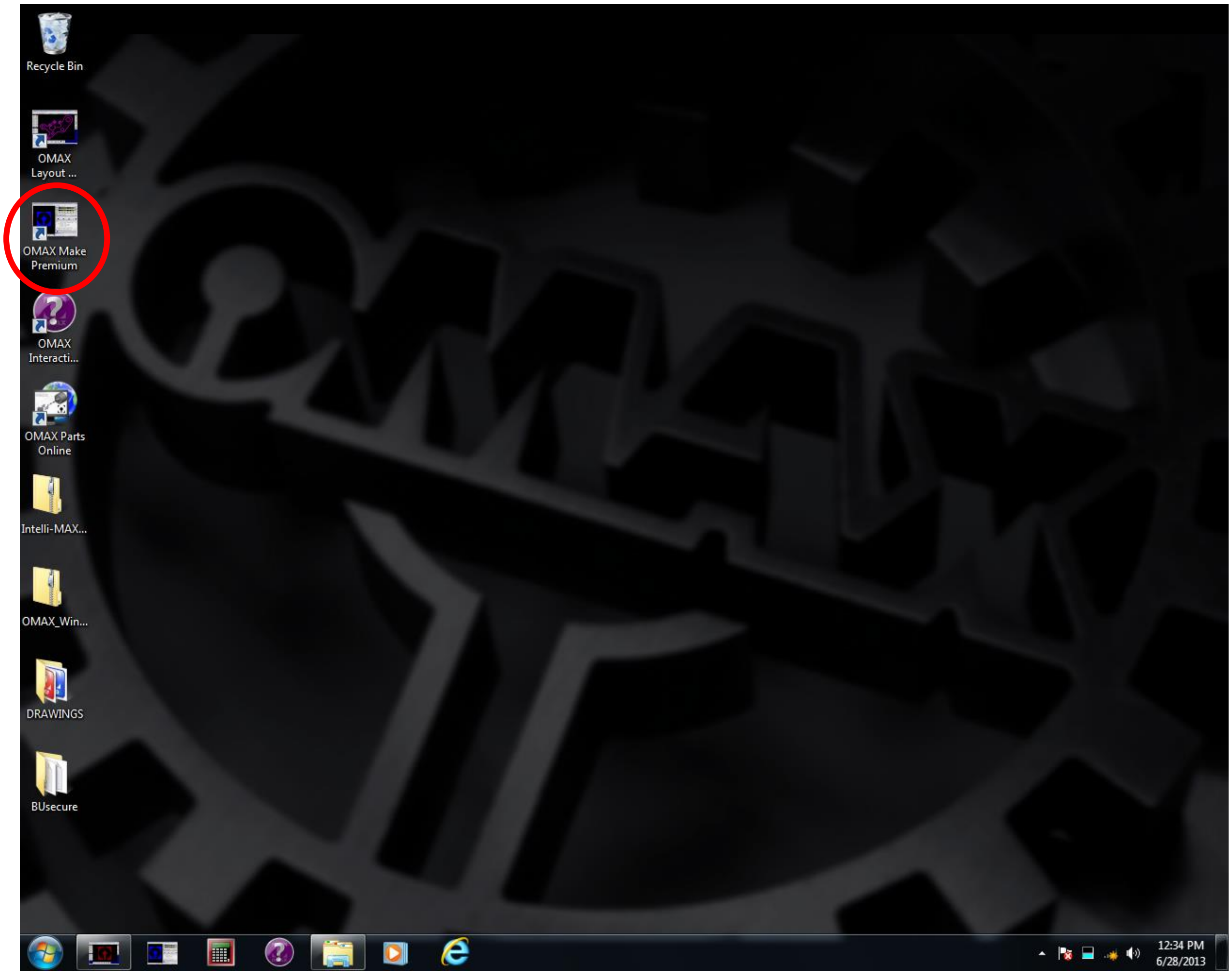




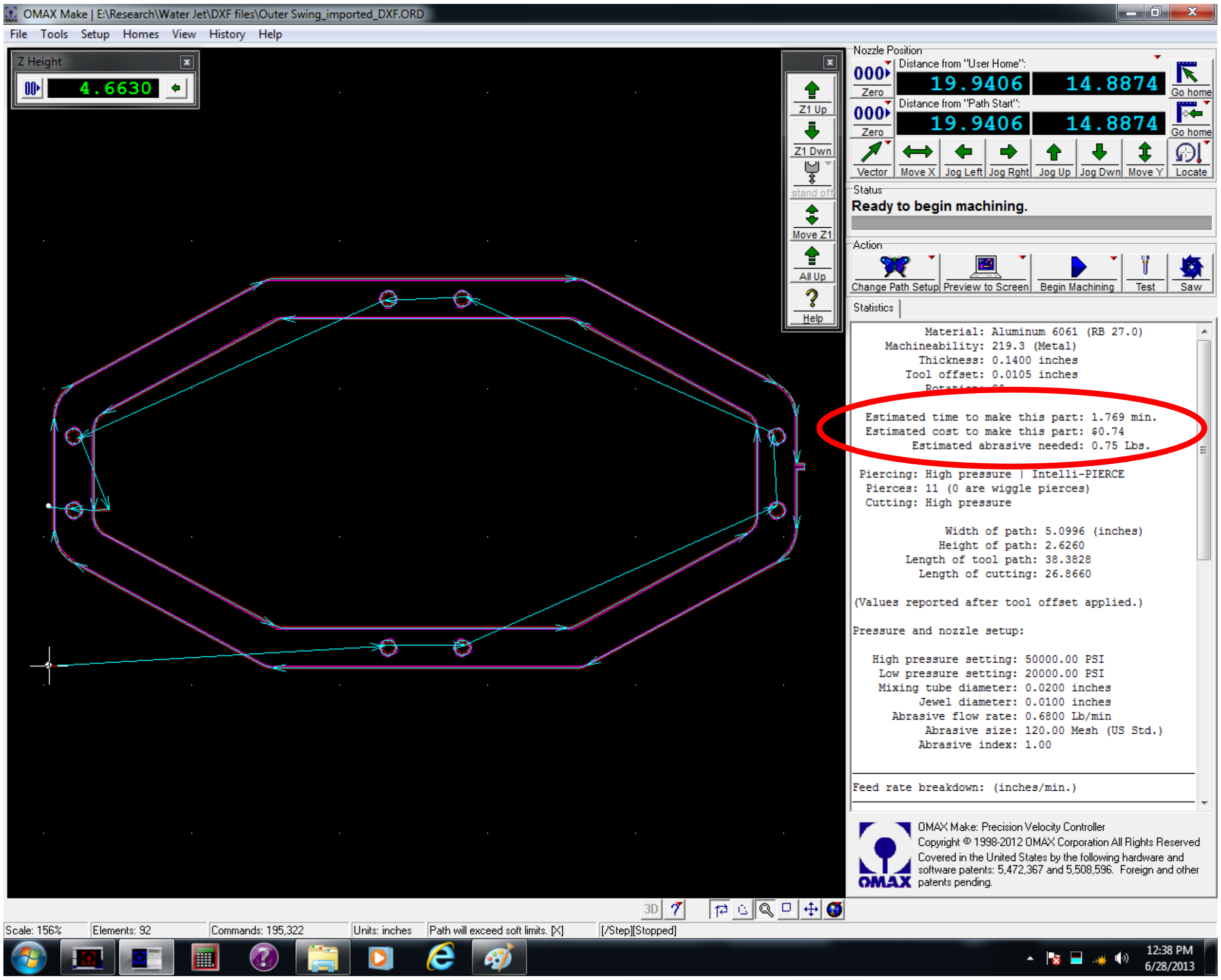
19.) Due to the added change, click on the start point of the green lines. This window should appear, check the green path to ensure that nothing weird happened to the path. Click "Save" to save the changes made to the path.



20.) Close the Omax Layout and click on the OMAX Make Premium icon to load the controller program with the *.ORD extension.



21.) Once the program is loaded, left click on the “Change Path Setup” button. This will open a window that allows you to put in material type and dimensional information as well as other cutting parameters. You can check for collisions, heads up traverses, and nesting from this window as well. Once all information has been entered click the OK button. The information window on the right side of the screen will have the estimates of cutting time and abrasive use. Write down the "Estimated time to make this part" (e.g. 1.769 min.) and the "Estimated abrasive needed" (e.g. 0.75 lbs) on the clipboard sign-in sheet (usually located on the table next to the wall).



Once all your part information is loaded, use the arrow keys and the page up and page down keys to locate the cutting jet. The following actions are produced by the keys:

a) Horizontal arrow keys move the cutting head in the X direction indicated by the key.
b) Vertical arrow keys move the cutting head in the Y direction indicated by the key.
c) Shift + arrow key is used for rapid travel in the X or Y directions.
d) Page up key moves the cutting head up in the Z direction.
e) Page down key moves the cutting head down in the Z direction.
f) The 7 key is rapid up in the Z direction.
g) The 1 key is rapid down in the Z direction.

22.) If this is the first use of the machine after a shut-down, the nozzle needs to be cleared before cutting with abrasive. Move the nozzle a few inches up and to the right of the stock being cut. Position the nozzle between slats. Move the nozzle down to about 1 inch above the water in the tank. Turn on the charge pump on the left side of the pump table. Click on the "Test" button just to the right of the "Begin Machining" arrow. A window labeled "Test Pump and Nozzle" will open. Select "water only" and pump pressure "high" then press the "Start Test" button. The jet will start and a timing window will open. The test can run for up to 60 seconds, but can usually be stopped after 10 or 20 seconds once it is clear that any remaining abrasive has been cleared from the nozzle. Turn off the charge pump once the nozzle test is completed.

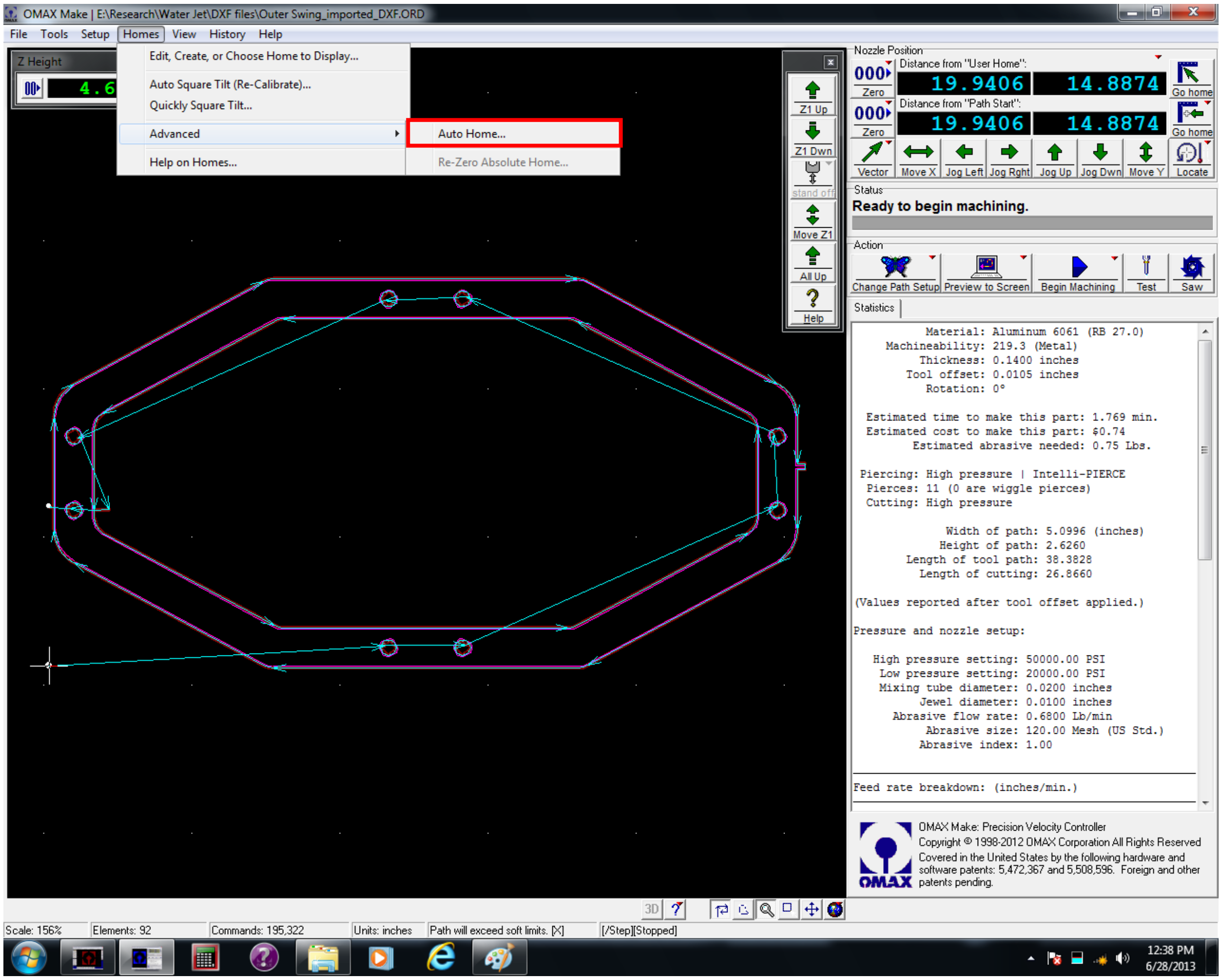
23.) Move the cutting nozzle toward the upper right corner of the cutting tank. This will move it out of the way, so that the material to be cut can be located in the cutting area.

24.) Locate the stock to be cut using the right angle guides in the lower left corner of the cutting tank.

25.) Use the carpenter's clamps to clamp the stock against the angle guides. Locate the clamps in a position to avoid any collision with the cutting head assembly as it cuts the part. (Do not use excessive clamping force on thin materials that might cause them to distort or buckle.)

26.) Move the nozzle in the positive Z direction far enough to clear the sides of the top surface of the cutting tank. Using the X and Y arrow keys, move the nozzle to near the lower left corner of the tank.

27.) Go to Homes > Advanced > "Auto Home..." The cutting arm will move to a specific corner that is set as the default origin. Once the arm moves to that location, a message will pop up verifying its arrival at that location.



28.) Remove the rubber protector on the nozzle to better see its position.

29.) Carefully look over the stock that you plan to cut to determine the highest point on the stock. You will use this point (or area) to set the clearance of the nozzle above the stock.

30.) Make sure that the cutting nozzle will clear the top of the stock before moving it over the work piece.

31.) Move the cutting nozzle until it is over the highest point on the stock.

32.) If the Z axis value is not displayed in the upper left corner of the screen click on view and then click on "display Z axis coordinates." A small window should open with the Z axis coordinate.

32.) Get the 0.060" gage located in a bin under the door at the bottom of the control console.

33.) Place the gage on the high point of the stock under the tip of the cutting nozzle.

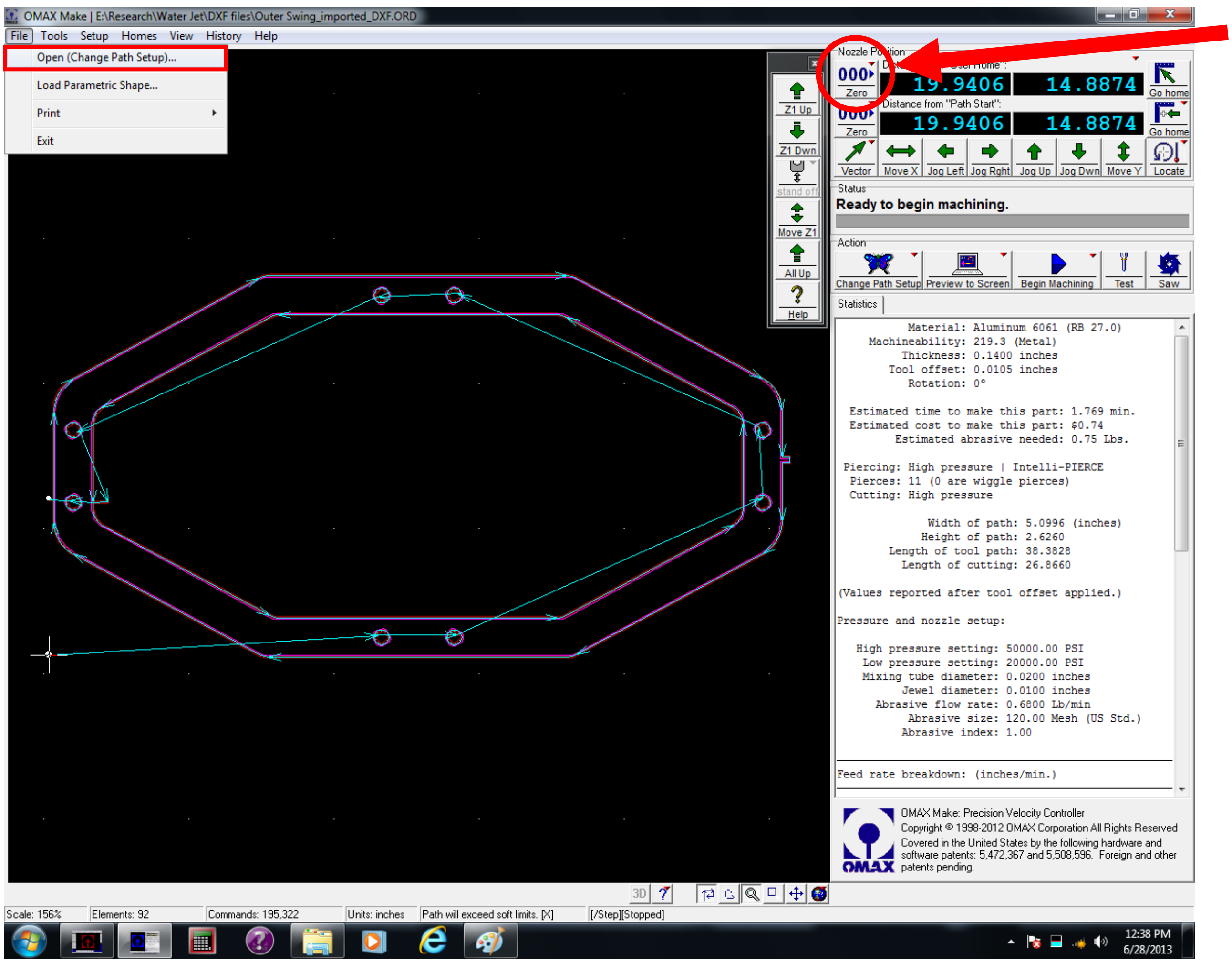
34.) Very carefully move the nozzle until it is touching the top of the gage and then move it down in small steps as the gage is brought parallel to the top of the stock. Move the gage slightly after each step until there is very little (but some) vertical clearance between the end of the nozzle and the top of the gage. The Z axis position will display in the upper left corner of the screen.

35.) Click on the zeros at the left of the Z axis display to establish the zero Z position for the end of the cutting nozzle.

36.) Repeat the Z axis clearance test near the corners of the area you expect to cut to be sure that the 0.060" minimum clearance is maintained. If Z must be raised to maintain 0.060" clearance, be sure to reset the Z zero.

37.) Select a point on your stock that you would like to be 'User Home." Usually this is a specific identifiable point on the stock, perhaps at the lower left corner or some specific distance from that corner. Using the X and Y arrow keys, move the nozzle to this point. In the upper right hand corner of the screen left click the zeros under the position display labeled "Distance from User Home." This saves the user home position which is a reference point on the stock. Now move the nozzle to the point where you would like to star the cutting path. Left click the zeros under the position display labeled "Distance from Part Zero." This saves the starting point for the cutting path. This point can also be located by typing in dimensions using the "move X" and "Move Y" commands under the position displays. Plus X moves the nozzle to the right and plus Y moves the nozzle away from the front of the tank.

38.) Once the home positions have been established and you are ready to cut the part, left click on the "go home" arrow next to the path start distance display. The nozzle should move to the path starting position.

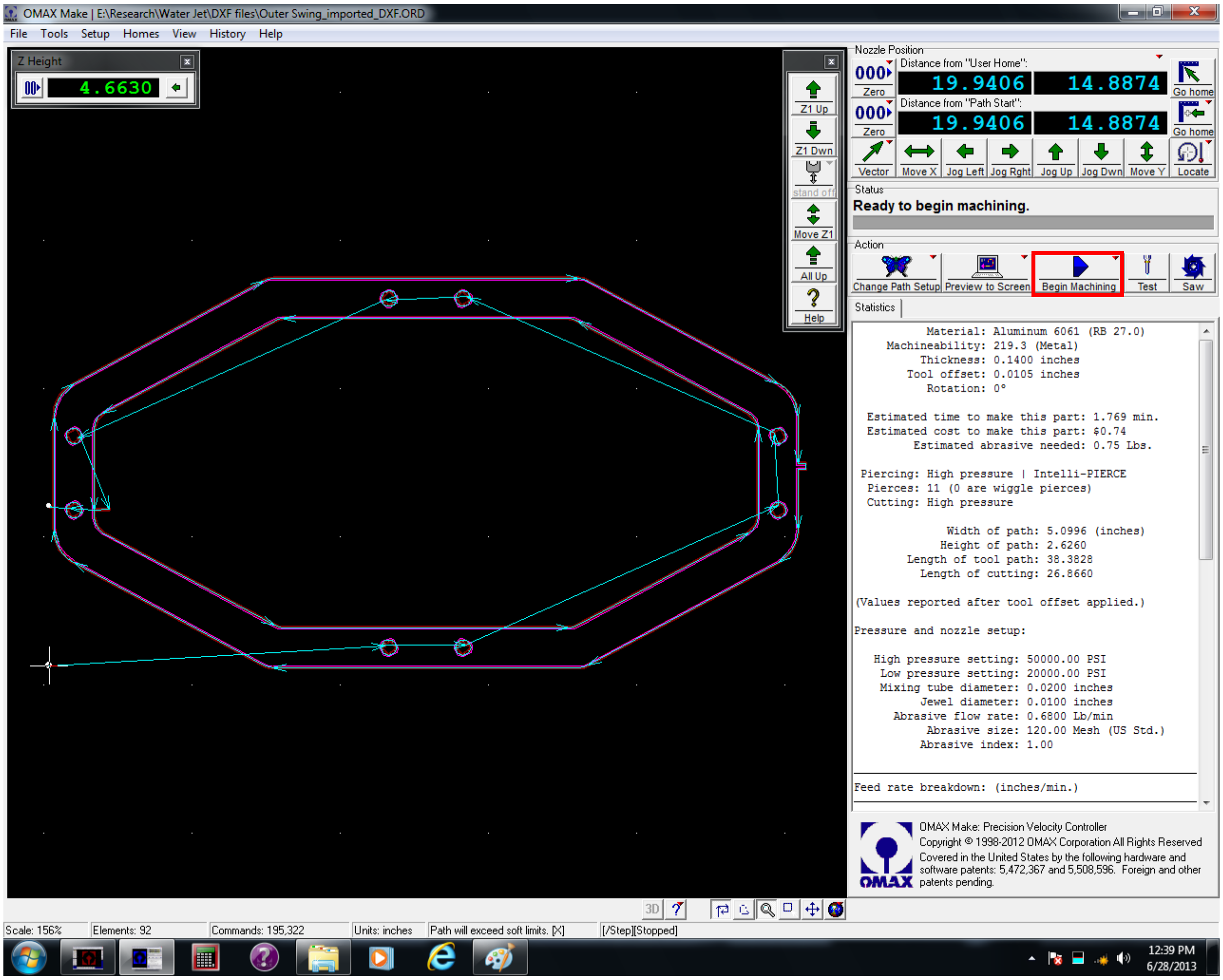


39.) Place the rubber protector back around the nozzle. (You will probably have to raise the nozzle in the Z direction to do this. Once the protector is back on, left click on the go home arrow next to the Z display. The Z axis will return to the 0.060" clearance position.

40.) Use the control on the console to raise the water level in the tank so the rubber spray cup is about half submerged.

41.) The charge pump switch is located on the left side of the pump enclosure. Turn it to the on position.

42.) Click "Begin Machining" when ready to cut out the object. A window will pop up, click "Yes." A second window will pop up, click "No." The arm will move to the zero point and start its route, which can be seen on the computer. Watch the path of the arm to make sure it is moving in the desired direction, and if not click the "Pause" button. Once the arm completes the entire path, turn off the pump and lower the water level. Move the nozzle up in the Z direction to be sure it clears any cut parts and then move it a good distance away from the part and carefully remove the part.



43.) When you are not actively cutting the charge pump should be turned off.

44.) When it is time to shut down the machine use the following shut down procedure.

Shut Down

1.) Clear the nozzle using the procedure of step 22 above. Leave the nozzle parked in the upper right quadrant of the tank and several inches above the water level.

2.) Exit the Make program.

3.) Shut down the windows computer using the normal computer shut down process and wait until it is completely shut down.

4.) Turn off the controller (computer) with the rotary switch on the front of the controller.

5.) Press the power button on the pump system to turn it off.

6.) Turn off the power to the pump system by moving the lever on the 480 volt disconnect box into the down position.

7.) Turn the handle of the air intake valve of the abrasive tank to the closed position and the exhaust valve to the open position. When all the air is released and the pressure gauge reads 0 psi, then turn the exhaust valve back to the closed position.

8.) The water to the RO system should be running continuously, so check it.

9.) Turn the cutting tank chiller power switch to the off position.

10.) The Abrasive Removal system should be running continuously to prevent solid abrasive buildup on the bottom of the cutting tank.

11.) The power to the Reverse Osmosis (RO) system should be on 24/7.

Maintenance Check List

1.) The nozzle assembly should be replaced when the jewel orifice needs replacing.

2.) The nozzle filter should be changed when the filters on the charge pump system need changing.

3.) The mixing tube should be rotated 90 degrees every 10 hours of pump operation.

4.) The Tilt-a-jet needs to be squared after each mixing tube rotation

Operating Instructions

Sodick VZ300 EDM

BRADLEY UNIVERSITY

Start Up

1. Make sure air supply to machine is on. Check the pressure gage on the right rear of the machine. The nominal range is 0.4 to 0.6 with 0.5 being the target.

2. Turn on the main power switch to the machine. It is located in the left rear of the machine.

3. On the right top of the display press the “Source on” button and wait for the computer system to come up and load all the operating software.

4. After the computer has finished coming up the screen shown in Figure 1 will appear. Press the “Power on” button next to the Source on button to supply power to the machine itself.

5. **Machine coordinates**:
   a. The machine has 5 axes - X,Y,Z,U,V
   b. X,Y, and Z are the basic operating axes for the machine. When viewed from the front of the machine +X is to the right, +Y is toward the back of the machine, and +Z moves the upper head of the wire feed upward from the table.
   c. U and V are used to describe the motion of the upper head when it does not follow the basic operating coordinates for the machine. +U is in the +X direction, but may not have the same coordinate as X. +V is in the +Y direction, but may not have the same coordinate as Y. U and V are axes parallel to the X and Y axes but at a higher Z coordinate than the lower head that moves in X and Y. **Normally U and V have the same values as X and Y when straight cuts are being made. U and V will have different values when tapered cuts are being made. The difference will be calculated by the machine when the values of the taper are established and entered.**

6. **Machine Home**:
   a. When the machine first starts the screen shown in Figure 2 will appear. It prompts for **Limit Move**. When you press enter it will move to machine home or zero coordinates in the lower left corner of the table. **Before pressing enter, be sure that no stock has been mounted on the machine that will interfere with the motion of the cutting wire heads to the lower left corner of the work space.** The lower head will move to machine home/zero for X and Y. The upper head will end up at machine home/zero for U and V. The zero for U and V will actually end up at minus X and Y machine coordinates. This difference is related to the ability to cut tapers.
   b. Once the home move is completed, the machine automatically calls up the program to move U and V back into alignment with X and Y. Two alarm beeps will signal completion.
   c. While in this screen check the resistivity of the water by looking at the term RESIST in the box in the upper right hand corner of the screen. It should be between 55,000 and 65,000. It needs to be in this range for proper cutting by the wire. If it is below 55,000 you will need to wait for the deionizing system to treat the water to bring the level within range before cutting.

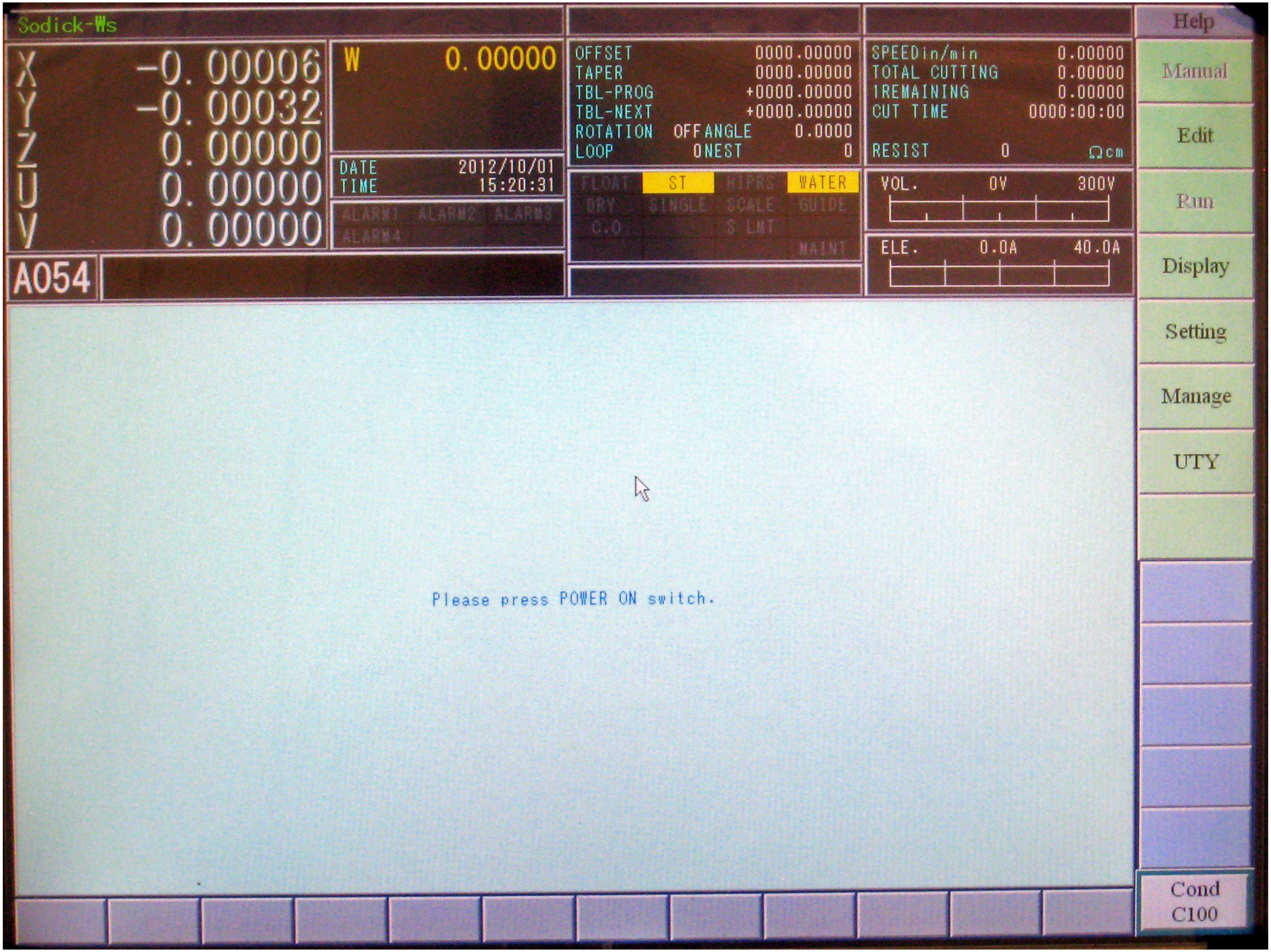


Figure 1 - Power On Screen

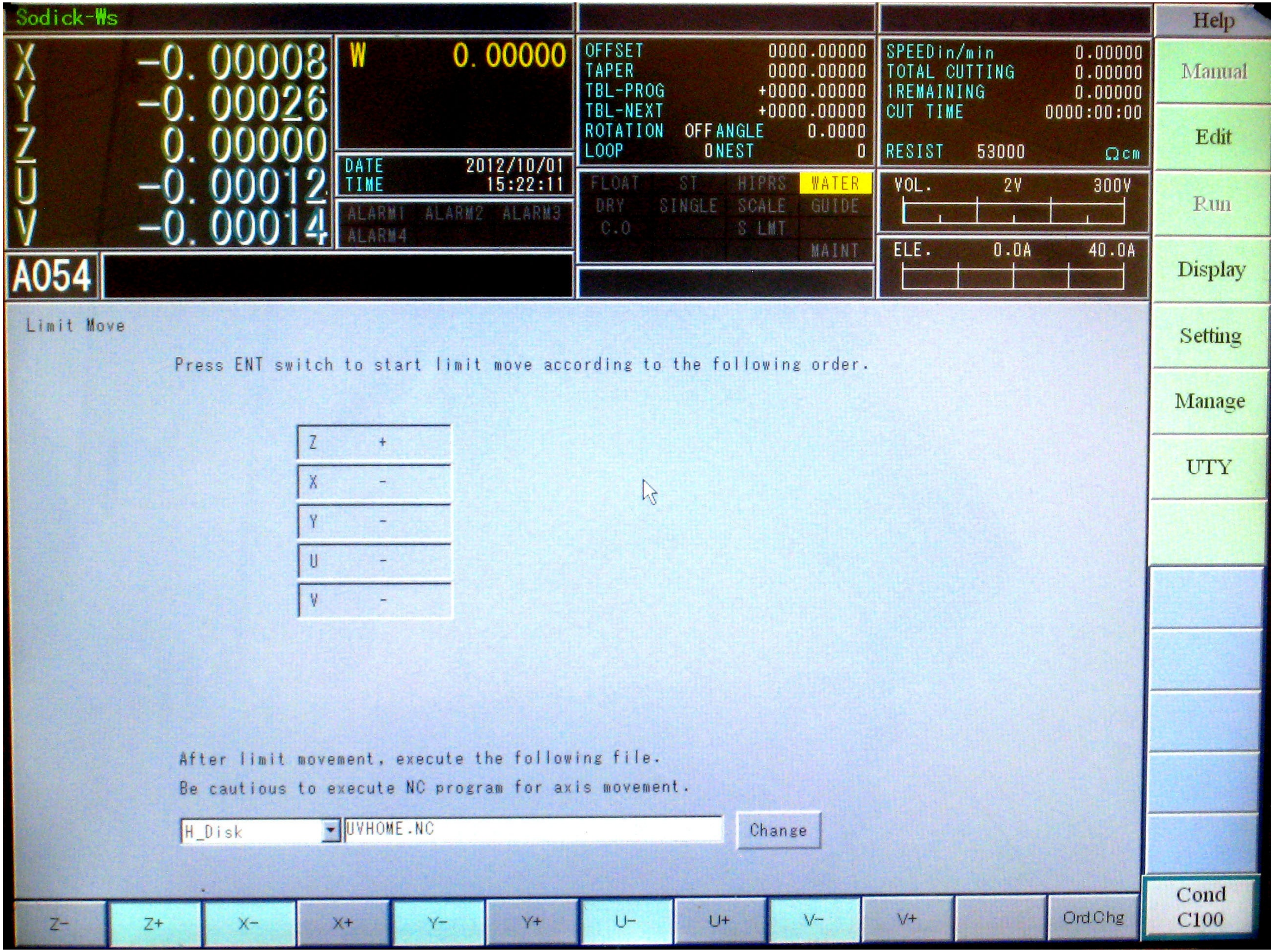


Figure 2 - Machine Home Screen

7. **Move Actions**:
   a. After home calibration is completed the machine will go to **Manual** in the green buttons in the upper right hand portion of the screen. Submenu buttons will now appear in the blue area in the lower right portion of the screen and the **Codeless** button will be lit. Now Click on the **Move** button near the left end of the buttons along the bottom of the screen. The screen should appear as Figure 3.
   b. You are now able to move the cutting wire to any location in the cutting area. Typically the location you choose will be the zero point for the coordinate system you will use to cut your part. This means it will be dependent upon where on the base you mount your stock to be cut.
   c. Once you have mounted your stock and know where you want the coordinate system zero to be you need to make sure that **Move** is selected under "move type".
   d. Next you need to select the number of the coordinate system you want to use for your part. (The machine can store a number of different systems to accommodate different parts.) The default coordinate system is 54 and is shown as **A054** in Figure 3. You can change the coordinate system by changing the number in the box on the "Coord sys change" line. For now the number 55 through 59 can be used.
   e. Make sure that the "Movement" line has the ABS box selected to use absolute coordinates. In the "ST" line make sure that the ON box is selected.
   f. You may now use the control pendant shown here to move the cutting wire to the starting location for your part. Press the MFR0 button for rapid traverse and use the +X, -X, +Y, -Y buttons to move the wire near where you want the starting point. Make sure that the Z axis is high enough to clear any stock you may have mounted.
   g. As you near the starting location for your part press the MFR1 or MFR2 button to slow the traversing speed. Typically MFR2 is best as you get near the location you want.
   h. If the starting point is in a hole within the stock, very carefully move the lower head under the stock using a 0.005" feeler gauge to make sure there is adequate clearance. **If the clearance is less the 0.005", the stock must be repositioned so that the clearance is 0.005" or slightly greater.**
   i. Once you have the cutting wire positioned at the coordinates you want to be the zero for your part click on the **Coord Set** button in the lower left corner of the screen.

8. **Coordinate Setting (X, Y, U, and V):**
   a. The screen should now look like Figure 4.
   b. On the line “Coord set type” make sure that the Set box is clicked
   c. On the line “Axis and Value” click on X and then click on Y. Windows with X = 0 and Y = 0 will open and the screen will appear as in Figure 5. Simply press enter to set these as the zero coordinates for your part.
   d. The screen should now appear as shown in Figure 6 where the coordinates X, Y, U, and V are zero and green in color. The Z coordinate is in yellow and is not changed. Z zero will be set in the next step with positioning the upper head over the stock used to make the part.

9. **Coordinate Setting (Z zero):**
   a. Go back to the move screen by clicking on the **Move** button to the right of the **Coord Set** button.
   b. Now use the pendant and the Mfr0 and Mfr2 buttons to bring the upper head down to near the surface of the stock to be cut. If the head is not located over the stock sufficiently, move X and Y to locate it over the stock.
   c. Use a feeler gauge to carefully set the Z height to 0.005" above the stock. You should be able to slide the feeler gauge and feel it lightly touching on both sides.
   d. Now click on the **Coord Set** button. Under (2) Axis and Value click on Z. The value of 0.0000 should show in the Z widow that opens. Press enter and the machine will set this position at 0.005" above the stock as Z=0.0000. The screen should now appear as in figure 7. This is now the zero position for coordinate A054.

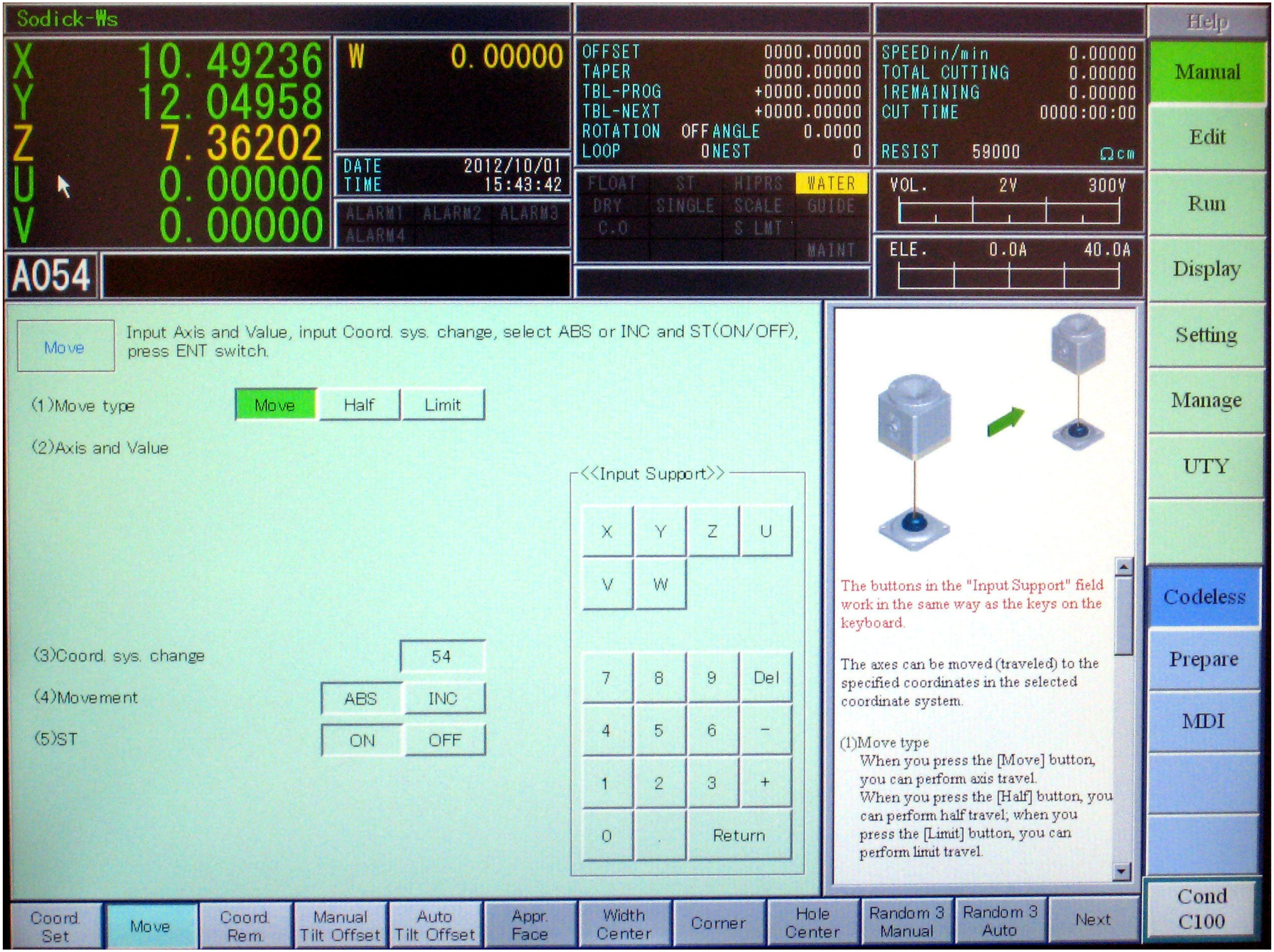


Figure 3 - Move Screen

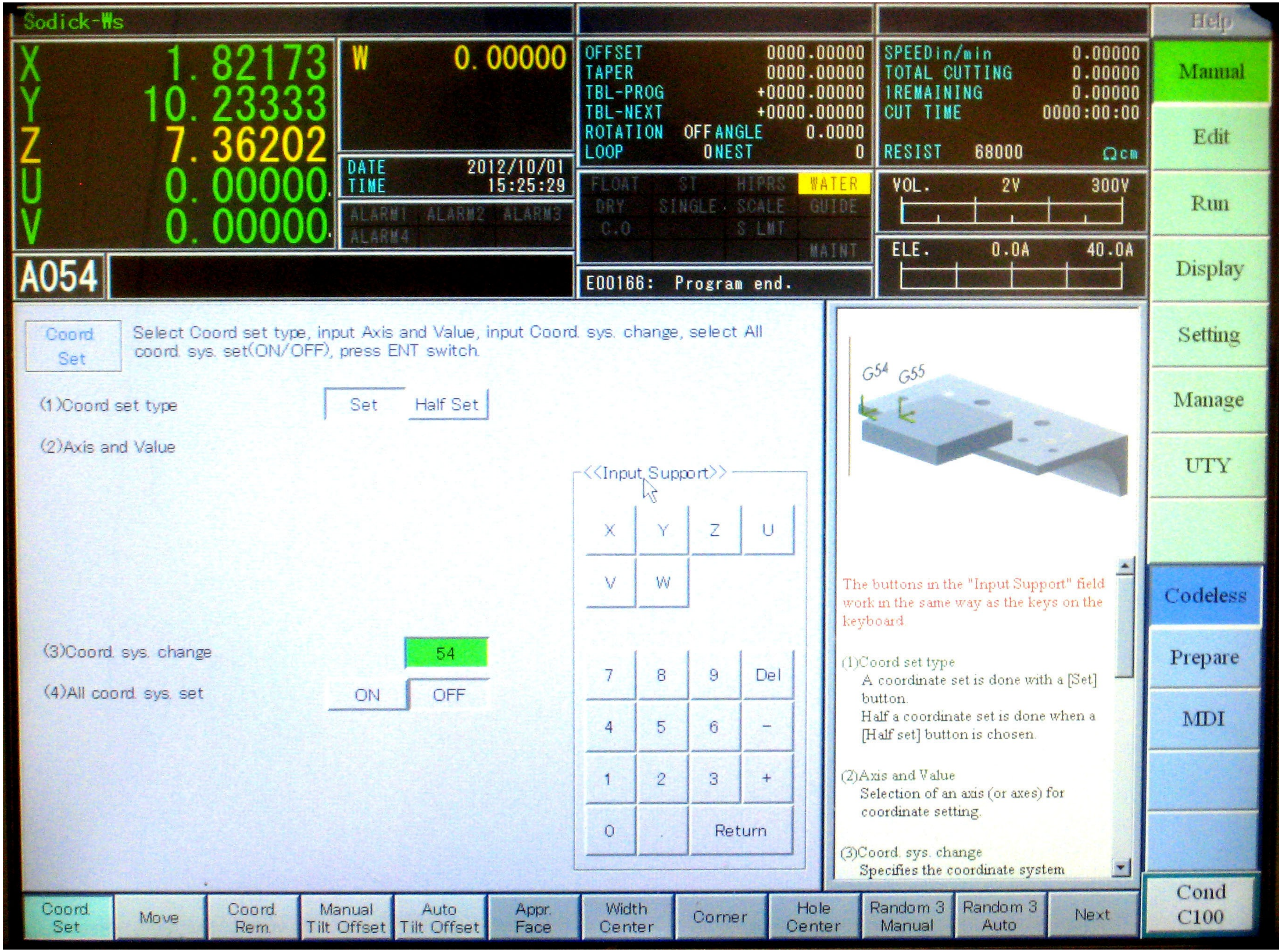


Figure 4 - Coordinate Set Screen

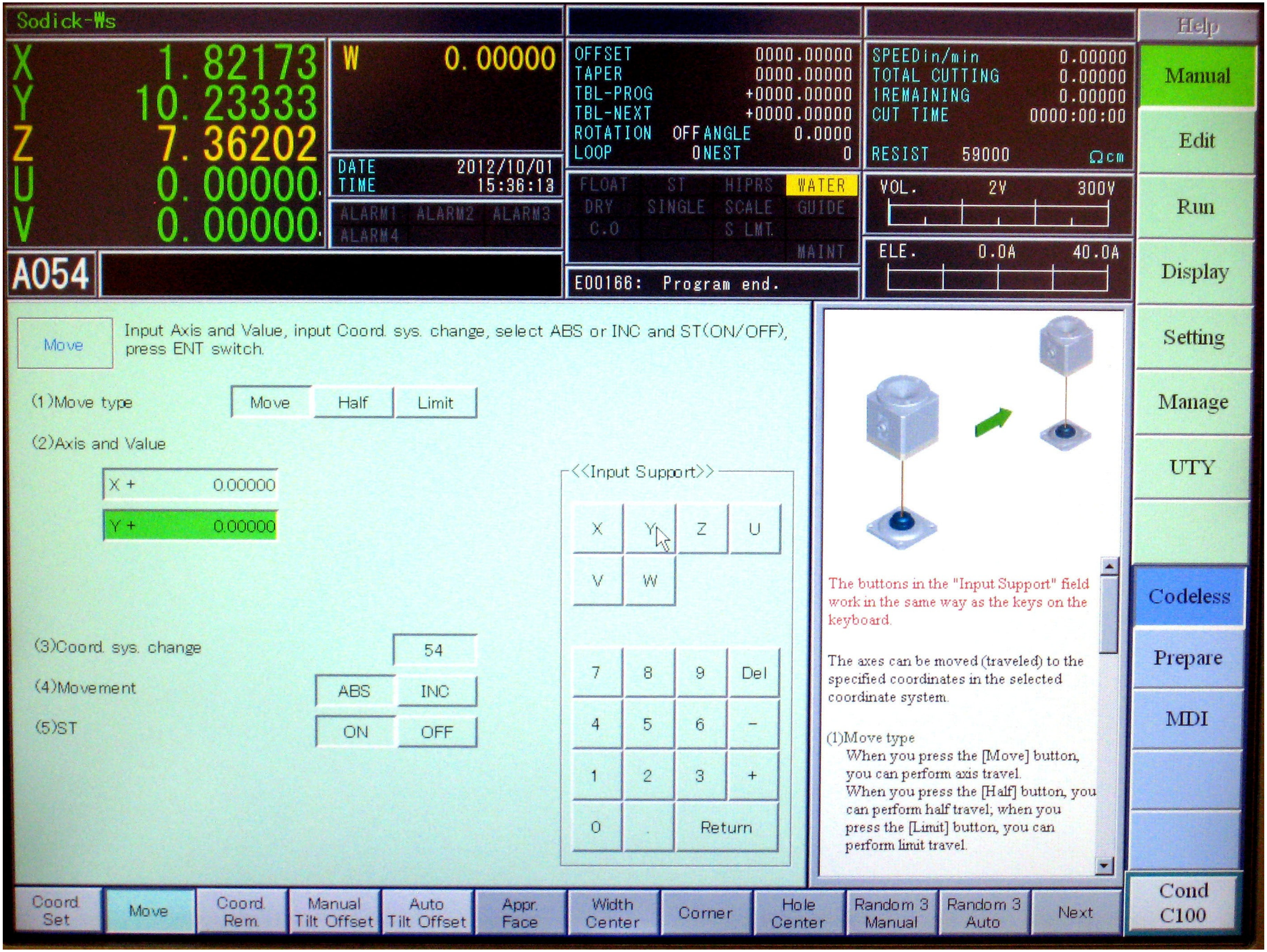


Figure 5 - Coordinate Set Zero

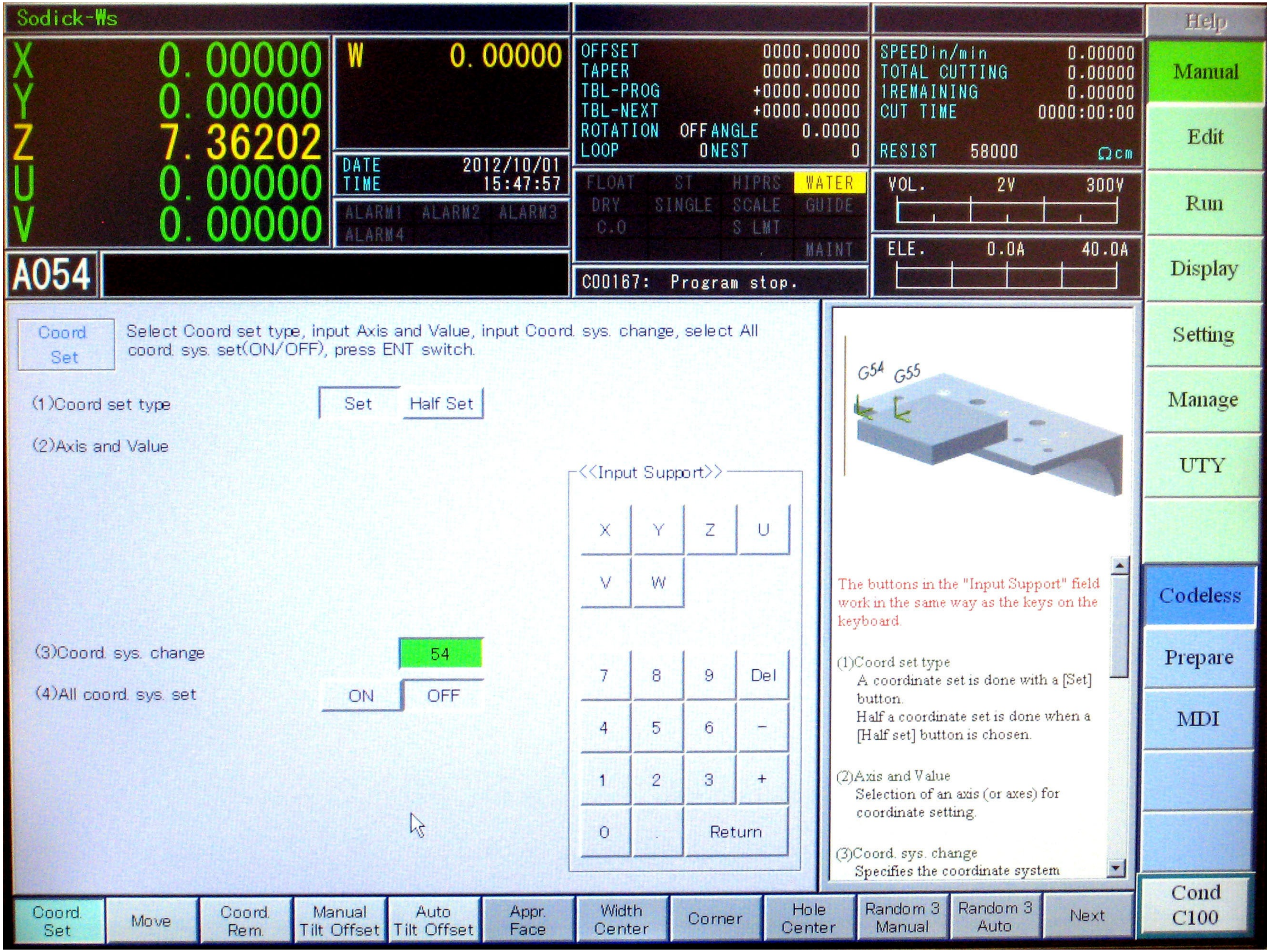


Figure 6 - X, Y, U, and V set to Zero

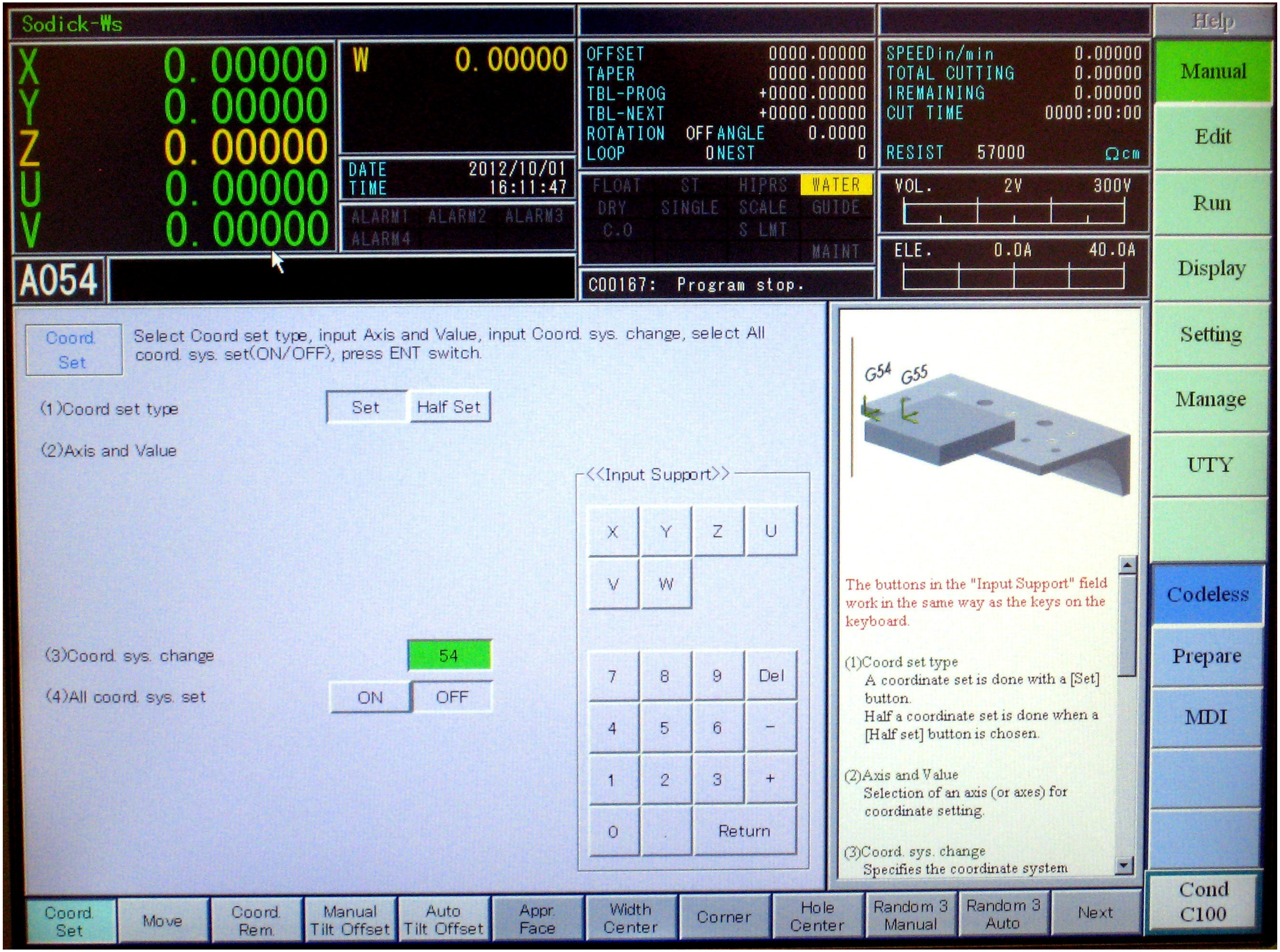


Figure 7 - Z Axis Zeroed at 0.005" Above Stock

10. Thread Wire:

a. If the wire is not threaded, now is the time to thread it.
b. Click on the **Move** button to get to the move screen.
c. Use the pendant to move Z up about1/2" to 1" above the work piece and then move X and Y to locate the heads where there is no stock between the upper and lower head. This could be just outside the edge of the stock or in the center of a pilot hole in the stock.
d. On the left side of the machine there is a small panel of buttons as shown to the right. Under the heading AWT (Automatic Wire Threading) press the button labeled II (Thread).
e. Water will now flow and the wire feed system will automatically feed the wire from the upper head through the hole in the lower head.
f. When you need to cut the wire simply press the button under AWT labeled I (Cut).

11. Cutting a Part:

a. If you set the X, Y, and Z zeros to be the starting point for your part, go again to the **Move** screen and click on X and Y under (2) Axis and Value. Two windows with X = 0.0000 and Y=0.0000 will open. Press enter and the heads will move to that location.
b. Now click on Z under (2) Axis and Value. The window with Z=0.0000 will open. Press enter and Z will move to 0.005" above the stock.
c. Click on the **Edit** button in the upper right hand portion of the screen.
d. Click on the **NC Edit** button in the lower right edge of the screen and the screen shown in figure 8 will appear.
e. Click on **Load** in the upper center of the screen and a screen similar to figure 9 with the available programs will open.
f. Select a program and click OK.
g. NC code will now appear in the window. Click on the Graphic button in the lower right side of the screen. The screen shown in figure 10 will open.
h. Click on the **Draw** button on the left side of the bottom row. A screen similar to figure 11 will appear. It will have the drawing of the part you loaded.. Click on the **Save** button in the lower left corner of the screen.
i. Click on the **Run** button in the upper right hand corner of the screen. Click on **NC Run** in the lower right hand edge of the screen. Make sure that the Graph button in the lower right corner of the screen is on. The screen will be similar to Figure 12.
j. Once the wire is located in the starting position, **press the home key to start at the top of program then press enter to begin the cutting process.** You will be able to follow the process by watching the small red star trace the outlines of the part. At the same time you will be able to see the G code being executed in the window on the lower right hand portion of the view window. The cutting process is represented in figure 13.

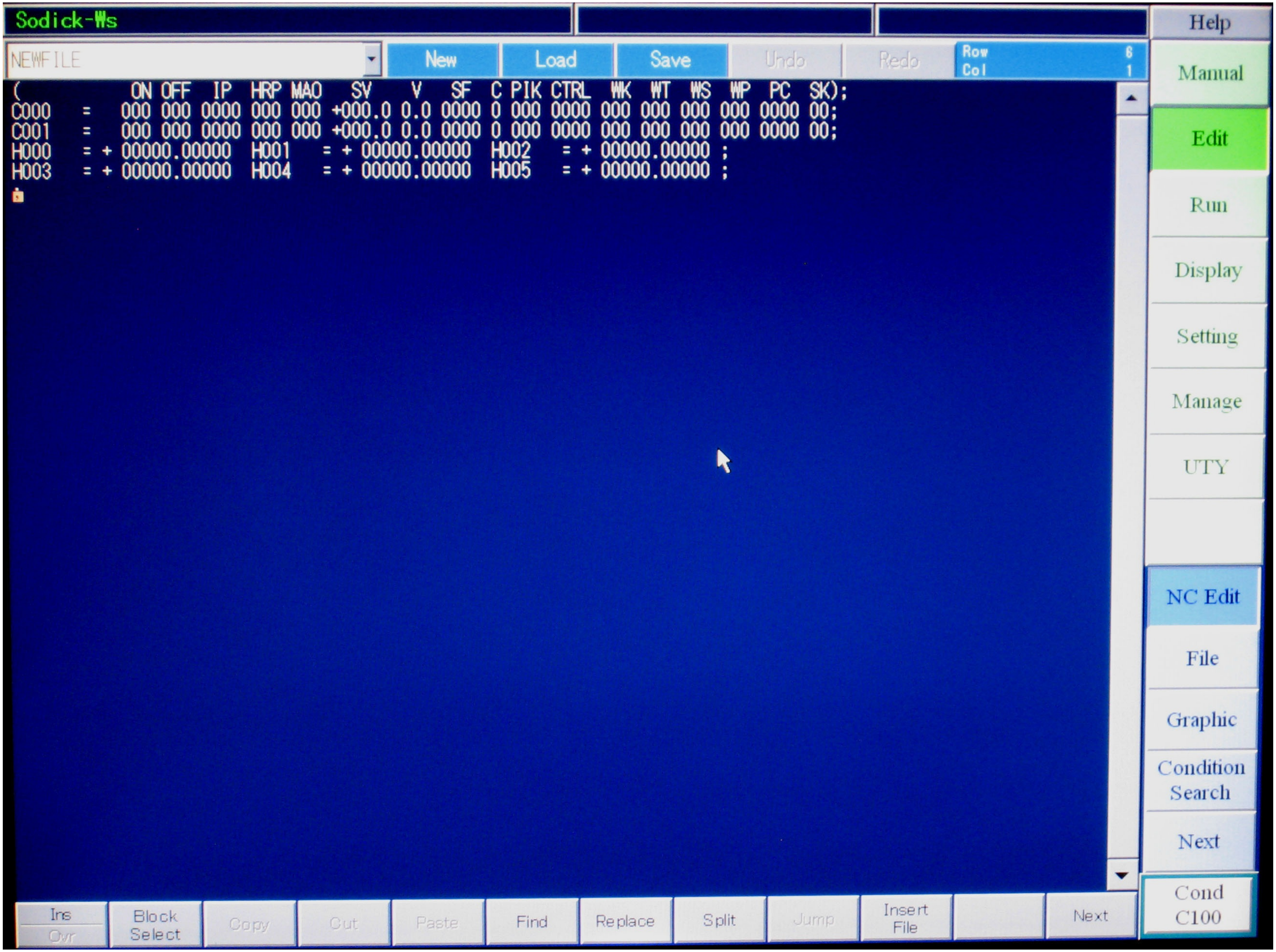


Figure 8 - Edit NC Edit Program Load Screen

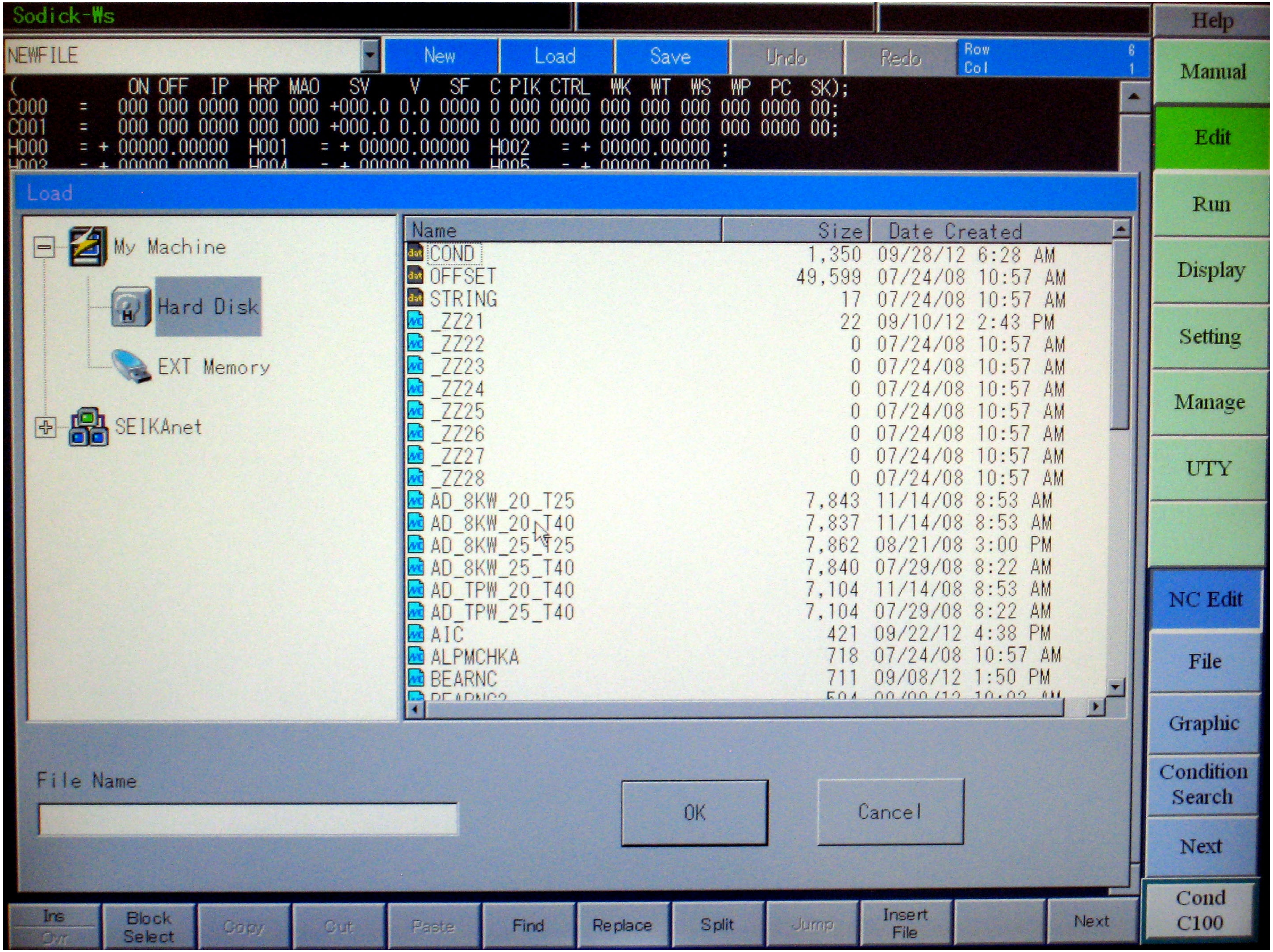


Figure 9 - Edit NC Edit Available Programs

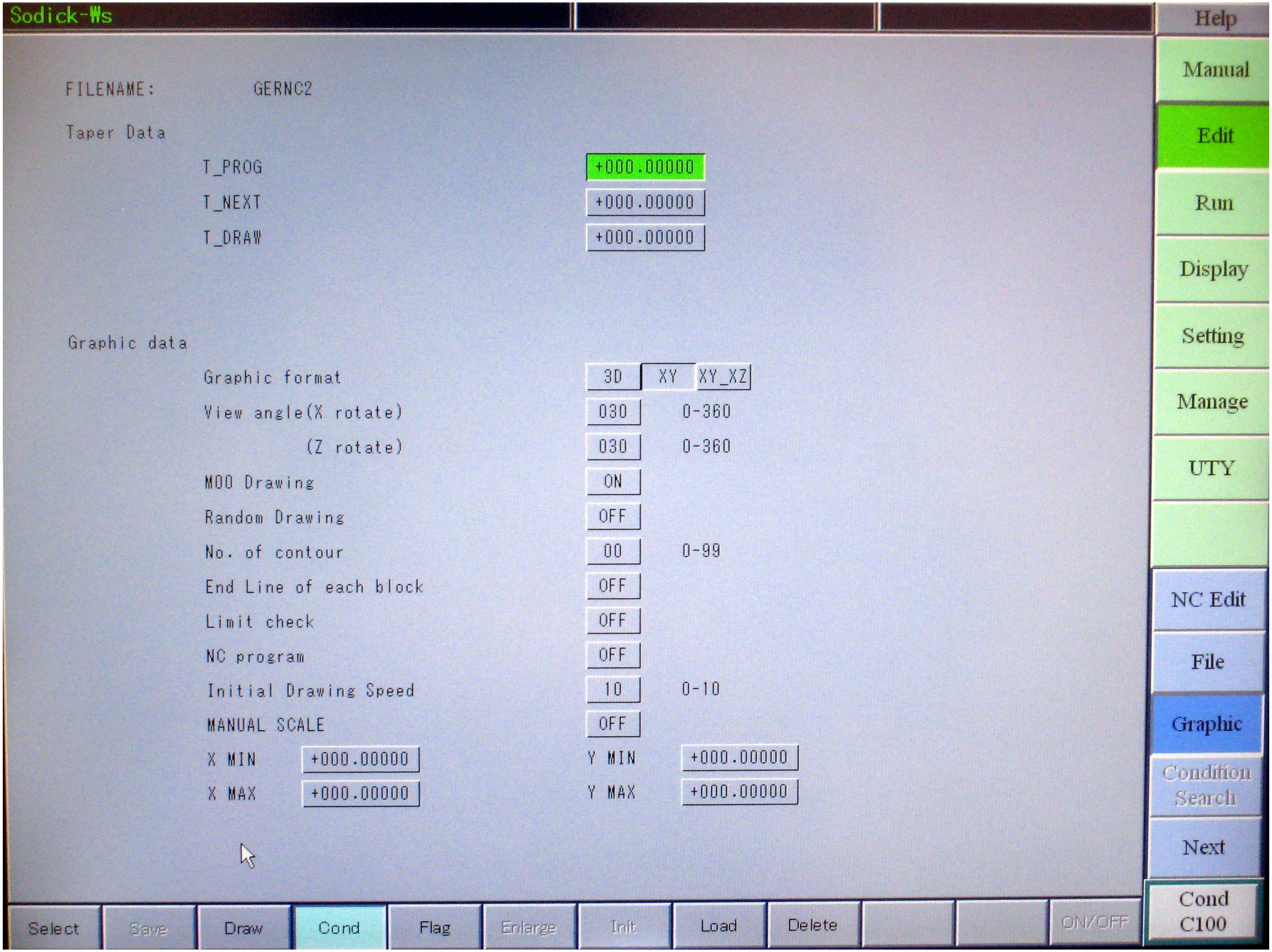

Sodick-Ws
Help
Manual
Edit
Run
Display
Setting
Manage
UTY
NC Edit
File
Graphic
Condition Search
Next
Cond C100
FILENAME: GERNC2
Taper Data
T_PROG +000.00000
T_NEXT +000.00000
T_DRAW +000.00000
Graphic data
Graphic format 3D XY XY_XZ
View angle(X rotate) 030 0-360
(Z rotate) 030 0-360
M00 Drawing ON
Random Drawing OFF
No. of contour 00 0-99
End Line of each block OFF
Limit check OFF
NC program OFF
Initial Drawing Speed 10 0-10
MANUAL SCALE OFF
X MIN +000.00000
Y MIN +000.00000
X MAX +000.00000
Y MAX +000.00000
Select
Save
Draw
Cond
Flag
Enlarge
Init
Load
Delete
ON/OFF

Figure 10

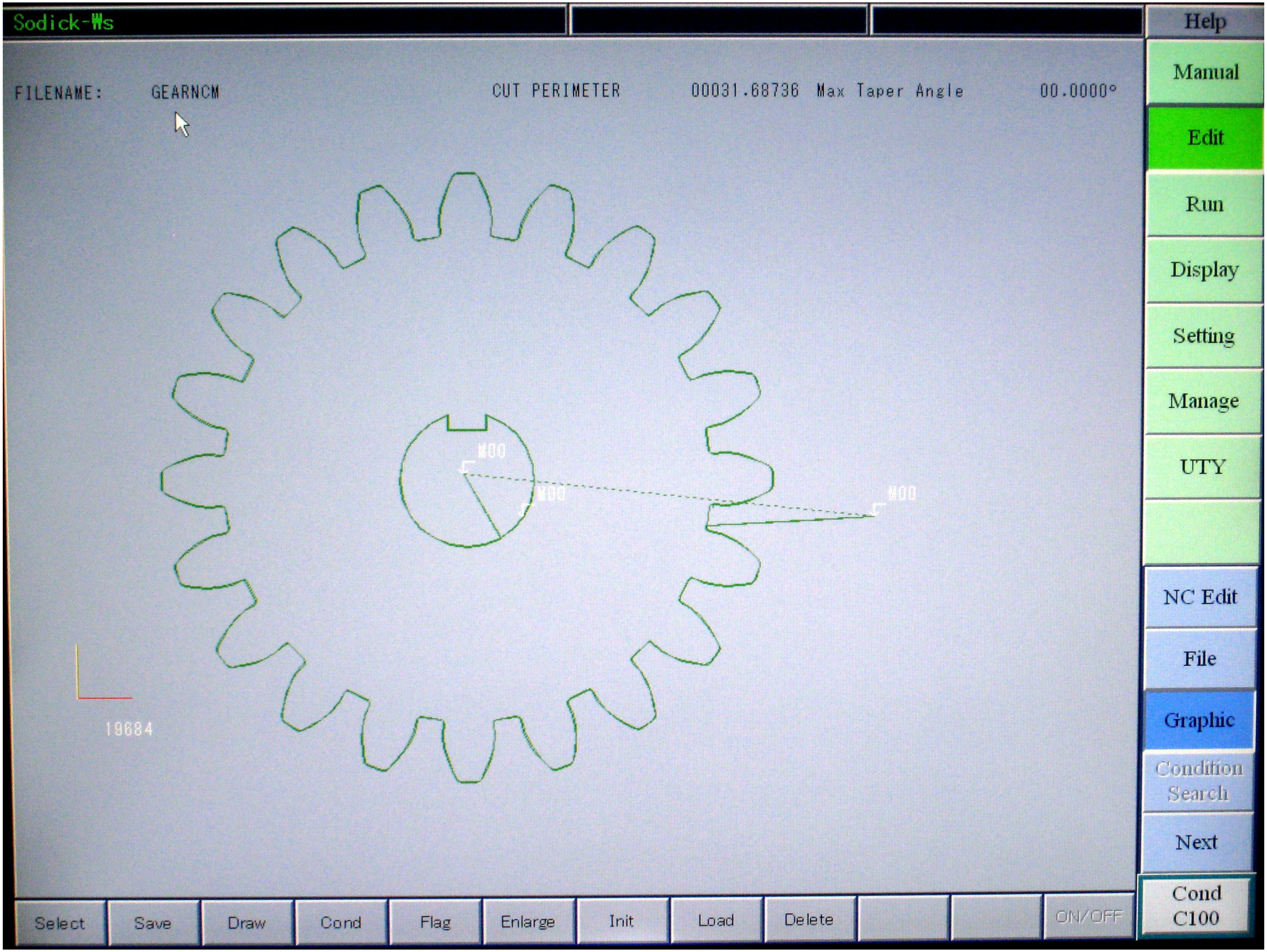

Sodick-Ws
Help
FILENAME: GEARNCM
CUT PERIMETER 00031.68736 Max Taper Angle 00.0000°
Manual
Edit
Run
Display
Setting
Manage
UTY
NC Edit
File
Graphic
Condition Search
Next
Cond C100
M00
M00
M00
19684
Select
Save
Draw
Cond
Flag
Enlarge
Init
Load
Delete
ON/OFF

Figure 11

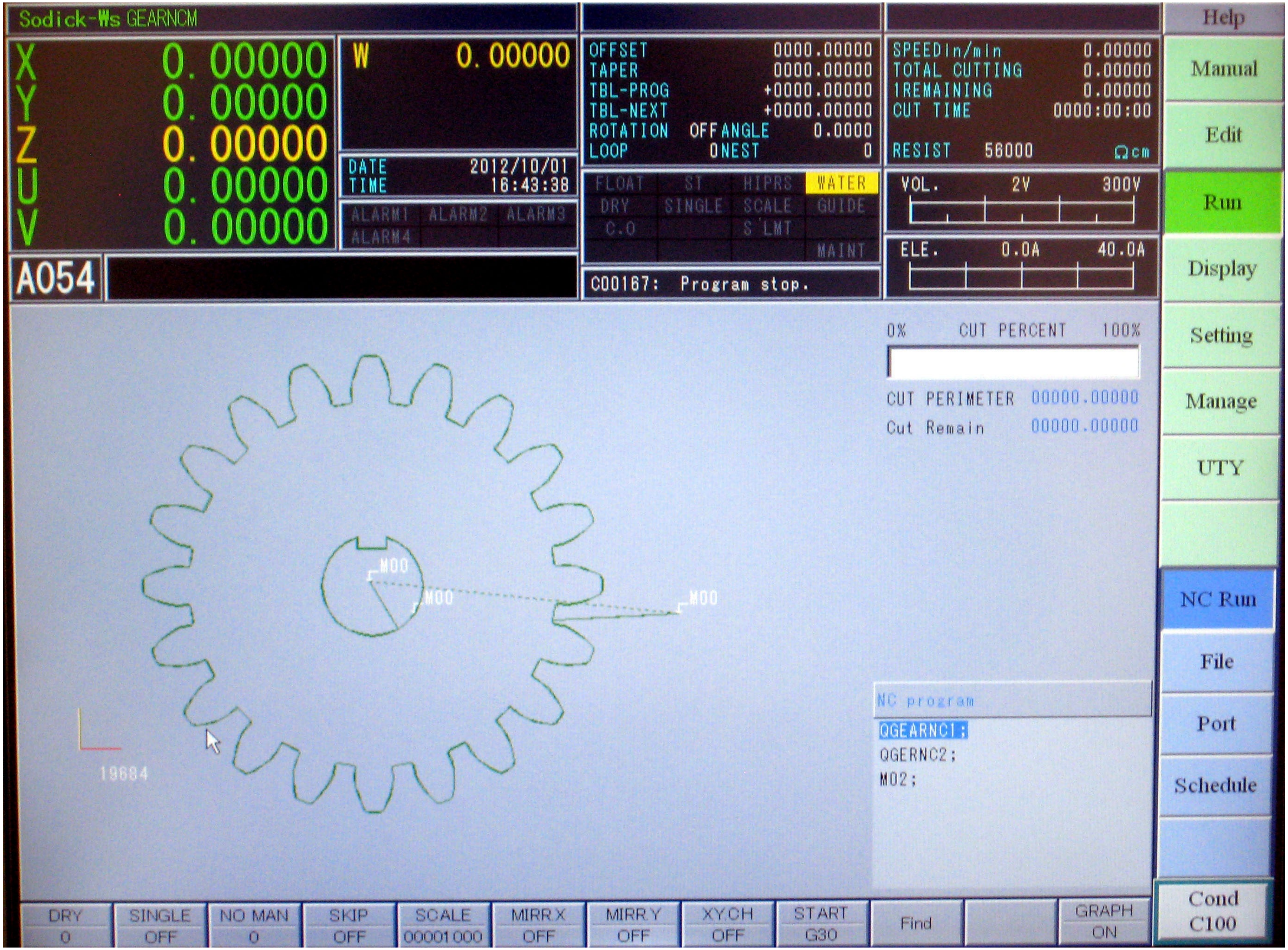

Sodick-Ws GEARNCM
X 0. 00000
Y 0. 00000
Z 0. 00000
U 0. 00000
V 0. 00000
W 0. 00000
DATE 2012/10/01
TIME 16:43:38
ALARM1 ALARM2 ALARM3
ALARM4
A054
OFFSET 0000.00000
TAPER 0000.00000
TBL-PROG +0000.00000
TBL-NEXT +0000.00000
ROTATION OFF ANGLE 0.0000
LOOP ONEST 0
FLOAT ST HIPRS WATER
DRY SINGLE SCALE GUIDE
C.O S LMT
MAINT
C00167: Program stop.
SPEEDin/min 0.00000
TOTAL CUTTING 0.00000
1REMAINING 0.00000
CUT TIME 0000:00:00
RESIST 56000 Ωcm
VOL. 2V 300V
ELE. 0.0A 40.0A
Help
Manual
Edit
Run
Display
Setting
Manage
UTY
NC Run
File
Port
Schedule
Cond C100
0% CUT PERCENT 100%
CUT PERIMETER 00000.00000
Cut Remain 00000.00000
M00
M00
M00
19684
NC program
QGEARNC1;
QGERNC2;
M02;
DRY 0
SINGLE OFF
NO MAN 0
SKIP OFF
SCALE 00001000
MIRR X OFF
MIRR Y OFF
XY.CH OFF
START G30
Find
GRAPH ON

Figure 12

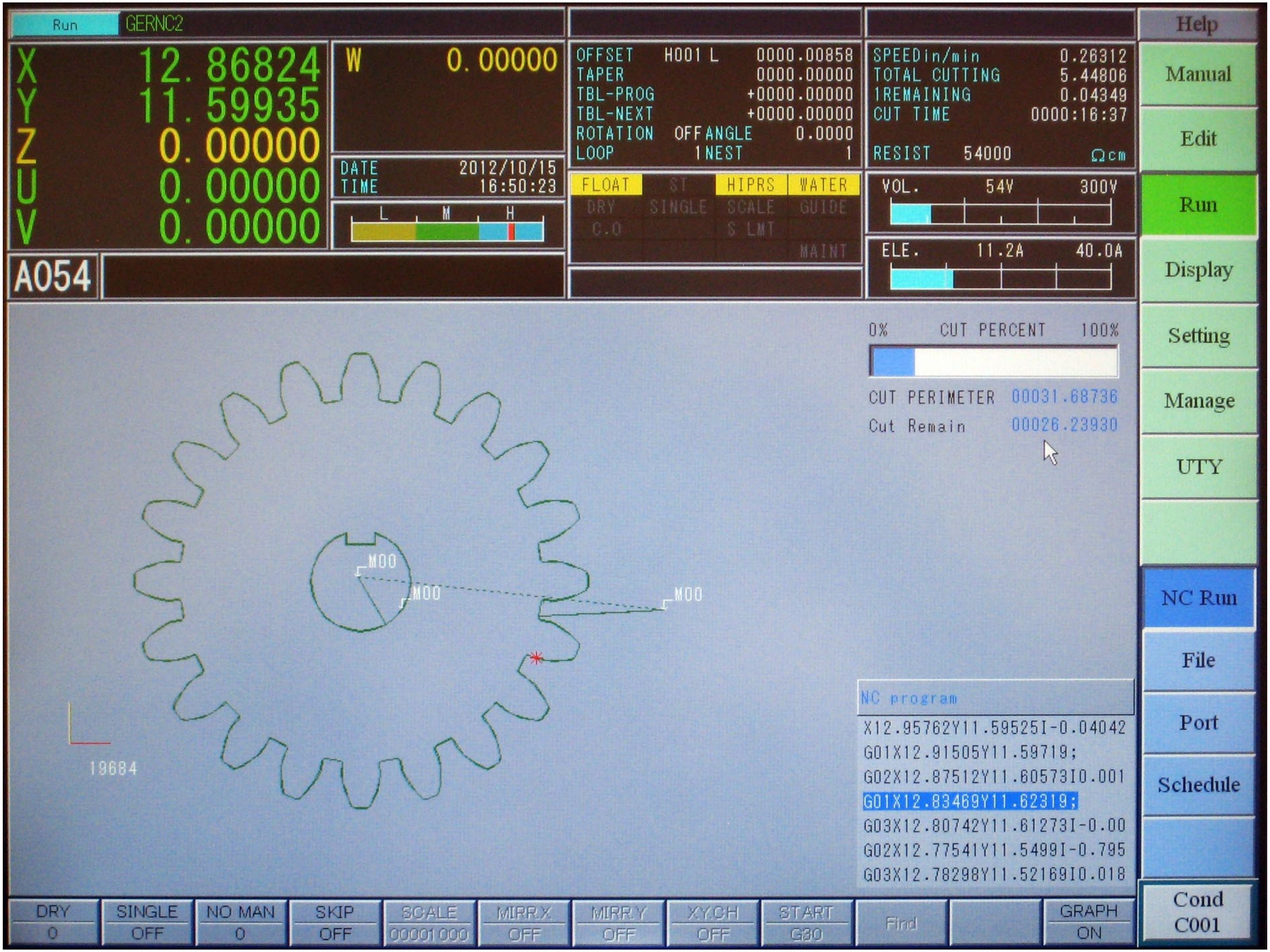


Figure 13 - Run NC Run Enter for Cutting

12. Machine Setup on an internal hole - Options:

a. For those parts that require cutting an internal feature such as a female spline, there are three built-in programs in the machine for exact part setup. Those three programs are - **Hole Center, Random 3 Manual,** and **Random 3 Auto.** For all three programs a small hole must be drilled in the stock to pass the wire through.

b. **Hole Center** is a program that moves the wire in the X and Y directions until it detects contact with the sides of the hole. From the coordinates of these contacts it determines the center of the circle that is the hole and moves there. This location can now be established as X and Y zero coordinates for machining the part.

c. **Random 3 Auto** is a program that works similar to **Hole Center** except that is randomly selects three different touch points on the sides of the hole and from that determines the center of the circle.

d. **Random 3 Manual** is a program that functions as **Random 3 Auto** except that you must manually select the three points to be used to determine the center of the hole. This program is the most useful if the hole has some feature such as a keyway that would cause a problem for the other two methods.

13. Random 3 Manual Procedure:

a. Press the Manual and Codeless button on the right side of the screen and then press the **Random 3 Manual** button at the bottom of the screen. The screen should look like Figure 14.

b. If you have not done this already, using motion speed MFR 1 or MFR 2, move the heads approximately over the center of your starting hole and thread the wire as described section 10 above.

c. Using the pendant control set the motion speed to MFR 2. Now old down the **ST** button while moving the wire in the X or Y direction until it contacts the side of the hole in the position you have selected. When contact is made you will get a red warning on the screen as shown in Figure 15. Release the **ST** and motion buttons and wait while the system resolves the exact point of contact. Then press the **ACK** (Acknowledge) button.

d. You will be prompted to press one of the three measurement point buttons as shown in Figure 16.

e. Repeat steps c and d above for the remaining two measurement points.

f. Once all three measurement points have been entered you will be prompted to press enter to move the wire to the center of the hole as shown in Figure 17. Press Enter.

g. Once the machine has moved to the center of the hole go to **Manual, Codeless,** and **Coord Set.** As described in

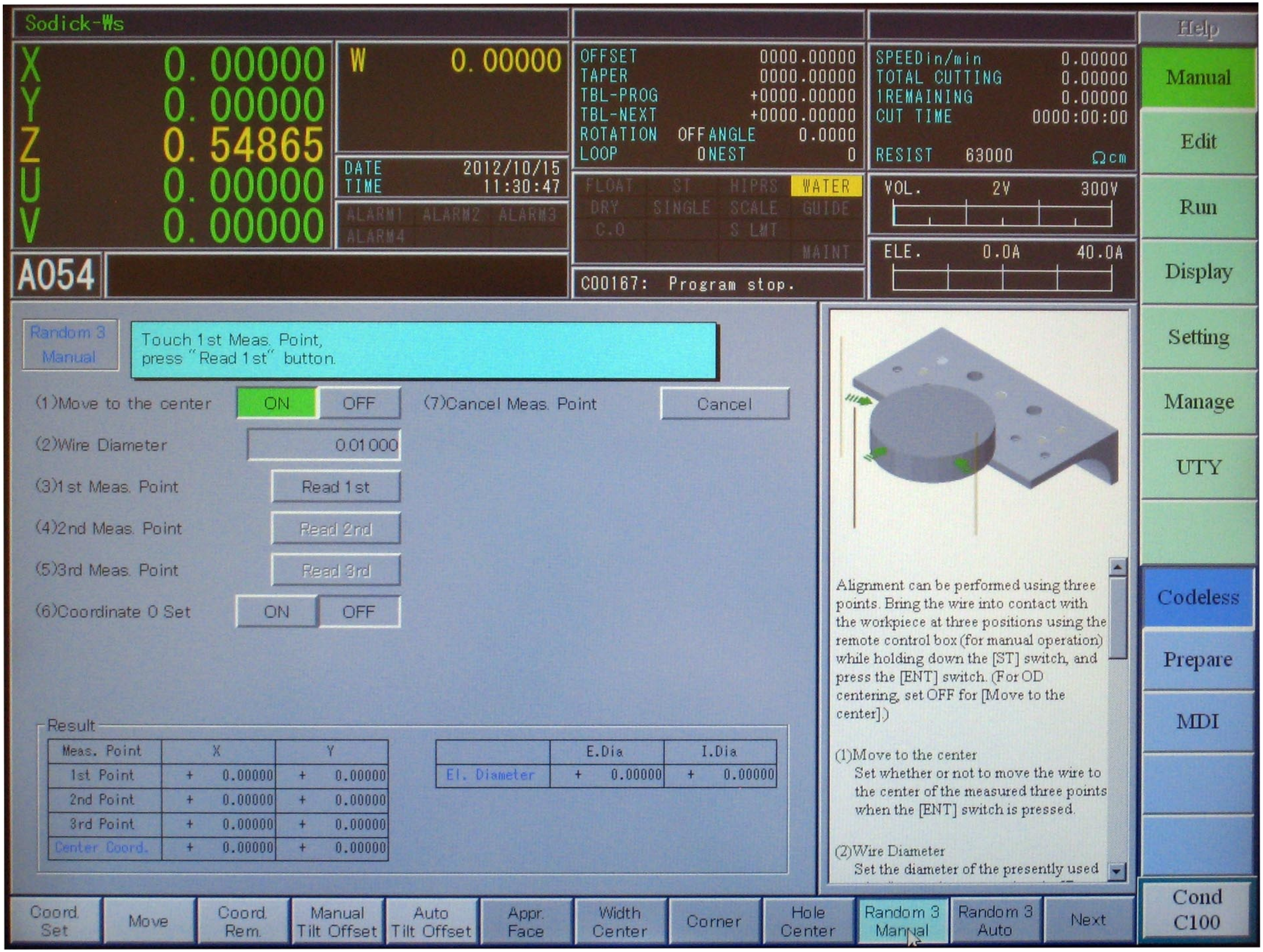


Figure 14 - Random 3 Manual Step 1

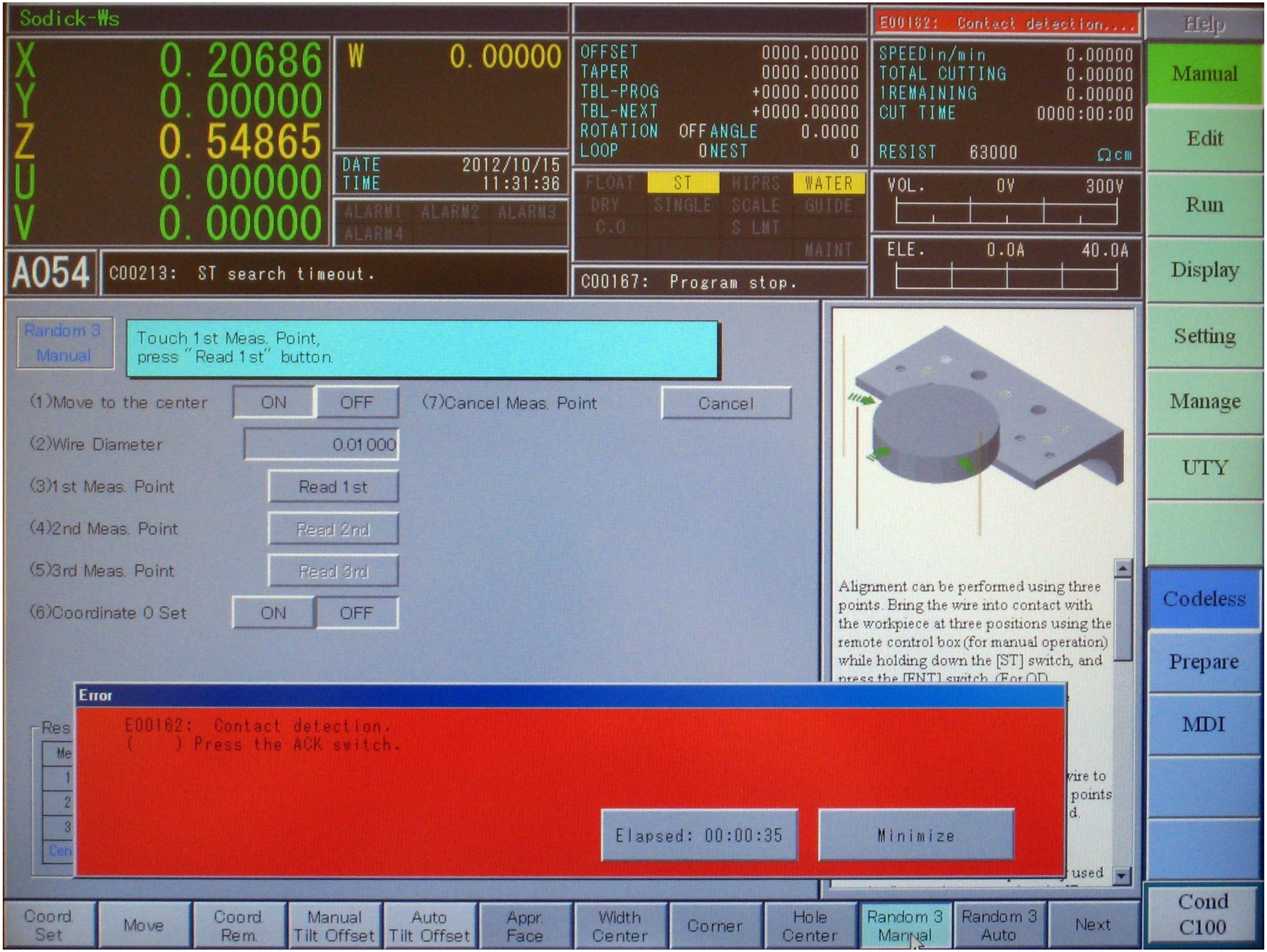


Figure 15 - Random 3 Manual Step 2

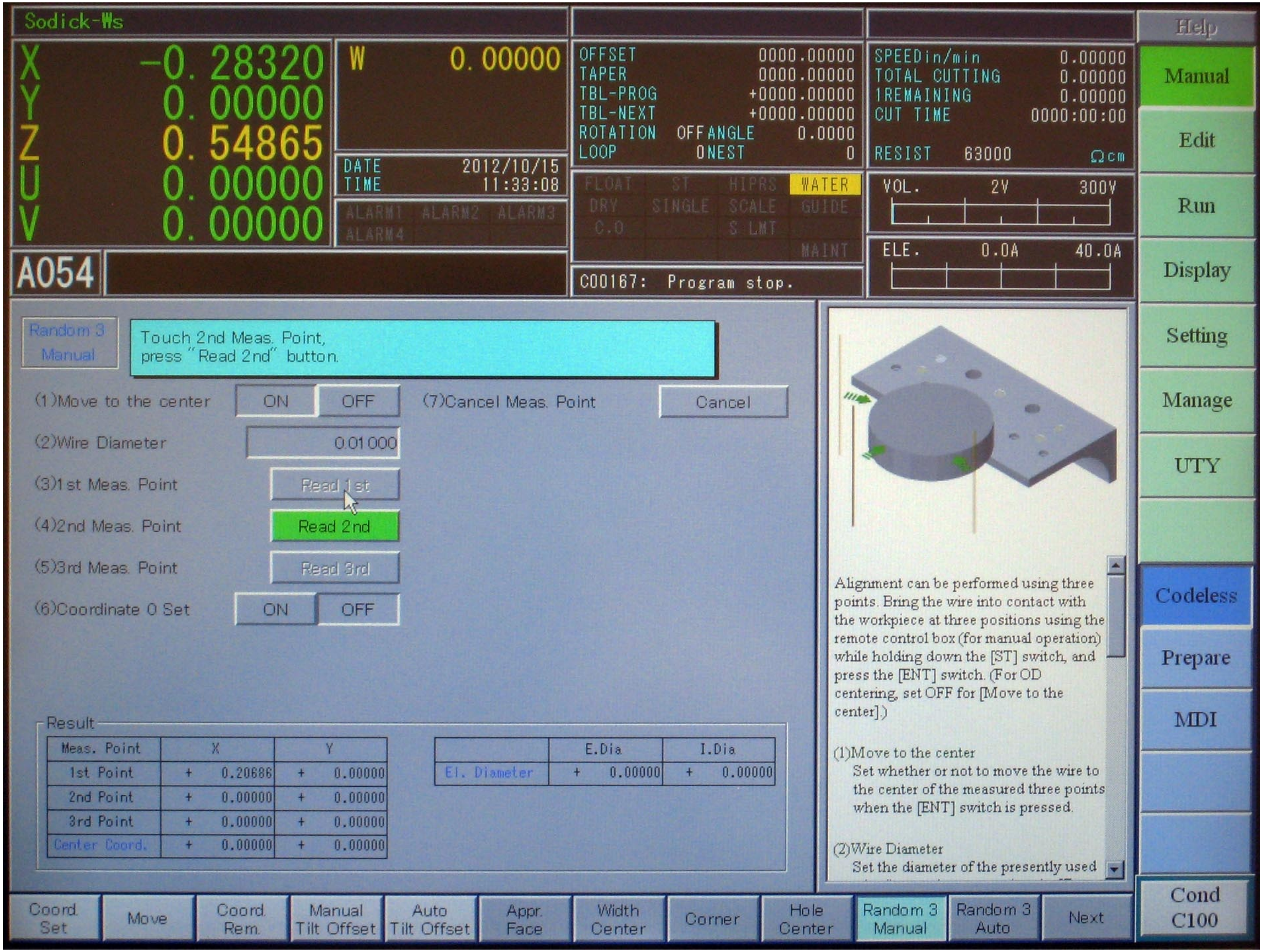


Figure 16 - Random 3 Manual Step 3

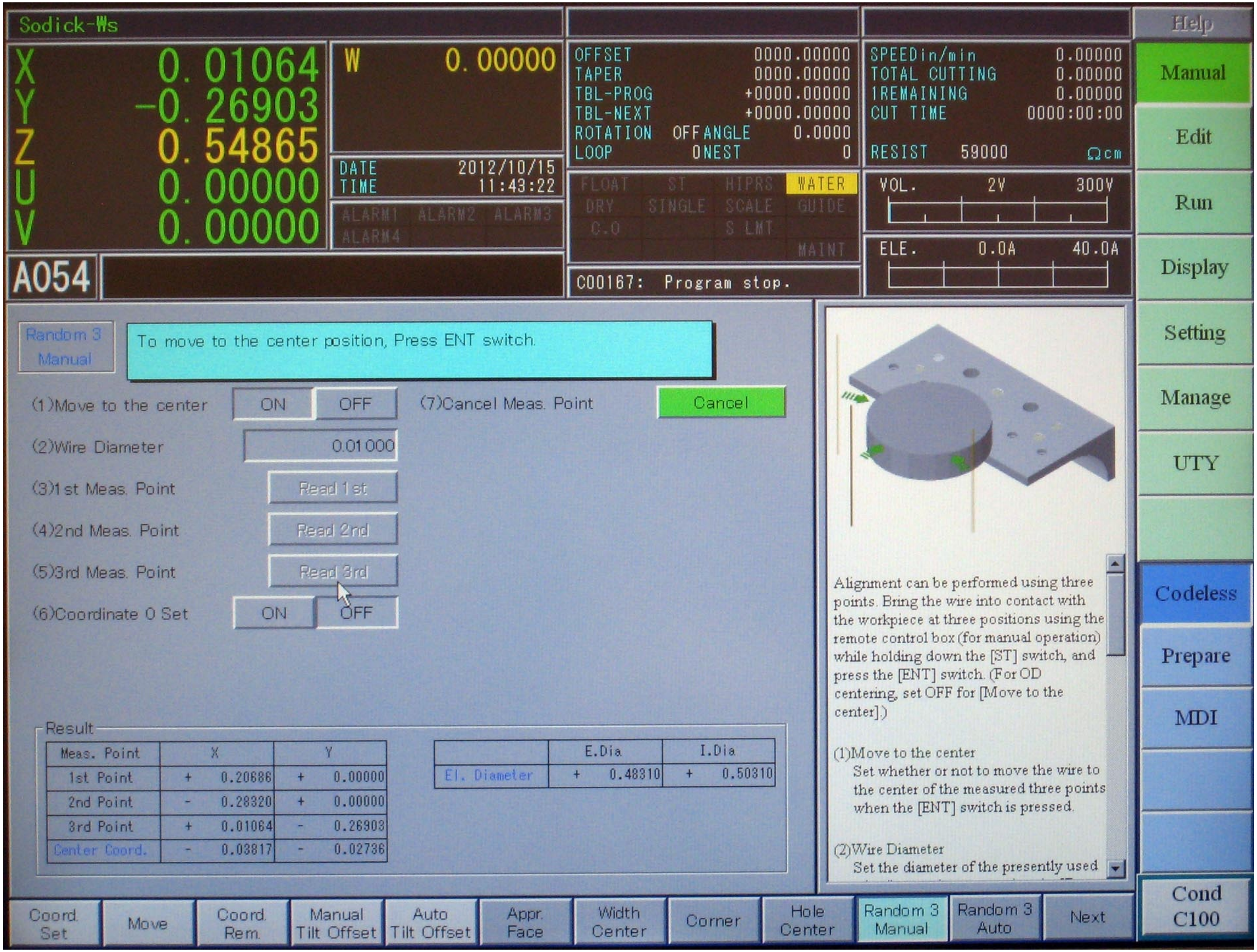


Figure 17 - Random 3 Manual Step 4

14. Loading a DXF File from an External Flash Drive

a. YOU MUST USE THE SODICK FLASH DRIVE. Place the DXF file in the folder labeled **UTY**.
b. In the **Manual** mode click the UTY button on the right hand side of the screen, then click the File button.
b. Click on **External Memory** (the DXF file should be in the UTY folder)
c. Use the mouse to copy the file(s) to **Heart NC**.
d. Click on the **Heart NC** button in the lower right portion of the screen.
e. Click on **file** on the bottom left of the screen.
f. Click on **open.**
g. Highlight the filename of the list and click OK. (The DXF drawing should appear)
h. Click on **wire cut defs** and select **Die** or **Punch** from the list. (Die is for a female part and Punch is for a male part.)
j. Select **machining parameters** and click OK.
k. Select **machining conditions** and then click **Find(F)**. The DXF shape will appear.
l. Follow the instructions in the lower left corner of the screen. (When doing the approach you may have some difficulty in getting the approach set. You will have to try selecting the point until the machine is satisfied it can find the point.)
m. Click on **Gen NC Data** and the cutting path will be generated and shown on screen.
n. Click on **Edit** and then **NC Edit** on the right hand side of the screen.
o. Click on **load** in the top center of the screen.
p. Select the file from the list and the NC program will show on the screen.

Items to check or include later in notes:

If it becomes necessary to home the machine again after it has been started press the **Manual** button in the upper right hand corner of the screen. When the **Manual** screen comes up press the **Codeless** button on the submenu near the center of the right hand edge of the screen. Next press the "**Coord. Set**" button in the lower left corner of the screen. Assuming that you are making no changes in the coordinate setting, hit the enter key and the machine will go to home.

To realign U and V with X and Y press the Move button just to the right of the **Coord. Set** button. Type Move then V with no numeric input and then hit enter. This will zero V with Y. Repeat to zero U with X.

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Engel Austria GmbH has launched a smartphone app called e-calc, for making sure the Engel injection molding press perfectly matches the specific application.

After entering a few parameters, e-calc automatically supplies the values required for material and component-dependent design of the injection press, as well as the machine setup data. The materials data is stored in the software, and e-calc guides the user, step by step, as it computes values such as required stroke volume, fill pressure, the resulting clamping force, screw speed and cooling time.

Materials data contained in the app include the melt, mold and pre-drying temperatures and times, factors of viscosity and wall thickness, temperature conduction and demolding temperatures, permissible screw speeds, enthalpy values and guidelines for processing loss.

The new software has a glossary of technical terms.

"E-calc is one of the first apps to be developed for the injection molding industry," said Wolfgang Degwerth, head of the customer service division at Engel in Schwertberg, Austria.

In philanthropic news, Engel's North American headquarters, Engel Machinery Inc. in York, Pa., supplied a hybrid tie-barless injection press, and automation, for Bradley University's new manufacturing laboratory—custom-painted in Bradley red. Bradley is in Peoria, Ill. The highly visible press, an Engel e-victory, has 30 tons of clamping force.

The laboratory was made possible by a grant from the U.S. Department of the Army. It is used by students in four engineering programs, including mechanical engineering, industrial and manufacturing engineering.

"The machine will be a key element in the educational programs for plastics and injection molding, as well as for developing molds and producing pilot part runs for student senior projects," said Richard Johnson, professor of mechanical engineering.

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Educating engineers about manufacturing

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By PlasticsToday Staff
Published: July 16th, 2013

A vital part of good engineering is understanding the manufacturing processes that make designs a reality. To that end, Bradley University's College of Engineering and Technology features a Manufacturing Laboratory for Next Generation Engineers, and the lab will now feature an Engel hybrid injection molding machine.

The lab, which is supported by a grant from the U.S. Dept. of the Army, has just installed an Engel e-victory 80/30 tiebarless press as the "last significant acquisition." The lab is meant to integrate modern manufacturing methods into the engineering curricula of four engineering programs: mechanical engineering, industrial and manufacturing engineering, and technology.

According to Richard Johnson, professor of mechanical engineering, "The machine will be a key element in the educational programs for plastics and injection molding, as well as for developing molds and producing pilot parts for student senior projects."

The 30-ton press will also play a role in an ongoing research program to develop "improved models for characterizing the mechanical behavior of plastic parts." Different techniques for building molds for short-run prototype parts will also be explored.

The lab also features the following equipment:

- CNC 5-axis machining center
- CNC turning center
- SLA and thermal deposition AM systems
- Mechatronics assembly system
- High-precision waterjet machining system
- Wire EDM for 2D moldmaking

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