Charpy Impact Testing

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***Abstract*— This lab report used a Charpy pendulum impact test rig to analyze the differences in energy absorption of a ductile and a brittle specimen. The lab used two different methods to calculate energy absorbed: change in potential energy, and strain estimation. Both methods used a data acquisition device (DAQ) to process information from a potentiometer and a ½ Wheatstone bridge/strain gauge system attached to both sides of the pendulum. The potentiometer was used to calculate the angular position of the pendulum as it swung down. Since the potentiometer measured position as a voltage between 0V and 5V, a three-point Monte Carlo simulation was used to establish a calibration constant of 68.65 °/V. This converted the voltage values into degrees. The potential energy method used this angular position value to calculate the difference in height between the downward swing (before impact) and the upward swing (after impact). Removing losses due to various energy sinks in the system, the net result was a breaking energy of 6.47 J ± 1.28 J for the brass specimen and a breaking energy of 5.74 J ± 1.05 J for the marble specimen. The strain estimation method used the force at impact times the distance traveled into the specimen to calculate the work done. The net result was a breaking energy of 3.70 J ± 0.142 J for brass specimen and a breaking energy of 2.47 J ± 0.07 J for the marble specimen.**

***Index Terms* – Brittle Fracture, Ductile Fracture, Pendulum Impact Test, Vibrations**

I. Introduction

THIS lab report analyzed the difference in impact fracture profiles of brittle and ductile materials. The impact device is known as a Charpy pendulum (Fig 1). This pendulum swings along a fixed path with a potentiometer-based position sensor attached to it. The potentiometer changes resistance as it is rotated which changes the voltage drop. This effectively assigns a voltage to an angular position value. However, the voltage needs to be converted into degrees/radians. This was done using a three-point Monte Carlo simulation which used the voltages at -90°, 0°, and +90°. Like previous labs, the Monte Carlo simulation created 4000 data sets that were within the uncertainty of the ° and voltage. This was then used to find a calibration constant in degrees per V and calculate the angle values of the potentiometer.

Using these angle values, it is possible to assign a datum, in this case the y axis, and calculate the angle from that datum. After this, it is possible to use simple trigonometry to find the change in height (1). With the change in height and the mass of the impactor arm, the change in potential energy (PE) can be calculated (2) [1]. This change in energy is the energy required to break the specimen plus the losses due to non-conservative forces in the swing down (3).

$$H = l - l\cos(\theta) \tag{1}$$

$$\Delta PE = Mg(H_I - H_f) \tag{2}$$

$$\Delta PE = U_{Break\ the\ Specmien} - U_{Losses} \tag{3}$$

The pendulum is configured in a ½ Wheatstone Bridge system with the two strain gauges connected to a data acquisition module (DAQ). Due to the fact that the strain in the 4130 steel pendulum is very small, an amplifier with an amp factor ($V_{Amp\ Factor}$) of 1100V is used to augment the strain values (4). The strain gauges were used in previous labs and are known to have a G_f of 2.1.

$$\epsilon = \frac{2(V_{amp} - V_{tare})}{V_{Amp\ Factor} G_f V_s} \tag{4}$$

As shown in previous labs, it is possible to calculate the stress values from the strain values using Hooke's law. After doing a few simple moment balances and rearranging and substituting terms, a direct relationship between strain and impact force can be found [1]. This impact force (F_{im}) times the distance the impactor head travels into the part ($ld\theta$) is the net work done (W) during the impact of the specimen (5).

$$W = I \int_{\theta_1}^{\theta_2} \frac{E\epsilon I b}{avc} d\theta \tag{5}$$

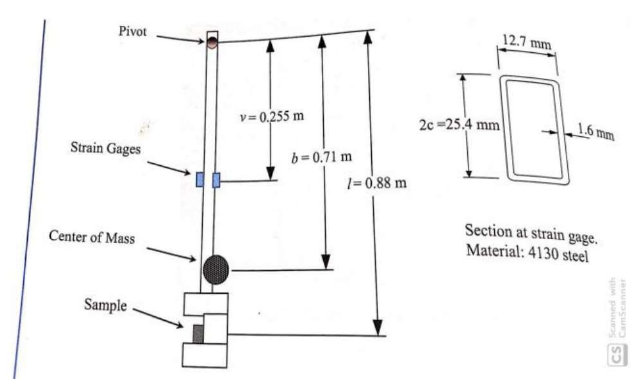

Fig 1: Dimensions of the pendulum impactor. [1]