NAME: Oluwasina Olowookere

STUDENT NO.: 1006648068

COURSE: MSE238

TITLE: Project FInal

I. Introduction

This project will highlight what procedures produce a good engineering alloy by analyzing the Multi Principle Element Alloy Dataset. The objectives of the project are to visualize the data and research the role a materials processing procedure plays in its yield strength as well as other relationships such as the correlation between grain size and yield strength. Statistical procedures such as data visualizing, line fitting, standard error and summary statistics will be used to classify and the data will be visualized using functions such as ggplot, rowMeans and a handwritten function. The anticipated outcome is a set of ordered visualized data that shows a clear relationship between the processing procedures and the material's yield strength. The project also references the Beaches dataset and gives an indication of stability with respect to time by using R-bar and X-bar control charts. The expected outcome is a visualization of the stability distribution with respect to time in days. This project uses visuals to support claims that be made quantitatively and acts as an information source.

II. Statistical Theory and R Modules used

In this project, the statistical theories that were utilized are as follows:

- Construction of box plots to see the distribution of yield strength and get a visual as to where the median yield strength is located
- Histograms were used to get the frequency of the Yield strengths that were provided in the dataset.
- Determining the line of least squares in plots and standard error reporting
- Data summary techniques such as determining the average Yield strength
- In the Beaches dataset, methods such as Control Charts were used to determine how the ecoli changed over time on the beaches

The R code modules that were used are as follows:

- The 'tidyverse' library gives me access to visualization functions such as ggplot, geom, facet and the ability to customize plots in such a way that made relationships clear.
- The 'dplyr' library was used to access functions such as "rowMeans"
- The select function
- Handwritten Functions

III. Results and Discussion

The first thing that needed to be done to the datasets was to import them using the read.csv function, this makes it so that the datasets are assigned to variables and stored. The purpose of analyzing the MPEA dataset was to determine what would make an ideal/good engineering material. In order to determine this, I conducted some research on what properties most engineers were seeking when it comes to metals. According to my research, the most sought-after properties are Yield Strength and Youngs Modulus. A high Yield Strength implies that the material has high ductility, which is defined as he ability of a material to have its shape changed (as by being drawn out into wire or thread) without losing strength or breaking. A high Youngs modulus means that the material can undergo large stress without leaving its elastic region which is extremely desired because it allows for no plastic deformation in that region. Once a material starts to plastically deform, it will continue to deform if still loaded and get past its Ultimate Tensile Stress and then it begins to Neck and fracture.

Using this basis, I started out by creating a boxplot of the Yield strength which can be seen in the figure below. The box plot suggested that the median Yield strength is around 889.9615 MPa.

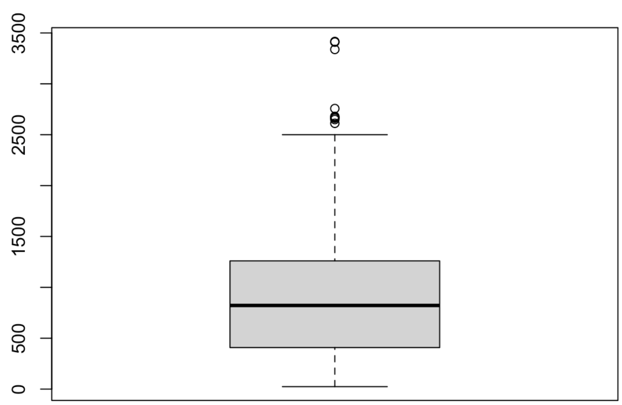


Figure 1.(Box Plot of Yield Strength)

Using this, I went further to see the distribution using a histogram, which can be seen in Figure 2 below.

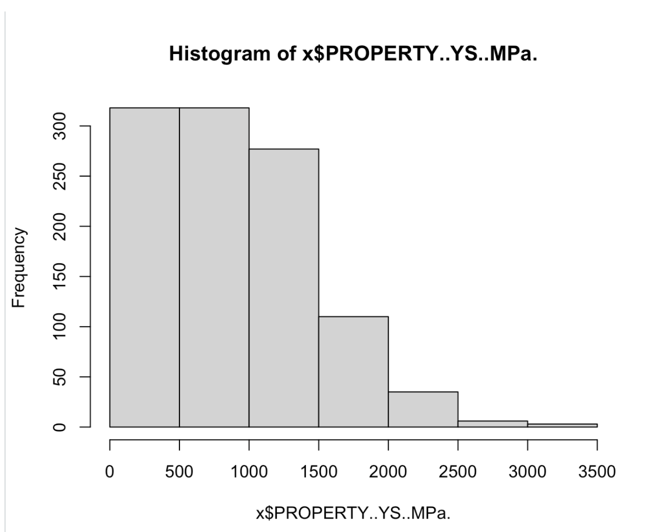


Figure 2. (Histogram of all materials in the database yield strength)

The histogram is skewed to the right which means that there are a few materials that are under the average yield strength

For the purposes of this project, I defined every material that had a yield strength below that of the average as not suitable. The goal is to maximize the usability of a selected material. To achieve this, I began using the visualization tools in R to view the relationships that existed between the yield strength and other factors. The relationships that I focused on in reference to the yield strength of the material were:

- Grain size
- Phase type
- Temperature

When analyzing the grain size and yield strength relationship, I visualized the data in such a way that I would be able to get multiple interpretations. For instance, in Figure 3 below, I faceted the data in such a way that I would be able to obtain information about the phase types (Single-phase or Multiphase) as well as the grain size. The data in Figure 3 suggests that as the grain size increases, the yield strength reduces and that single phase metals have higher yield strength than multiphase materials.

The reason why grain smaller grain size accounts for higher material strength is that when you give a material enough energy, dislocations will move throughout crystalline grains, distorting the lattice itself. When grain boundaries are present, there is nowhere for dislocations to move to.[1] Increasing the number of grain boundaries in a system will increase the ratio between grain boundaries and dislocations which results in an overall stronger material. This is supported by Figure 3 below.

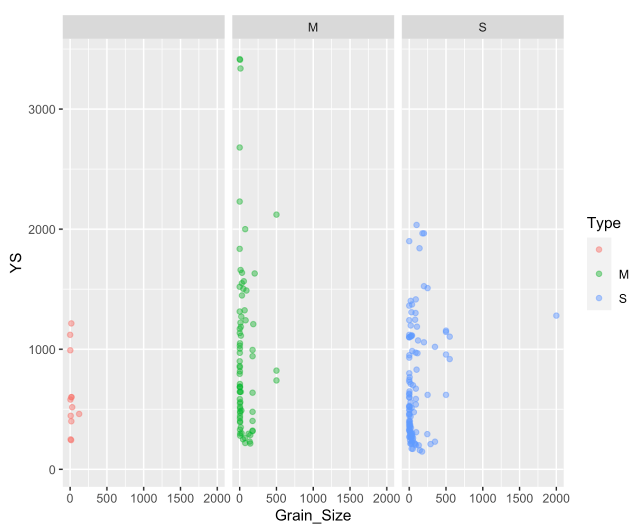


Figure 3. (Grain size and Yield strength relationship)

The next relationship that was analyzed was the relationship between temperature and yield strength. This relationship was the same for all phase types, as seen in Figure 4. The plot suggests that materials processed at lower temperatures have higher yield strength. We can interpret it like this because the linear fitting has a negative slope which indicated a decreasing relationship between temperature and yield strength. This goes back to support the earlier statement that when materials are given enough energy, they will start to dislocate. The main idea here is that dislocation is the mechanism for the degradation of yield strength.

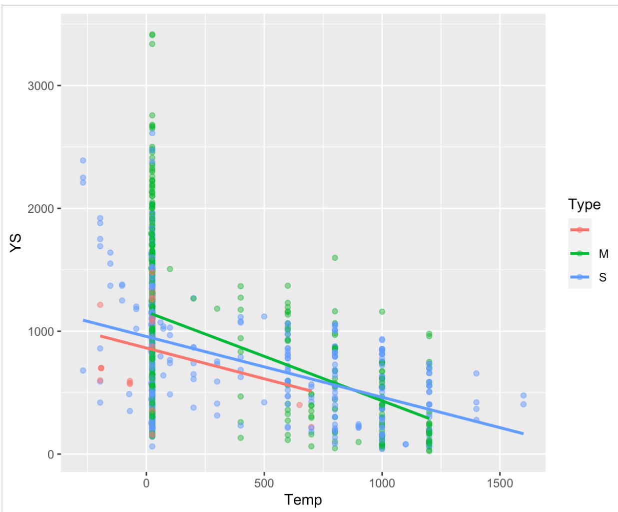


Figure 4. (Temperature VS yield Strength plot)

In order to aid the selection of suitable engineering materials, I wrote an R function that takes the dataset as an argument and asks the user for the desired Yield Strenght and elastic modulus they want. The function will then take this input and pull out row entries that match or are better than the user input.

This led me to further investigate the relationship between temperature and grain size, to assert the truthfulness of my findings, and the plot suggests that the findings are accurate.

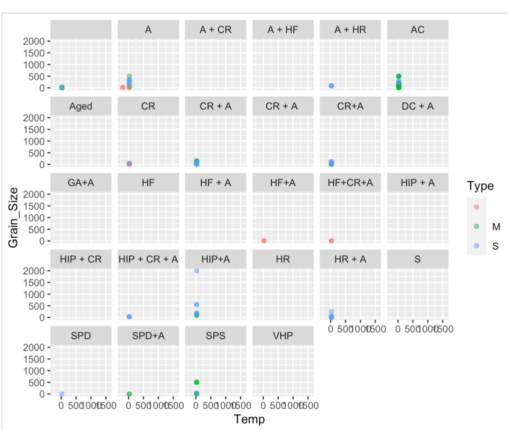
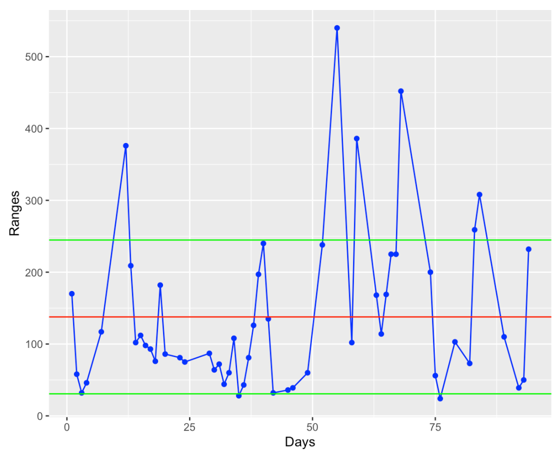


Figure 5. (Temperature and grain size)

For the beaches dataset, I used a X-bar and R-bar control charts to show the relationship between the eColi and their change over time. In Figure 6 and 7, we see the X-bar and R-bar control charts, the red line indicates the mean of all the sample means and the mean of all the sample ranges. The values for the control chart were gotten using the Table of Factors for X-bar and R-chart control charts.[3] This control is accurate because we do not notice any order, meaning that the data is random and does not exhibit any trends.



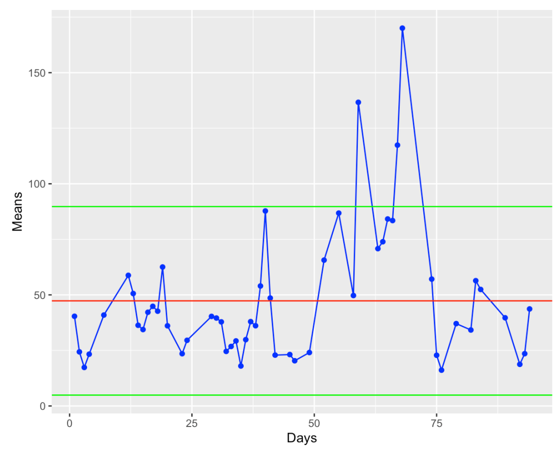


Figure 6. (R-bar chart for beachesdataset)

Figure 7. (R-bar chart for beaches dataset)

There are points where both the range and the mean of eColi go above the upper control limit which lets us know that these points are out of control and need to be investigated. The charts let us know that as time progresses, the eColi is relatively stable but goes out of control quite a few times.

IV. Conclusion

This project will highlight what procedures produce a good engineering alloy by analyzing the Multi Principle Element Alloy Dataset. The objectives of the project were met by visualizing the data and research the role a materials processing procedure plays in its yield strength as well as the relationships between grain size and yield strength. It was found that the reason why yield strength increases with increasing grain size is because of the energy being put into a system.

This finding aslo supports the relationship that was seen in the plots where energy in form of heat reduced the grain size of a material and the smaller the grain size of a material was, the higher its yield strength. The handwritten function took in the desired yield strength and elastic modulus and gives an output of the materials with those specifications. anticipated outcome is a set of ordered visualized data that shows a clear relationship between the processing procedures and the material’s yield strength.

The project also references the Beaches dataset and gives an indication of stability with respect to time by using R-bar and X-bar control charts. The control charts also show the findings of how eColi in Toronto beaches become toxic as time passes using control charts. The purpose of this project is to act as an information source on the things that make materials good engineering materials as well as the growth of toxic eColi over time.

V. References

[1]B. Wellman, “Grain Size and Material Strength,” 2010. https://materion.com/-/media/files/alloy/newsletters/technical-tidbits/issue-no-15---grain-size-and-material-strength.pdf (accessed Apr. 05, 2022).

[2]“Definition of DUCTILITY,” www.merriam-webster.com. https://www.merriam-webster.com/dictionary/ductility#:~:text=%3A%20the%20quality%20or%20state%20of (accessed Apr. 06, 2022).

[3]“SOLVED:FACTORS FOR x AND R CONTROL CHARTS Observations in Sample, n d2 1.128 1.693 2.059 2.326 2.534 2.704 2.847 2.970 3.078 Az 1.880 1.023 0.729 0.577 d3 0.853 0.888 0.880 0.864 Ds Da 3.267 2.574 2.282 2.114 2.004 1.924 1.864 1.816 1.777 5 0.483 0.419 0.373 0.337 0.308 0.848 0.833 0.820 0.808 0.797 0.076 0.136 0.184 0.223 10 11 13 1s 16 18 19 20 21 22 23 24 25 3.173 3.258 3.336 3.407 3.472 3.532 3.588 3.640 3.689 3.735 0.285 0.266 0.249 0.235 0.223 0.212 0.203 0.194 0.187 0.180 0.787 0.778 0.770 0.763 0.756 0.750 0.744 0.739 0.734 0.729 0.256 0.283 0.307 0.328 0.347 0.363 0.378 0.391 0.403 0.415 0.425 0.434 0.443 0.451 0.459 1.744 1.717 1.693 1.672 1.653 1.637 1.622 1.608 1.597 1.585 3.778 3.819 3.858 3.895 3.931 0.173 0.167 0.162 0.157 0.153 0.724 0.720 0.716 0.712 0.708 1.575 1.566 1.557 1.548 1.541 Source: Reprinted with permission f…,” www.numerade.com. https://www.numerade.com/ask/question/factors-for-x-and-r-control-charts-observations-in-sample-n-d2-1128-1693-2059-2326-2534-2704-2847-2970-3078-az-1880-1023-0729-0577-d3-0853-0888-0880-0864-ds-da-3267-2574-2282-2114-2004-1924--96338/ (accessed Apr. 06, 2022).