Features' Behavior of Tensile Testing Data of Brass

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***Abstract*—In this study, the relationships of four features of brass sheet were analyzed with any linearity. Tensile testing is widely used to find a material's maximum force that it can consume without any change to its structure. Tensile testing can identify a material's strength, behavior of its properties, and indicator of the best material to use for a specific application. A material with linear elasticity abides by Hooke's law; thus, the stress-strain curve is linear.**

I. Introduction

Tensile test data of a brass sheet was used. The brass sheet's thickness is of 1.5 mm with grain sizes of 11μm, 25μm, 133μm. [8]However, two datasets of the brass sheet of 11μm and 133μm were analyzed. Each of the grain sizes contains three datasets. Only one dataset was selected to be analyzed from the three datasets for each of the 11μm and 133μm grain sizes. An alloy is a substance made by melting two or more elements together. One of the elements must be a metal. This substance is an impure mixture in which it preserves the characteristics of a metal. An alloy crystallizes upon cooling into a solid solution, mixture, or intermetallic compound. The components of alloys cannot be separated using a physical means.

Alloys are stronger, less malleability, and an increased resistance of corrosion in comparison to the predominant metal of the alloy. A metal alloy made of copper and zinc or a Cu-Zn alloy is defined as brass. The composition of brass is generally 70 % copper and 30% zinc. Based upon composition, its melting point is low from the ranges of 1652°F to 1724°F.Typical mechanical properties of metal alloys include ductility, tensile, and yield strength. [3]

Ductility is the measurement of deformation right before breaking. Tensile strength is the measurement of the required maximum force(tension) or tensile stress to the breaking point of the material. Tensile stress is the pulling of the material. Yield strength is the maximum stress applied before the material change its shape permanently. The average values of these properties are 75 MPa,300 Mpa, and 68 % EL. [5]

II. Methods

Ordinary least squares(simple) linear regression was used for creating a model of the data. Linear regression is used to predict or show the relationship between variables. It corresponds to minimizing the sum of square differences between the observed and predicted values. The four features selected were paired up with each other to show their relationship. Each variable was paired up for certain reasons that will be explained.

The linear model of each graph is displayed under each graph.

The Load vs. Extension graph is a main product from the tensile test. It is usually converted into a stress- strain graph. The stress-strain graph is the outcome from constant values divided by Load vs. Extension graph. Each graph will have the same shape. [4]

In the Stress vs. Load graph, the stress is related to the amount of applied load. The Load vs. Time graph represents the load and its magnitude plotted in a decreasing order. In the Extension vs. Time graph, the creep test determines the amount of deformation a material experiences over time while under a continuous load at a constant temperature. The creep test also observes the extension or strain with respect to time. [1]

Even with ordinary least squares, linear algebra is a key factor both in machine learning and linear regression. Matrix decomposition or matrix factorization occurs when a matrix is decomposed into a product of two rectangular matrices. The product of these matrices will have a lower dimensionality than the original matrix. Least squares use matrix decomposition to solve linear systems of equations. Linear algebra is important in machine learning for various of reasons: more perspectives and in- sight on formulating solutions of machine learning problems. It can include training/testing data, matrix factorization, customization of parameters, and
foundation on statistical concepts.

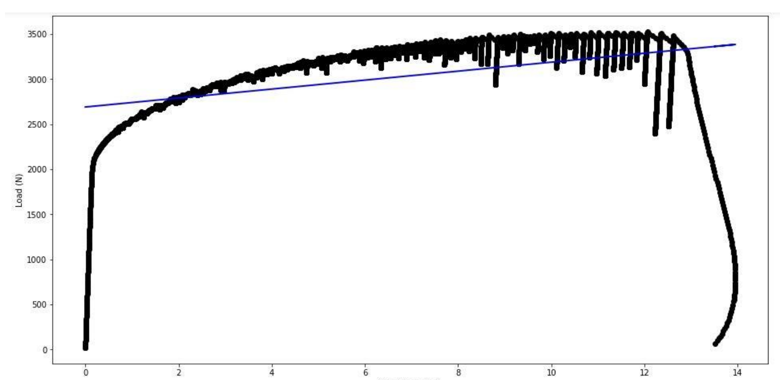
Linear Algebra is used by the least squares for the equation of Ax=b. The expectation is to find some linear combination of A that gives the vector of observed values. However, linear regression omits finding a perfect model that fits b. It uses another vector in A that will be closer to be. The error calculated is that of vectors p and b. It is desired to minimize the error between two vectors. If b does not fit the model initially then, p is used instead that may show a better approximation or better fit of the model.

Machine learning algorithms are used to give an analysis of a set of information. However, linear algebra is the translation of the data that math is performed known as vectors and matrices, which trains the algorithm.

The invention of linear algebra was created by Hermann Grassmann. In the *Theory of Extension*, foundational topics include what is currently known as linear algebra. This work was a part of his collected works during the time he hoped to improve his own career. Inner products, linear transformations, free linear spaces, and linear combinations are a few of these foundation topics discussed in his work.

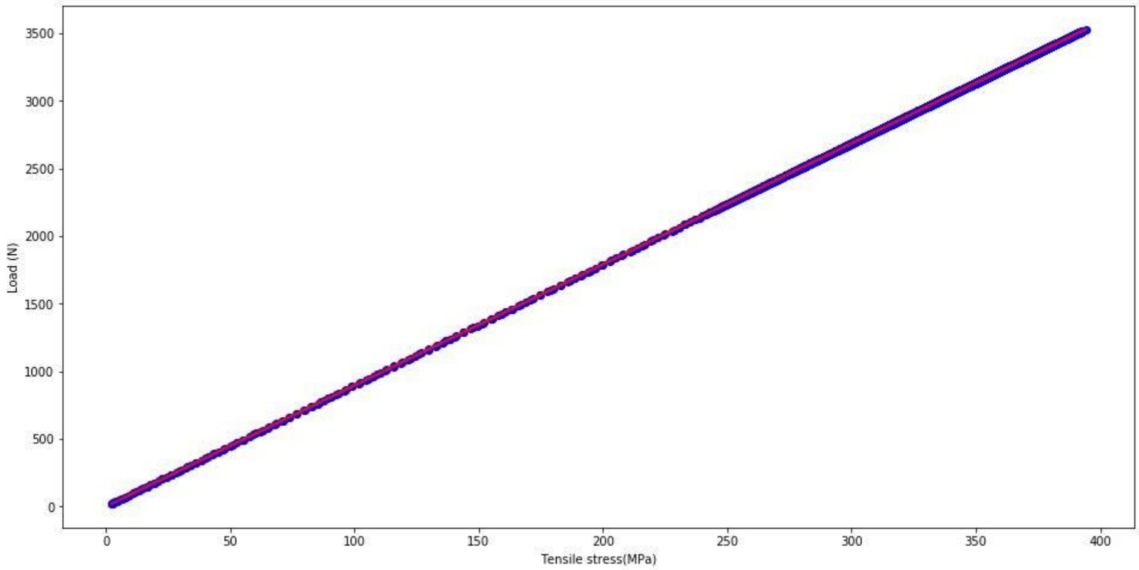
III. Data Analysis: Grain size 11um

A. Load vs. Extension



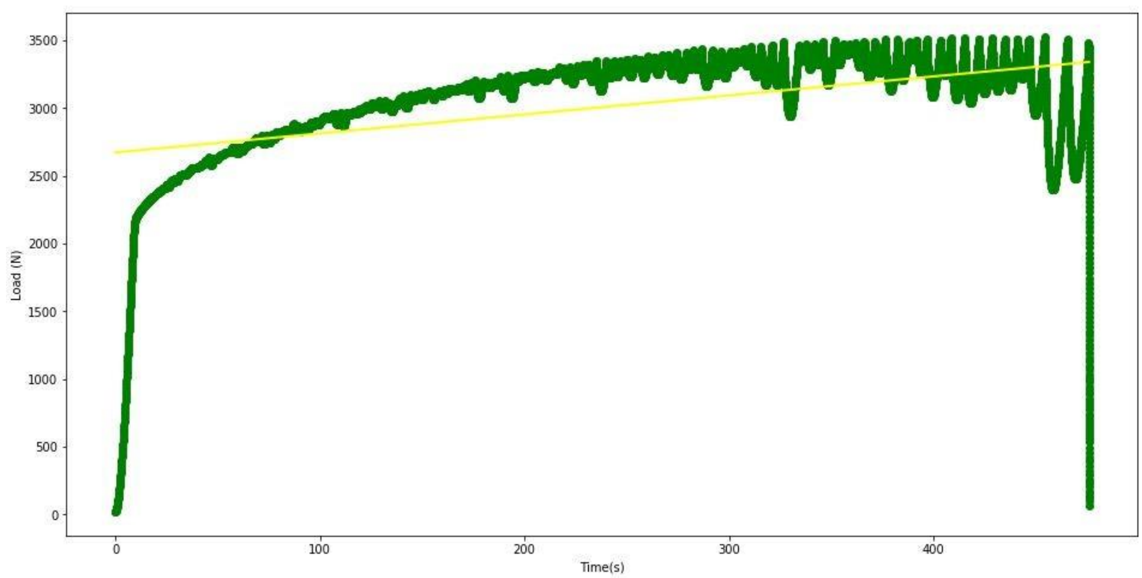
Non-linear relationship between load and extension; The linear model is: Y = 2691.3 + 49.745X

B. Load vs. Tensile Stress



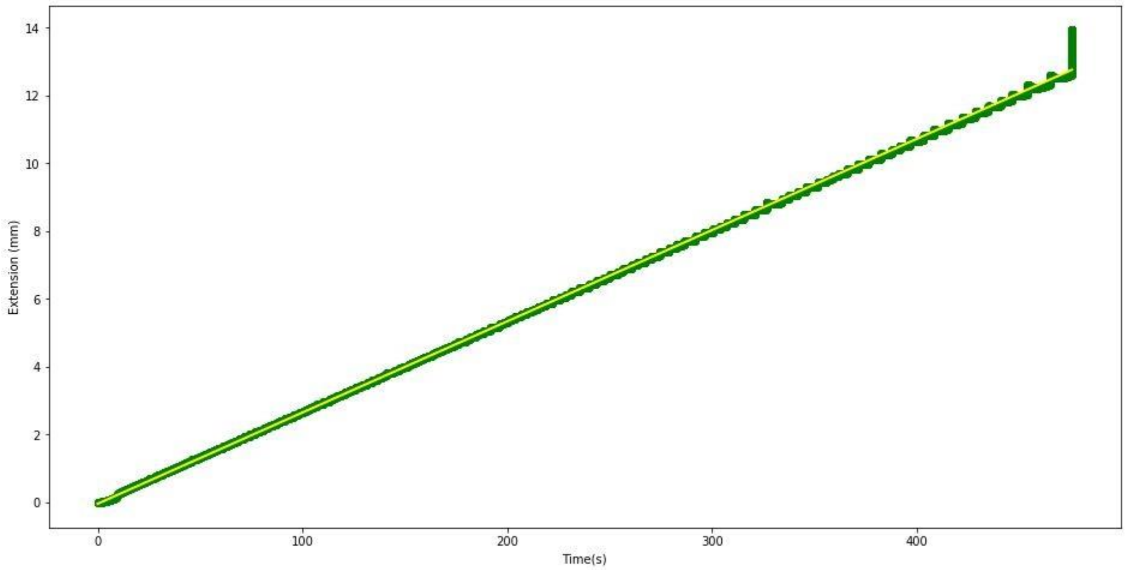
Linear relationship between stress and load; The linear model is: Y = -1.2733e-06 + 8.954X

C. Load vs. Time



Non-linear relationship between load and time; The linear model is: Y = 2673.5 + 1.4027X

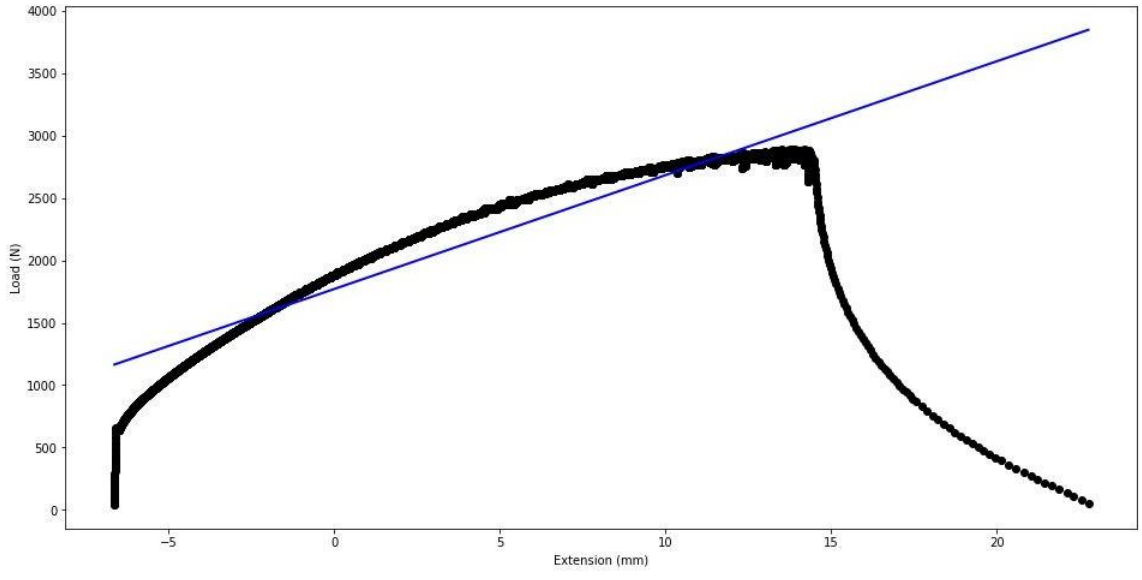
D. Extension vs. Time



Linear relationship between extension and time; The linear model is: Y = -0.041703 + 0.026903X

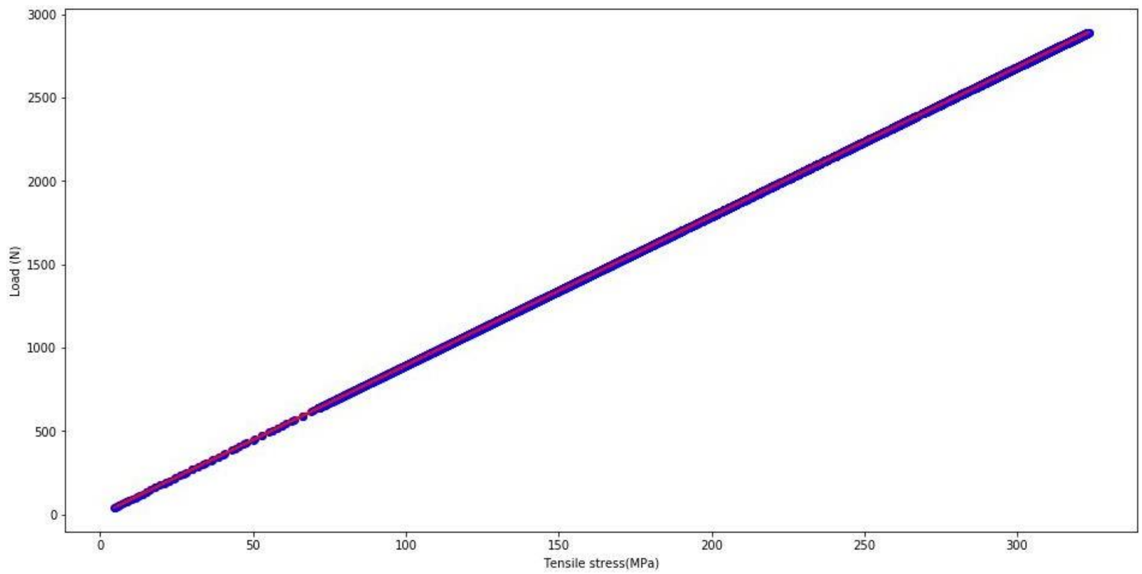
IV. DATA ANALYSIS:GRAIN SIZE 113UM

A. Load vs. Extension



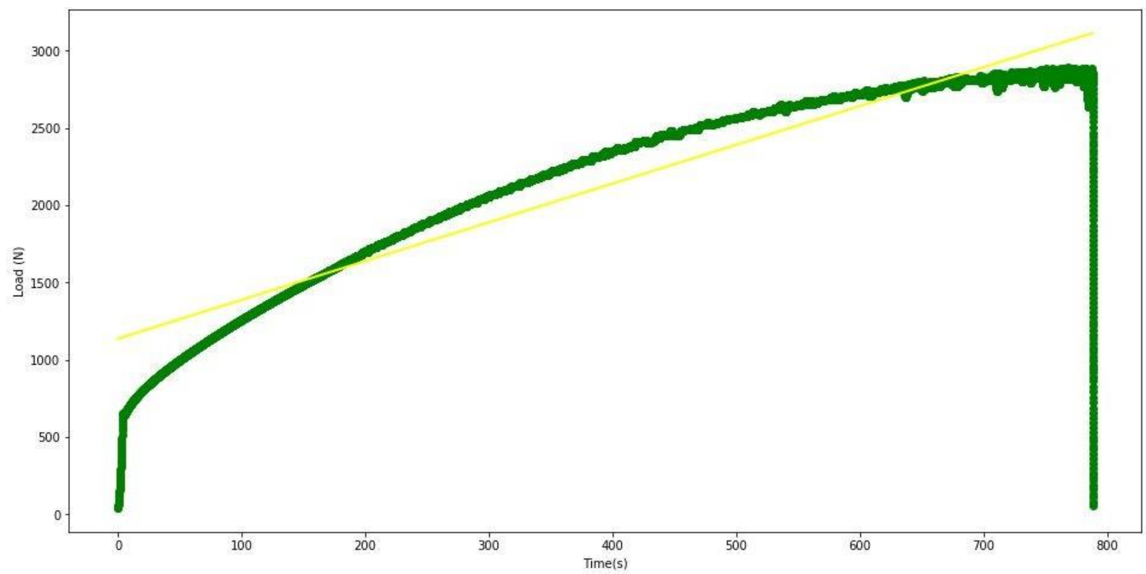
Non-linear relationship between load and Extension; The linear model is: Y = 1770.4 + 91.275X;

B. Load vs. Tensile stress



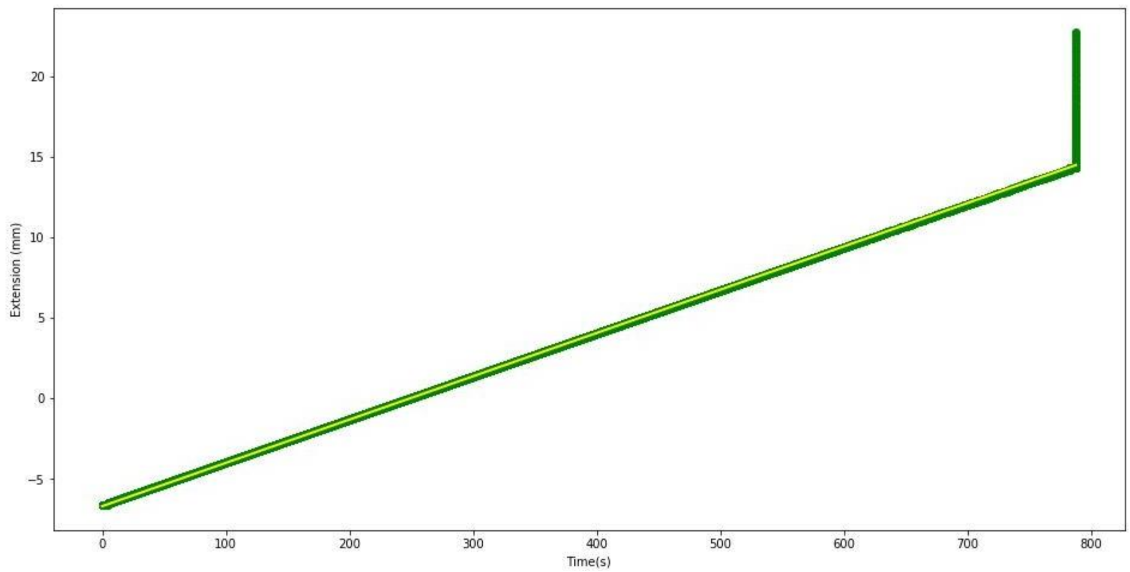
Linear relationship between tensile stress and load;
The linear model is: Y = -6.0924e-07 + 8.9392X

C. Load vs. Time



Non-linear relationship between load and time;
The linear model is: Y = 1136.9 + 2.5099X

D. Extension vs. Time



Linear relationship between extension and time; The linear model is: Y = -6.6928 + 0.026878X

Further explanation and relevancy of the graphs will be explained in the Results section.

V. Results

A. Graph results for Grain size 11um

Load v Extension Results: The R^2 value of this graph has a low score of 0.146 but has a high F-statistic score of 845.1.

Load v Tensile stress Results: The R^2 value of this graph has a perfect score of 1 and F-statistic score of 1.7e^{17}

.**Load v Time Results:** The R^2 value of this graph has a low score 0.160 but has a high F-statistic score of 943**.**

Extension v Time Results: The R^2 value this graph is 0.999 and a F-statistic score of 4.184e^{06}.

B. Graph results for Grain size 133um

Load v Extension Results: The R^2 value of this graph has an acceptable score 0.783 but has a high F-statistic score of 2.885e^{04}.

Load v Tensile stress Results: The R^2 value of this graph has a perfect score of 1 and has a high F-statistic score of 7.363e^{17}.

Load v Time Results: The R^2 value of this graph has an acceptable score of 0.817 and has a high F-statistic score of 3.565e^{04}.

Extension v Time Results: The R^2 value of this graph has an acceptable score of 0.997 and has a high F-statistic score of 2.321e^{06}

C. Score Significance

It is apparent to see that some of the graphs are linear and other are non-linear. Graphs such as figures 1,3,5,and 7 appear to be logarithmic. Coefficient of determination (R^2)scores are the proportion of the variance in the dependent variable that is predictable from the independent variable. F-statistic scores represent the variation between sample means / variation within the samples. Most often, it is used when comparing statistical models that have been fitted to a data set. It identifies the model that best fits the population from which the data were sampled. Both scores range from 0-1 with 1 as the highest value.

VI. RELATED WORK

Flax fibers were examined for its tensile properties with the intent of validating its importance of the hemicelluloses and hemicelluloses/pectins ratio. To meet this end goal, the correlation between the stress-strain and fiber composition had to be investigated.

The tensile properties were Young's Modulus, tensile strength, and tensile strain along with the specified sample number. There were three types of stress-strain behavior among the six samples such as, purely linear, linear in two different regions, and non-linear until the threshold point. The assumption of these regions likely depended upon the relation of the stress-strain and the chemical composition of the fibers. From their research, it appears that the third sample that had a non-linear stress-strain behavior correlates to high values of the tensile properties. [6]

Extension vs. force correlation focuses on the indentation on hard materials. This study addresses the surface energy from the fracture of the material. Though, it is interesting that the fracture's toughness' surface energy is greater than the total surface energy of the fracture.

The tensile properties tested in this study were elastic modulus, yield strength, and yield stress. The extension vs. force correlation represents a linear relationship of for more brittle materials. The study concluded with a better understanding of friction in hard materials. [2]

Yield strength vs. Tensile strength correlation related to the hardness of steel materials. The strain-hardening potential is from the ratio of the yield strength and tensile strength. A steel that can achieve the maximum amount of hardening during plastic deformation.

The hardness potential and the correlation of the yield strength vs. tensile strength displays the level of hardness of the steel. It was observed that steels with a higher hardness value had a low yield strength vs. tensile strength ratio. However, the yield strength and tensile strength are not the only factors that influences the strain hardening potential. Other material properties were considered in correlation.

In the least squares linear regression, the average yield strength and tensile strength related to the hardness correlation was calculated. The analysis of the regression reveals that the steels' yield strength was linearly correlated with its hardness.

These three similar research studies are similar to this research in several ways such as, the analysis of the correlation of the tensile or material properties behavior of each specimen. The examination of calculated using the stress vs. strain or extension vs. force curve and linearity with respect to those properties. All the results from the studies, shown the characteristics of these materials. [7]

VII. CONCLUSION AND FUTURE WORKS

Analyzing any linear relationship among the features of the datasets were the primary goal of research. In reality, all materials abide by Hooke's Law to a certain degree. For example, the non-linear graphs of load vs. extension abides by Hooke's law to a point. This is where deformation of the material cannot be undone, and it is permanent.

Tensile stress vs. load graphs and extension vs. time graphs make sense for each to be linear. One displays the amount of the load applied in relation to the stress; yet, the other shows the deformation under a continuous applied load with respect to time.

The results show that the behavior of the brass sheet does have elasticity. The future works of the research includes adding extra factors to investigate the behavior of the brass sheet. Also, the influence of these factors that relates to the four chosen factors with inspecting any linearity among all the parameters.

Yield point is one of the desired additional features to be implemented in the further research. The point on the stress vs. strain curve indicates the range where, the material’s elasticity changes into the behavior of plasticity.

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