More Efficient Data Collection with Positron Annihilation Spectroscopy

by

Kevin Laughlin

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DEPARTMENT APPROVAL

Of a Senior Thesis submitted by

Kevin Laughlin

This thesis has been reviewed by the research advisor, research coordinator, and department chair and has been found to be satisfactory.

Date  Evan Hansen, Advisor

Date  Jon Johnson, Committee Member

Date  Stephen McNeil, Research Coordinator
Positron Annihilation Spectroscopy (PAS) is a non-invasive way of finding the density of defect in materials. This is important because the amount of defects in a material can greatly alter its integrity. The S-parameter is an indicator of the defect density, and is compared with an S-parameter of a sample with a known defect density. The placement of the source compared to the detector can cause artificial changes in the S-parameter, which will cause problems with the interpretation of the data. PAS can also be used to find elemental differences. Defects in a material can be removed or created in localized areas. They can also be detected, and can be distinguished from areas of low defect density using the detector and acquisition setup. The placement of the source compared to the detector as well as the data collection time are more of a software than geometric problem, and can be easily solved.
Acknowledgments

I would like to thank all of my classmates that helped keep me sane and make things fun. I’d also like to thank my family for supporting me. I’d especially like to thank Dr. Evan Hansen, it was his love of physics that helped me realize that physics is what I want to do. If it weren’t for him, I would not be where I am today.
Chapter 1: Introduction

1.1 History

The positron is the antimatter counterpart of the electron. The positron and electron are identical in every way, except for charge. Paul Dirac first theorized positrons in 1928 in his paper “The quantum theory of the electron.” Positrons were “seen” in the following years, but were mistaken as protons. It wasn’t until 1932 that Carl D. Anderson discovered an unknown particle in a cloud chamber with the same charge to mass ratio as the electron, but positively charged. Anderson coined the phrase positron and received the Nobel Prize for his findings. Because the electron and positron are anti-matter pairs, when an electron and a positron come in contact they annihilate each other and give off two 511 keV gamma rays. The 511 keV gamma rays come from their rest mass energies, and as known from Einstein’s most famous equation $E = mc^2$. This means that when the electron positron pair annihilate, their masses convert into energy in the form of gamma rays.
Figure 1 – This is a Feynman diagram showing how a positron and electron annihilate, creating two roughly 511 keV gamma rays. [7]

1.2 Positron Annihilation Spectroscopy (PAS)

In PAS positrons are introduced into materials, where they will annihilate with characteristic electrons of that material. Positrons often come from high-energy sources and must slow down before they annihilate. In 1949, DeBenedetti et al [10] discovered that the two gamma rays aren’t always 511 keV, when produced in a material where the positrons have thermalized. Instead, these rays can be Doppler shifted due to the overall momentum of the positron-electron pair right before they annihilate. Both gamma rays will be 511 keV if the total momentum of the pair is zero. The gamma rays will be Doppler shifted in the direction of momentum if the total momentum is not zero. The electron causes most of the shifting energies. This is because the positron typically thermalizes, and slowing down to low momentum.
The electrons that are closer to the nucleus have a higher momentum while the electrons that are on the outer shell have a lower momentum.

Whether a positron annihilates in a vacancy in the material structure or not will greatly change the probability of the energy shell of the electron it will with which it will annihilate. This is because when there is a vacancy or hole in the atomic structure, it is more energetically favorable for the positron to go to the vacancy. This increases the probability of the positron annihilating with an outer shell electron that has lower momentum. When there are no vacancies the positron will be more likely to annihilate with a core electron then if there were vacancies. These core electrons have higher momentum and will consequently increase the chance of the gamma rays being Doppler shifted.

Figure 2 – The path that a positron is most likely to take before annihilation. [6]
PAS uses this fact to help determine the relative defect density of a material. When there are a large amount of annihilation events, there will be an energy distribution curve centered around 511 keV. The shape of the distribution can be characterized by parameters, such as the Sharpness parameter and Wing parameter. The sharpness parameter in particular, or ‘S-parameter’, depends on defect density. If the material contains a lot of defects, the amount of positrons that annihilate in vacancies will increase. When the positrons annihilate in a vacancy they annihilate with the valence electrons that have lower momentum. This causes the peak to be much more narrow than normal, increasing the S-parameter. On the other hand, if there are few or no defects in a material then the positrons will annihilate with more core electrons with high momentum. This will cause the curve to widen, and subsequently decrease the S-parameter.

Figure 3 – This depicts the likelihood of annihilation of a positron with an electron when there are no vacancies, vacancies, and open spaces. This figure was supplied by http://www.positronsystems.com/ psi/technology/ [8]
1.3 Purpose

One of the reasons that PAS is used is because of its non-invasive properties. Some techniques require the need to cut up a sample and put in under a microscope, or use a hardness probing technique. With PAS this is not needed because the only things that are affected by it are the electrons, and they get replaced really easily with less damage done to the material.

When a metal has few defects in the structure, it is much more malleable than if it had more defects. On the other hand, if there are too many defects in a material, the tensile strength of that material weakens and the material becomes brittle. Being able to test how many defects there are without having to do a tensile test can be a great benefit, especially if the other testing methods would cause damage to something that shouldn’t be damaged. [11]

1.4 How it works

In PAS, the S-parameter is used to help us understand what the relative defect density is. To find the S-parameter, the gamma rays are counted and then the data is placed into a bin based on how much energy they had. The result is a curve centered at 511 keV.
Figure 4 – Here are the locations of the parameters that were used. The Sharpness Parameter is the area in the middle, while the Wing Parameters are on the edges. This Figure came from Gagliardi [2]

To find the S-parameter all of the counts close in energy to the center are added up, and divided by counts in the whole PAS curve. As seen above in figure 4 the S area is the area in the middle. The counts include background noise, but we have a program that will subtract the background noise from the rest of the data. A simplified equation for this process is given by

$$S = \frac{R_S - \mu_B W_S}{R_T - \mu_B W_T}$$

Where $R_S$ is the area in the middle of the curve, $R_T$ is the total area of the curve, and the $\mu_B W$ terms are for the background. This is a fairly simplified equation, for the rest of the math see reference [2].
Chapter 2: Experimental Setup

2.1 Detector and Acquisition setup

The detector that is used is a high purity germanium crystal detector. When a gamma ray enters the detector, it excites and knocks electrons off of the atoms it passes by, until the gamma ray has deposited all of its energy. Because there is a high voltage, electrons that are scattered off are directed towards the center of the detectors with high energies. As these electrons are traveling towards the center of the detector, they knock off more electrons. This creates a cascading effect all the way down to the core of the detector. The higher the energy of the gamma ray, the more electrons knocked off. The electrons that are knocked off create a current pulse. The detector then calculates how much energy there was based upon how big the current was, and then sends this information to the computer.

The computer then takes the data that it receives and interprets how much energy the gamma ray had. This data of gamma rays with certain energies are then counted and placed in bins. This continues on until the desired amount of data has been collected, and a distribution curve is created. For these experiments, that number has been around 100,000 counts in the region of interest. The operator then inputs some regions of interest into the POSITRON ANNIHILATION program, and the data is then converted into the parameters that are needed. The user can easily read this file in an excel sheet. This program also produces the S-parameter for the given data. For more instructions on this section, see Appendix 1.
\section*{2.2 Positron Source}

There are many different positron sources that are used for PAS. The source that is used depends on the needs of the experiments. Some of the source types are positron beams, stationary sources, and the production of positrons inside of a given material. The most common, and the one used for these experiments, was a Sodium-22 tablet that is contained inside of a kapton film. $^{22}\text{Na}$ decays into Neon-22 by $\beta^+$ emission and a neutrino, where $\beta^+$ is a positron. The $^{22}\text{Na}$ source that is used was a 10 $\mu\text{Ci}$ source. $^{22}\text{Na}$ has a half-life of 2.6 years, and the source is a couple years old and its activity has dropped to around 5 $\mu\text{Ci}$.

\section*{2.3 Motors and Physical Setup}

The research setup included both stationary setups, and movable setups. For the stationary setup, the positron source and materials were placed close to the detector and left alone until the data was collected. These experiments usually only had a few data collections per sample. With the movable setup, there was a system of motors and holders that allowed the sample to change its position. This became useful when performing defect mapping, where we would need to take many data collections from the same sample. If a 2D defect density map is needed for many data points this setup is ideal.
Figure 5 – Setup of the PAS system. The HPGe detector had to be kept at a Liquid Nitrogen temperature in order for it to work properly. The LN2 tank is seen at the right. The motor system can be seen in front on the detector, and its control system is at the bottom of the picture.

For instructions on how to run the detector and collect data, please see Appendix 1.
Chapter 3: Experiments

There have been many experiments and other peoples’ work that I have based some of my research on. For a better understanding and information, see references [1] – [5], [9].

3.1 Different Copper pieces

I wanted to see if different copper pieces could be distinguished from each other that had not been annealed. I took a copper gasket and cut it up into pieces 1 inch long. Two copper pieces were then tested against a sample of annealed copper, and they were shown to be different. The results are shown in figure 7: the two pieces that I had were shown to be cold worked and had a high defect density.

![S parameter vs Cu](image)

Figure 7 – The difference between annealed copper and cold worked copper. The difference in their S-parameter makes it is easy to tell them apart.
I then took some of these pieces and heated two of them to 200°C, two to 500°C and left two of them as is. The Chemistry department allowed us to use their tube furnaces to heat up the copper pieces. The tube furnace only had a diameter of about 1 inch where the copper could be placed. The copper pieces were placed in a ceramic boat and then the boat was placed inside the glass tube that was in the furnace. Because copper oxidizes when it is heated too much, we attached argon gas to the ends of the tube to make sure that this did not happen. We then heated up the pieces two at a time, getting them to different temperatures. The first set was only heated to 200°C with a heating rate of $100 \frac{^\circ C}{min}$ until it reached its maximum temperature. The temperature was then held there with a dwell time of 30 minutes. We then let it cool, the whole time running argon gas through the tube. It took over an hour to get the temperature down to an acceptable level to take it out of the furnace. I then went to the 500 °C temperature set. We went through the same procedure of heating with a ramp rate of $100 \frac{^\circ C}{min}$ until it reached 500 °C continually having the argon running. Unfortunately, the argon got shut off about half way through the dwell time which caused the copper pieces to slightly oxidize. We decided to redo this set of copper pieces. So we went through the same procedure with two new copper pieces with the same ramp rate and a dwell time of 30 minutes. We then let the copper pieces cool down for 4 hours until they reached around 70 °C. The pieces were then taken out and stored in a safe container with the other pieces. All of these pieces were then tested to see if there was a difference in them using PAS. The results were as expected and are seen in figure 8.
3.2 Different Materials

Since the S-parameter deals mainly with the electrons of the atom, it was thought that PAS could tell the difference between materials. Different atoms have different electron orbitals with different momentum. Because of this, if PAS is used on different materials there should be a difference that shows up in the S-parameter, allowing the ability to distinguish different materials. It was decided that we would test out this theory. We obtained a few rods about 1cm in diameter of various materials. They were: steel, brass, aluminum, and three different types of plastics.
We had two slices from each removed from the end of each of the rods as seen below in figure 9.

![Picture of the rods with their slices. From top to bottom: White plastic, carbon, clear plastic, steel, aluminum, and brass.](image)

The sodium source was then placed between the two disks that were made out of the sliced material. These samples were then placed next to the detector to collect data. This process continued for all of the different samples for the same amount of time and placed in the same location. The data for each of the samples were then compared to each other to see if there is a discernible difference between them. The results, found in figure 10, showed that for most cases it is possible to tell the difference between them. For the cases that it was not easy to tell the difference between them, they were mostly made of the same material with slight differences in their makeup. This led to other questions that will be talked about in the Future Research chapter.
Figure 10 – The differing materials $S$-parameter is clearly distinguishable except for the last three materials, which are made of the same base materials.

3.3 Altering Placement of Source

While taking data, it takes a long time to obtain the desired amount of counts per sample. Knowing that the gamma rays that come from the samples come out and diminish in intensity spherically, the closer the source is to the detector the more counts per second there will be. This would enable us to minimize the data taking time. We were wondering what effects this would have on the data, so we took one
sample and put it on different places and distances from the detector. The results showed in figure 11 that the placement of the source did make a difference to the S-parameter. This causes problems, because the S-parameter doesn’t change for a given material, unless the material had been structurally altered. We looked into the causes and reasons why this was happening.

![S Parameter Vs Placement](image)

**Figure 11** – Two trials of the same sample with data taken at different places.

### 3.3.1 Pile up

When the material is brought closer to the detector, the amount of time needed to collect the same amount of data is decreased. This is because the count rate
increases. This is a good thing, because it lowers the data acquisition time, and
decreases the statistical uncertainty. But if the count rate increases too much, then the
detector won’t have enough time between entering gamma rays for it to reset. This
can cause pulse pileups, where energies are added together. Most of the energies that
are added are other 511 keV gamma rays and are beyond the scope of our detector.
The remaining rays come from the background radiation and could add only a few
keV to the gamma ray, altering the desired data. The reason why this is a problem is
that when energies are added together. This puts some of the gamma rays energies
into other energy bins. So, there will be counts where there aren’t supposed to be,
and some counts missing where they should be.

3.3.2 Pole Zero – Peak and Tail Pileup

One of the things that can both contribute to and help this problem is called
Pole Zero. This is a feature of the software that is used to interpret the data. The
software takes the current pulse that comes in the detector and shapes the pulse.
When the detector receives a pulse of current, it reacts like a capacitor where the
voltage of the pulse doesn’t go directly to zero. Instead, it drops off exponentially.
The pulse will have a tail after it is shaped, and when Pole Zero is used correctly, the
tail voltage will get subtracted away to the zero voltage line so that the pulse just
looks like a really skinny peak. When the Pole Zero function is not set at the right
settings, the tail of the pulse will either trail off above or below the zero voltage line.
When this happens, if the pulses are too close to each other the gamma ray that came
in later will have an altered energy. If the Pole Zero had the tail come off too quickly, the energies that are read will be too low. On the other hand if the Pole Zero has the tail too high then the energies of the incoming gamma rays are registered too high and are placed in the wrong energy bin.

Figure 12 – The top figure is of a correctly configured pole zero, the middle figure is of a pole zero that is too high, the bottom figure is when pole zero is too low.
We theorized that when this happens there will be more than the regular curve. We thought that there would mostly be the normal energies with a few of the altered energies. So I came up with an equation to test this hypothesis. The first equation was to test to see if it would give a correct S-parameter with the same parameters, such as FWHM and peak.

\[ S = \frac{\int_{S^+}^{S^-} \frac{1}{\sigma \sqrt{2 \pi}} e^{\frac{(x)^2}{2\sigma^2}} dx}{\frac{1}{\sigma \sqrt{2 \pi}} e^{\frac{(x)^2}{2\sigma^2}} dx} \]

Where \( \sigma \) is related to the full width half maximum. This equation did end up giving the correct S-parameter for a desired data set. The next thing to do was to alter this equation, adding on a part for a second curve that would encapsulate the gamma rays that have their energies altered due to poor Pole Zero.

\[ S' = \frac{\int_{S^+}^{S^-} \frac{1}{\sigma \sqrt{2 \pi}} e^{\frac{(x)^2}{2\sigma^2}} dx + \int_{S^+}^{S^-} \frac{1}{\sigma \sqrt{2 \pi}} e^{\frac{(x-\mu)^2}{2\sigma^2}} dx}{2 \int_{-\infty}^{\infty} \frac{1}{\sigma \sqrt{2 \pi}} e^{\frac{(x)^2}{2\sigma^2}} dx} \]

Where \( \mu \) is how much the average bin change of the energies are. The results agreed fairly well with the experimental data, showing that there is a peak change in the data. This can be seen in Table 1 below.
Table 1 – This table shows that when a second peak of higher energy gamma rays is superimposed onto a normal peak, the S-parameter will change.

<table>
<thead>
<tr>
<th>$\Delta$Peak Channel</th>
<th>S-parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>.556</td>
</tr>
<tr>
<td>.5</td>
<td>.552</td>
</tr>
<tr>
<td>1</td>
<td>.540</td>
</tr>
<tr>
<td>1.5</td>
<td>.521</td>
</tr>
</tbody>
</table>

The Pole Zero can be altered by going into the settings of the acquisition setup software and manually changed. There is also an automatic Pole Zero, but it needs to be checked manually to make sure that the energies in the region of interest have the optimal tail correction.

3.3.3 Geometry

Another reason we came up with for the changing in the S-parameter is that when the source is placed really close to the detector, some of the gamma rays that enter the detector don’t attenuate all of their energy. This is because when the source is placed near the detector, there are more parts of the detector that are likely to only have a little bit of the Germanium that the gamma rays will travel through. These areas include the corners of the detector.
3.3.4 A Fix to This Problem

As mentioned before, there were some easy fixes to some of these problems, such as Pole Zero, but they only work so well. Some of the other problems couldn’t be solved with the software that we had. Even with these problems, I thought that there could still be a way that we could take more data in a shorter amount of time. One of the things that entered into my mind was that if the S-parameter changed for one set of data, it should change for another set of data as well. I thought that the differences in S-parameter because of the position should be the same for all materials. I decided to test this hypothesis by taking two different samples and placing them at different places around the detector while taking data. Every place that I placed one sample, I would place the second sample there afterwards. This was
done for five different places with the two materials. After I made every measurement, I retook the data for both samples to make sure that the results would stay consistent. These results are shown in figure 15.

Figure 15 – This figure shows that the S-parameter is able to distinguish varying defect density even though the S-parameter changes over position. As seen, this is only possible with a relative S-parameter.

What was found supported the hypothesis that the change in S-parameter would remain roughly the same for different materials. This meant that as long as there was a reference point where there was a known S-parameter, the samples could be brought closer to the detector increasing the count rate and decreasing the time needed to take a set of data.
Chapter 4: Conclusion

4.1 Experimental Results

The results that we have obtained show that it is possible to tell the difference between materials that have different defect densities, even though the peaks have been shifted. It has also been shown that using PAS can tell the difference between different materials. It was also shown that it is possible to decrease the time needed to obtain a data set by placing the sample closer to the detector. This becomes really important when taking more than one set of data at a time, even though when doing this the S-parameter will come out to be skewed or altered from what it should be. This can easily be fixed by comparing the data received with a sample of known defects that is placed at the same location, as seen in figure 15.

4.2 Future Work

There are many interesting areas that can be studied by PAS. One of them would be to see differences in materials that cannot be seen by the naked eye. Another more interesting study would be in the W parameter. The W-parameter focuses on the shape of the wings or outer part of the curve. Understanding the W-parameter might hold clues to understanding better materials you are testing. It was shown that if materials are completely different they can be easily distinguished from one another using PAS. But for cases where the materials are made up of a couple different atoms, and are very similar or have mostly the same atoms in them, it becomes difficult or even impossible to distinguish between the materials when only
using the S-parameter. It is thought that the W parameter would help distinguish what materials are made of, and if this is so, chemical compositions would be easily found. Some techniques that are used to find the chemical composition of a material will destroy a piece of the material in question. Even though there are other non-invasive ways of finding the chemical composition of a material, PAS is another alternative. For more information on the W-parameter, see references [5] and [9].

4.3 Introducing Selected Defects

When Jacopo Lafranceschina went to school here he worked on being able to read a BYU-I plate with PAS, and I joined his team towards the end of his research. The goal was to read BYU-I from a copper plate and have the letters be a different S-parameter then the rest of the plate. He ended up using tape for the letters, and was able to read clearly BYU-I using the PAS system. I then wanted to know if it could be done only using copper and no other materials. I also wanted to know if the defects could be introduced structurally only and not visible to the naked eye. That is what all of the research so far has led up to. When using shot peening techniques, it is possible to make location specific defect densities, where different parts of a material would have different defect densities, which would lead to different S-parameters. But when you shot peen a material, the surface becomes deformed and it is easy to see where the defects are with your eyes. When you anneal a material, the whole thing looks the same, the S-parameter becomes the same for the whole thing. My idea to make is to only change the S-parameter in part of a plate and not the
others was to using a specialized heating method. My method would only heat parts of a plate that I want. My method would be to make a plate that has BYU-I cut completely through the material. I would then put holes in the sides of the plate that would allow water to flow through it. I would also have a solid plate of copper the same size as the BYU-I plate. I would place the solid plate beneath the cut out plate and tighten them together. I would then heat both plates above 500°C while pushing water through the cutout plate. This would cause the main part of the plate to increase to over 500°C while keeping little grooves of the copper under 200°C. This would be a large enough temperature gap that would enable me to tell the difference between the letters and the rest of the plate.

There were a couple things to test before we went straight to the big plate. First I had to see if it was possible to make a temperature difference in a piece of copper. I decided that I needed to make a small simulation first and look at a heat map of a simple case. The case would be a tube with a divot in one side. The divot would correlate to where the upper plate would be cut through and the bottom of the divot would be where the two plates are connected. I would then run a computational fluid dynamics simulation that would keep the hole below 200°C while heating up the outside of the object to over 500°C. If the simulation proves successful then we would test it in real life.
Figure 16 – Heat map of what the desired divot would look like in order to read the invisible letters.
Bibliography


APPENDICIES

1) Collecting Data

COLLECTING DATA

Open Internet Explorer, in the favorites tab choose LYNX, it is the Canberra data collection software. Then set the desired parameters including; collection time, ROI, number of counts in the ROI, etc. Press the start button, and wait until the desired amount of data is taken. If you want to stop the data collection manually, press the stop button. Save the data, renaming it with the date and a brief description. This data can be found in C:/GENIE2k/CAMFILES/(FILE_NAME_).cnf

CONVERTING THE DATA

Open the desired saved data file in the gamma Acquisition and Analysis program. Click the Analyze button, Reporting, then Standard. A screen will appear and for the first box select BYUI Pos R2 .TPL, then BYUI DATA, and then hit execute. This will create a file that can be found in C:/GENIE2k/Repfiles/(FILE_NAME_).RPT. You will need to erase the .RPT and write .mpa. Then open C:/GENIE2k/POSITRON ANNIHILATION, then PosAnal.exe, and the WINDOWS FOR ANALYSIS.txt. The text file contains the windows needed for analyzing the data. Hit the add button, and plug in the window
values from the text sheet into the PosAnal.exe file. Hit the browse button, and add your files. Set the ADC control to 4 and then hit the Analyze button.

PUT IN EXCEL SPREADSHEET

Things have to be done in this order. First open Excel, and then click the open button. Make sure the “see all files” option is chosen. Choose your data file, it will be labeled output.dat and it will be in the location that your data was in. When it opens up there should be some options. Click the Delimited circle, then click next. Check the “Comma” box and hit the finish button. The Excel spreadsheet will then appear with all of the data and the parameters desired.
2) MATLAB code

MATRICE ACQUISITION PROGRAM

% MAIN PROGRAM
function

% Giving what everything means and should be
% n = 22;
% m = 18;
% x = linspace(0,378*(n-1),n);
% y = linspace(0,378*(m-1),m);

n = 6;
m = 12;
% linspace(a,b,c) makes an evenly spaced array between a and b, with an
% increment of size c.
x = linspace(0,360*(n-1),n);
y = linspace(0,360*(m-1),m);
p = length(x);
t = length(y);
p = p-1;
d = 1000; % go back distance of the 'Z' motor
pause(3)

for k=5:t
  % program to switch which window is being used
  fprintf('made it
')
  ProgramSwitch(1) % switch to left program on the screen (MUST BE GAA)
  GAA % function .m start sequence (Jacopo)
  v = exist ('c:\genie2k\repfiles\det03.rpt'); % Looks for existing data file from analysis
  sequence from Canberra GAA call det03.rpt

  % Data collection for already position sample in spot (0,0)
  % You MUST set the motor's-parameters in the ST400NT and position the sample before running
  % any of this

  while v==0
    pause(5) % waiting time
    fprintf('I am waiting for data acquisition to finish
')
    v = exist ('c:\genie2k\repfiles\det03.rpt');
  end
  % wait for GAA to write the file after the measurement is done
  pause(10)
  fprintf('good job, the acquisition is done, data found it
')
  newname = ['C:\Users\pas\Desktop\Kevin Data\New Data\',num2str(k),'.','\',num2str(1),'.mpa']; % CREATE NEW NAME (with full path) folder on desktop point1.mpa
  movefile('c:\genie2k\repfiles\det03.rpt',newname) % ACUTAL MOVING & RENAME using name created above
for i=1:p
    ProgramSwitch(2) % Goes to the second (right) program
    Go_Position(3,d) % move back
    pause(10)
    Go_Position(2,x(i+1)) % go new spot x direction if 1 y direction if 2
    pause(10)
    Go_Position(3,0) % move in
    pause(10)
    ProgramSwitch(1)
    GAA % start sequence
    v = exist ('c:\\genie2k\repfiles\det03.rpt'); % Checking to see if the program has written a file
    while v==0
        pause(10) % waiting time
        fprintf('I am waiting for data acquisition to finish\n') % STILL WAITING
        v = exist ('c:\\genie2k\repfiles\det03.rpt');
    end
    % File written
    pause(10)
    fprintf('good job, the acquisition is done, data found it\n') % FOUND IT
    newname = ['C:\Users\pas\Desktop\Kevin Data\New Data\',num2str(k),'.','num2str(i+1),'.mpa'];
    % newname
    movefile('c:\\genie2k\repfiles\det03.rpt',newname) % moving\renaming file
    try
        smail('byui.pas@gmail.com','point taken','line ',num2str(i),'. taken'))
    catch err
        end
    pause(5)
end
ProgramSwitch(2)
Go_Position(3,d) % move back
    try
        smail('byui.pas@gmail.com','point taken','line ',num2str(k),'. taken'))
    catch err
        end
% ended first line;

%%%%%% ended first line; %%%%

% OPEN PROGRAM AFTER EACH LINE IS DONE
% ProgramSwitch(2)
    pause(10)
% Closing program, because it breaks after a while
Close_Port
Close_Program
pause(2)

30
% Opening program that controls the motors
Open_Program
% Initializing
Ini_Board
pause(20)

ProgramSwitch(2)
Go_Position(3,d)
Go_Position(2,0) % move origin of line
pause(200) % pause for going back
Go_Position(1,y(k))
pause(20)
Go_Position(3,0)

end
Go_Position(3,d)
end