**Results**

Before beginning the experiment, measurements were made of the two types of test specimens that were to be used for Izod and Sharpe impact testing. Once these values were found, the error offsets of both the Izod and Sharpe impact testers were found by running engaging each of them with no specimens integrated in the machines’ test area and subsequently recording the difference in energy when the each machines’ hammer swung back to its original position. With these offsets in mind, the test procedure laid out in the Procedure was run, and the energy lost in impacting the Hot, Cold, and Room Temperature versions of each test specimen was found. All of these results have been summarized in Tables 4-1 through 4-3 below.

**Table 4-1. Test Specimen Dimensions**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Specimen** | **Length (ft)** | **Width (ft)** | **Height (ft)** |
| Sharpe | 0.182 | 0.035 | 0.035 |
| Izod | 0.243 | 0.035 | 0.0-35 |

**Table 4-2. Impact Testing Machine Offsets**

|  |  |
| --- | --- |
| **Test Specimen** | **Energy Offset (ft•lbf)** |
| Sharpe | 3.25 |
| Izod | -5.5 |

**Table 4-3. Energy Absorption for Izod and Sharpe Impact Testing**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Specimen** | **Material** | **Temperature** | **Energy Loss (ft•lbf)** |
| **Izod** | Aluminum | Cold | 12 |
| Room Temperature | 9.5 |
| Hot | 12.5 |
| Steel | Cold | 4 |
| Room Temperature | 65.5 |
| Hot | 63.5 |
| **Sharpe** | Aluminum | Cold | 15.5 |
| Room Temperature | 13.75 |
| Hot | 10.75 |
| Steel | Cold | 3.25 |
| Room Temperature | 25.5 |
| Hot | 26.625 |

**Discussion of Results**

With these values in mind, it was possible to calculate the work per unit volume associated with each impact test trial. This was accomplished by simply dividing the Energy Loss of each trial by the volume of the test specimen associated with it. The results of this process are listed in Table 5-1.

**Table 5-1. Work Per Unit Volume for Each Impact Test Trial**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Specimen** | **Material** | **Temperature** | **Work Per Unit Volume (lbf/ft2)** |
| **Izod** | Aluminum | Cold | 40945 |
| Room Temperature | 32415 |
| Hot | 42651 |
| Steel | Cold | 13648 |
| Room Temperature | 220080 |
| Hot | 216668 |
| **Sharpe** | Aluminum | Cold | 70517 |
| Room Temperature | 62555 |
| Hot | 48907 |
| Steel | Cold | 14786 |
| Room Temperature | 116011 |
| Hot | 121129 |

From this data, once notes that the energy required to fracture the steel specimens was greater than that for the aluminum specimens, regardless of temperature or test configuration. This indicates that harder, stronger metals, such as steel, are harder to fracture than softer, more ductile materials, such as aluminum. However, just because a metal is hard does not mean that it is tough. For example, if a manufacturer were to dose a steel specimen with as much carbon as possible in an attempt to increase its strength, and thus, its resistance to fracture, he or she may end up with a product that is too brittle and thus more likely to fracture sooner than its more ductile, less-ferrous counterpart. Hence, in order to achieve material toughness, one must strike a balance between strength and ductility.

\This fact is further underlined by the data collected for the various temperatures at which the specimens are tested. In the case of the steel specimens, lower temperatures made the specimen even more brittle, and thus, more prone to fracture. This led to the cold steel specimen being the first to fracture in both the Izod and Sharpe tests. The opposite trend was observed in the aluminum specimens. This results rests in the fact that lowering the temperature of aluminum, a fairly ductile metal, skews it in a more brittle, and thus, tougher state, thus making the cold aluminum specimens the hardest ones to fracture in each test. The opposite can be said if the temperatures reversed in each case: as the steel heated up, it became more ductile, and thus, less likely to fracture, while the aluminum became even more ductile than it already was, and more prone to fracture.

One noted exception to this trend is the case of the hot aluminum Izod sample run. In this case, the sample bucked the trends discussed in the previous paragraph and actually exhibited greater toughness than its counterparts. This is likely due to inconsistencies in the material properties of the samples being used, as it is hard to achieve identical characteristics between metals over the course of manufacturing processes. Other factors that may have contributed to this include inconsistencies of the temperatures of the specimens used during testing, estimation in reading the energy values listed by each testing machine, unaccounted energy loss contributions associated with sound and heat production, and variability in the test configuration of each test specimen (not all the specimens were aligned in the same manner for each test).

With those sources of error aside though, this experiment demonstrated the balance between strength and ductility necessary to produce a tough material, as well as the ways in which one can identify said toughness. Ultimately, it can be shown that steel is generally tougher than , with the caveat that it is much more susceptible to lower temperature environments, and thus, less suited for applications that involve long term exposure to cold weather (Such as Spacecraft Structures). Hence, the lab can be considered a success.