Multiple Linear Model to Study Mechanical Properties of Bronze Alloys Using MATLAB Language

Dr.Amin Daway Thamir* ***Abbas Khammas Hussein**

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Abstract

This work include prepare five alloys of bronze (Cu-5wt.%Sn, Cu-10wt.%Sn, Cu-15wt.%Sn, Cu-20wt.%Sn, Cu-25wt.%Sn).These alloys were then subjected to tensile tests to determine the tensile strength (MPa) and elongation(%) for each alloy. Tensile tests were performed according to ASTM-E8.MATLAB language was used to determine the mathematical model for tensile strength and elongation with respect to alloy composition.MATLAB results showed that there is a multiple linear model between tensile results and alloy composition.

النموذج الرياضي الخطي المتعدد المتغيرات لدراسة سبائك البرونز بأستخدام لغة الماتلاب

الخلاصة:

يتضمن هذا البحث تحضير خمسة سبائك من البرونز (Cu-5wt.%Sn, Cu-10wt.%Sn, Cu-15wt.%Sn, Cu-20wt.%Sn, Cu-25wt.%Sn) وبعد ذلك خضعت هذه السبائك الى اختبارات الشد لتحديد مقاومة الشد (ميكاباسكال) و الاستطالة (%) لكل سبيكة. اختبارات الشد قد انجزت طبقاً للمواصفة ASTM-E8. وقد تم استخدام لغة الماتلاب لتحديد النموذج الرياضي لكل من مقاومة الشد والاستطالة نسبة الى مكونات السبيكة. اظهرت نتائج الماتلاب بأن هناك نموذج رياضي خطي (من النوع المتعدد المتغيرات) مابين نتائج الشد والتركيب الكيمياوي للسبيكة.

Introduction

Bronze are generally considered alloys of copper containing tin and can certainly contain other elements [1]. Chemical, civil, mechanical, materials, aerospace, and biomedical engineers need to predict the tensile strength of metal parts as a function of their alloy composition [2]. A model is a representation of something constructed and used for a particular purpose. We use models constantly in all walks of life because they present a simplified view of the world which highlights the parts which interest us [3,4]. In this study we conclude the multiple linear model which interest us in engineering metallurgy.

The multiple linear model can be described as follows: Suppose that y is a linear function of the two or more variables x,, x_2,.... For example:

$$y=a_0 + a_1 x_1 + a_2 x_2 \qquad (1)$$

To find the coefficient values of a_0, a_b and ai to fit a set of data (y, x_h x_2) in the least squares sense, we can make use of then fact that the left-division method for solving linear equations uses the least square method when the equation set is overdetermined. To use this method, let n be the number of data points and the linear equation in matrix form as follows:

$$Xa= y \qquad (2)$$

$$a=\begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} \qquad (3)$$

$$X=\begin{bmatrix} 1 & x_{11} & x_{21} \\ 1 & x_{12} & x_{22} \\ 1 & x_{13} & x_{23} \end{bmatrix} \qquad (4)$$

* Department of Production Engineering & Metallurgy, University of Technology
** Department of Materials Engineering, university of technology

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University of Technology-Iraq, Baghdad, Iraq/2412-0758

$$y = \begin{bmatrix} y_0 \\ y_1 \\ y_2 \end{bmatrix} \quad (5)$$

where x_{1i}, x_{2i}, and y_{1i} are the data, i=l......,n. The solusion for the coefficient is given by a=X/y [5,6].

Experimental Procedure

The material provided for this study was in the form of commercially produced copper and tin. These materials was subjected to casting to prepare five-alloys of bronze as shown in Table (1).

Table(l) wt.% of Bronze Alloys	
X,(Sn)wt.%	X_2(Cu) wt.%
5	95
10	90
15	85
20	80
25	75

The samples then were subjected to tensile tests. Sub-size standard tensile bars were machined from the castings according to ASTM-E8. Aschematic depicting a finished tensile bar is shown in Figure(l).

Results and Discussions

The tensile strength and elongation data for alls are reported in Table(2)as follows:

Table(2) Tensile Results		
Alloy	Tensile (MPa)	Elongation(%)
Cu-5Sn	510	57
Cu-lOSn	520	68
Cu-15Sn	532	70
Cu-20Sn	540	73
Cu-25Sn	551	77

A correlation between mechanical properties and alloy composition can be discussed as follows:

1. Tensile Strength and Alloy Composition

The tension strength (y) required to break a bronze bar is a function of the percentages X] and X2 of each of two alloying elements present in the metal. The Table(2) gives the pertinent data and the linear model obtaining from these data using MATLAB language is (y= 0+ 7.04 xi+ 5 x_2). The script file is shown in Figure(2). The vector y_p is the vector of tensile strength values predicted by the model. The scalar Max_Percent_Error is the maximum percent error in the five predications.

Figure(3) and Figure(4) illustrate \ the tensile strength as a function of the f percentage X) and X2 of each of two alloying elements present in the bronze. ;

2. Elongation and Alloy Composition

In the same way the correlation of t the alloys is represented by (y) as as function to the percentage xi and x_2 off each of two alloying elements present inf the bronze. The linear model is (y=0 +| 1.455 X, + 0.555 x_2) and the script fiji' is shown in Figure(5). Figure(6) ancj Figure(7) show the accorelation ol elongation as a function of percentage Xi and x_2 of each of alloying elements present in the bronz

Conclusions

1. A multiple linear model of tensjj strength of bronze alloys is:
 Tensile-Strength (MPa)= 7.04(wt.%Sn) +5(wt.%Cu).
2. Tensile strength change linearly i function to the percentages of Sn Cu.
3. A multiple linear model of elongatj of bronze alloys is:
 Elongation (%)= 0+ *]A55(vd'J&* +0.555(wt.%Cu).
4. Elongation change linearly function to the percentages of Sn| Cu.

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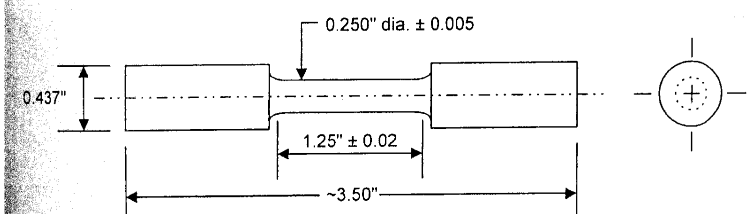


Figure(1) Schematic of machined tensile bar (astm-e8).

```
xl=[S 10 15 20 2S]';x2=[95 90 85 80 75];
Y=[510 520 532 540 551]';
X'=[ones(3ize(xr)) xl1 x2];
a=X\\y
yp'=X*a';
Hax_Percent_ErrQr=10Q*iax(abs((yp-y),/y))
```

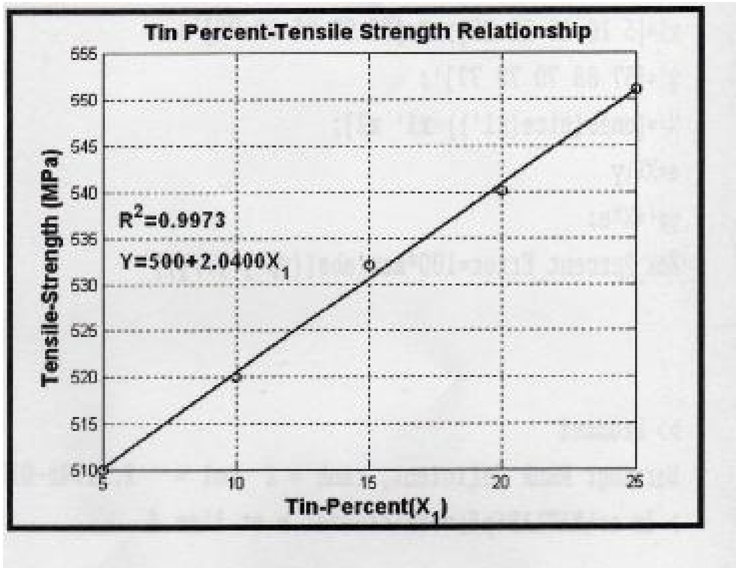
```
» bronze
laming: Rank deficient, rank = 2 tol = 2.1174e-Q13,
> In e:\HATLAB6pS\uork\bronze.n at line 4

a =

        0
    7.0400
    5.0000


Max Percent Error =
0.2632
```

Figure (2) Script file of tensile strength data.

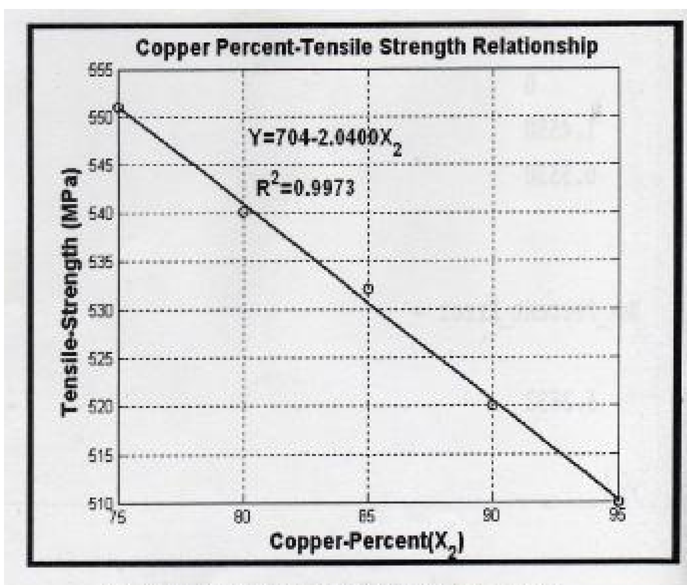
```
xl=[5 10 15 20 2S];x2=[95 90 85 80 75]';
y'=[57 68 70 73 77]';
X'=[Qnes(size(xl')) xl1 x2];
a=X\\y
yp'=X*a;
HaxJercentJrror=10Q*iaax(abs( (yp-y1),/y))
```

```
» bronzel
Warning: Rank deficient, rank = 2   tol =    2.1174e-013.
> In e:\MTLAB6p5Work\bronzel, i at line 4

a=

        0
   1,4550
   0,5550


HaxercentError =

   5,2632
```

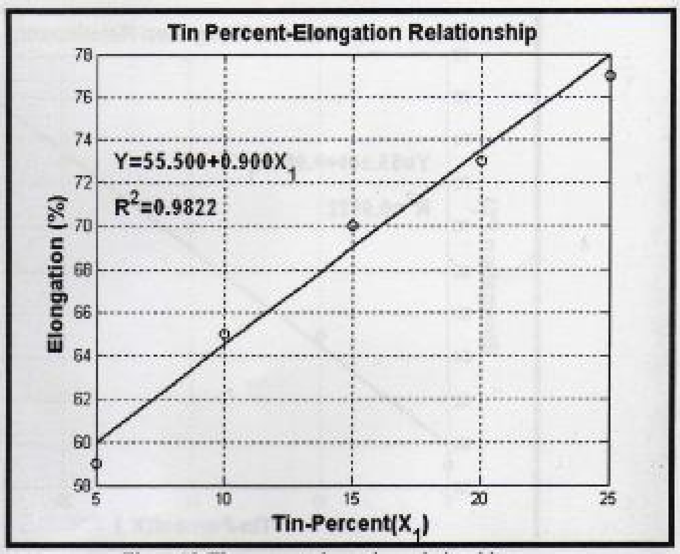
Figure(3) Script file of elongation data.



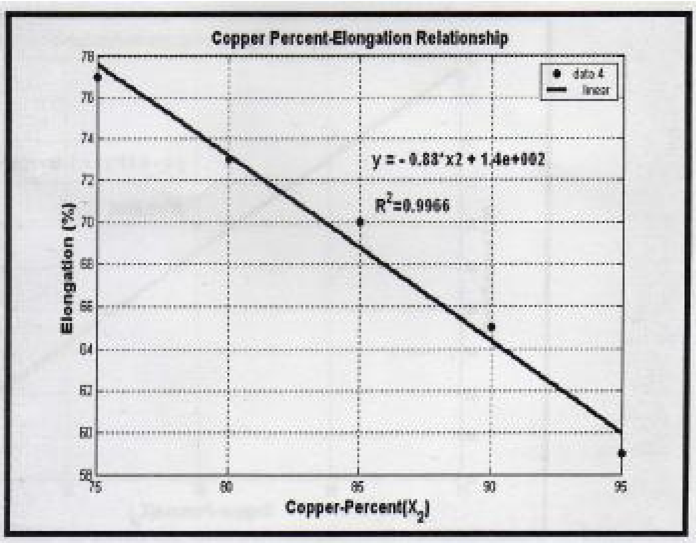
Figure(4) Tin percent-tensile strength relationship.



Figure(5) Copper percent –tensile strength relationship



Figure(6) Tin percent-elongation relationship.



Figure(7) Copper percent-elongation relationship.