MEEN 160

MATERIAL SELECTION IN MECHANICAL DESIGN

EXPERIMENT NO. 2

MECHANICAL PROPERTIES OF MATERIALS

BY

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INTRODUCTION

The purpose of this lab was to determine mechanical properties of materials using the tensile test and Brinell and Rockwell hardness tests. Most of the mechanical properties used for the selection of materials for mechanical and structural applications are obtained from the tensile test. The tensile test was used to determine the load-elongation behavior of a material subject to monotonically increasing uniaxial tension to failure. In the test, a stress-strain curve for the test material was obtained and the properties of yield strength, tensile strength, modulus of elasticity and percent elongation were determined. The Brinell and Rockwell hardness tests were less destructive than the tensile test and involved only a small indentation in the material, not failure of the material. The Brinell hardness test used a 10mm-diameter sphere as the indenter and the Rockwell B hardness test used a 1/16in-diameter steel sphere as the indenter. The hardness of the metal depended on the ease with which it plastically deformed. Thus, a relationship between hardness and strength for a particular metal was empirically determined. In this lab, tensile property-hardness correlations were determined for some annealed steels and non-ferrous alloys.

EXPERIMENTAL PROCEDURE

Tensile Test

For the tensile test, the initial gage length of the tensile specimen and the initial gage diameter were measured at six different locations along the gage length using a micrometer. The average diameter and its standard deviation were then calculated. The specimen was then loaded with the tensile test until failure and a stress-strain curve was created on a PC connected to the testing unit. The modulus of elasticity, yield strength, and tensile strength were determined from this curve. The final gage diameter was then measured from the broken specimen at the necked-down fracture region with a micrometer. The percent reduction in area was then calculated. Next, the final gage length of the broken specimen was measured. The percent elongation was then calculated from this measurement.

Brinell and Rockwell B Hardness Tests

For the Brinell and Rockwell B hardness tests a specimen was placed on the specimen platform and raised to the indenting material. After an indentation was made, the Rockwell B testing machine displayed the hardness test value while the Brinell test required further calculation. To do this, the Brinell test specimen was placed under a microscope and the diameter of the indentation was recorded. This diameter, along with the load (500 kg) used by the test, was used to calculate the Brinell hardness number.

DISCUSSION

The hardness of a metal depends on the ease with which it plastically deforms. Thus, a relationship between hardness and strength for a metal can be determined. Elasticity measures the stiffness of a material, so a correlation between a Rockwell B test and the modulus of elasticity does not exist.

Stiffness is another term for modulus of elasticity. Stiffness is due to the resistance between atoms, which the inner atomic bonding forces. Therefore, maintains having the same composition and crystal structure have the same modulus of elasticity or stiffness.

Brinell Hardness equation (BHN) is $p/(pi*D/2 * (D-(D^2-d^2)^{0.5}))$. D represents the diameter of ball and d represents the diameter of dent on the specimen.

$BHN = 1/(130-RB)$
$HRB = 130 - 500h$
$H= p/(pi *D*BHN)$
$HRB = 130 - 500(p/ (pi*D*BHN))$

$500p/(pi D BHN) = 130 - HRB$

$Pi D BHN/500p = 1/(130-HRB)$

Therefore, BHN is proportional to $1/(130 - HRB)$

Tensile strength is load divided by cross sectional area. In this experiment, the load did not affect the error of calculation. However, measuring diameter of samples, which is used to calculate the cross sectional area, can be the source of error to calculate tensile strength. This error is causes by human error and measurement error. The specimen did not have a constant area so that it creases the range of measurement errors.

At the upper yield point, a discrete band of deformed metal appears at a stress concentration such as a fillet. Coincident with the formation of the band, the load drops to the lower yield point. The band then propagates along the length of the specimen, causing the yield point elongation.

ANALYSIS DATA

Correlation of tensile properties and hardness exist between the various mechanical properties determined for all of the material studied in this lab. Graphs of E, σ ys, σ ts, %RA, %EL, and BHN versus Rb hardness show good, poor correlation, or no correlation.

Figure 1 Yield strengths versus Rockwell B hardness test, figure 2 Tensile strength versus Rockwell B hardness show different correlations than expectations. The correlation of two graphs is non linear, concave down and increasing respect to hardness.

Figure 3 Modulus of elasticity versus Rockwell B hardness shows no correlation.

Figure 4, Percent reduction in area versus Rockwell B hardness and figure 5, percent reduction in area versus Rockwell B hardness show different correlations than expectations. In the Figure 4, AISI/ASE 1018 steel normalized, AISI/SAE 1045 steel normalized, AISI/ASE 1018 steel cold drawn, AISI/ASE 1045 steel cold drawn show concave down, non linear, and tendency to decrease respect to hardness. In the Figure 5, except 6061 aluminum T6, one data point of AISI/ASE 1045 normalized steel causes to decrease the correlations.

Figure 6, Brinell Hardness versus 1/(130-Rb) and figure 7, Tensile strength versus Brinell hardness show positive slope linear relationships. BHN and 1/(130-Rb) has a proportional to each other so that the linear relationship between BHN and 1/(130 –Rb) is reasonable results. Also, tensile strength shows positive slope linear relationship.

A. Initial gage cross section (Ao) and its RMS uncertainty (Uao)

B. Modulus of Elasticity (E) and its RMS uncertainty (Uc)

C. Yield strength (σ ys) and its RMS uncertainty (U ys)

D. Percent reduction in area (% RA) and its RMS uncertainty (U ra)

E. Brinell hardness (BHN) and its RMS uncertainty (U_{BHN})

F. 1/(130-Rb) and its RMS uncertainty

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