

Impact Tower Laboratory

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Memorandum

Purpose

The purpose of the impact tower lab was to investigate the effects of temperature on impact resistance of two metallic samples and one unknown sample.

Procedure

Three aluminum and three steel samples were prepared in a machine shop. Preparation involved cutting the bulk metal down to test sample size and cutting a small notch in one side of the sample.

One aluminum sample and one steel sample were placed in the oven and heated to 500 degrees Celsius, and one aluminum sample and one steel sample were set aside to be chilled in liquid nitrogen. The final two samples, one aluminum and one steel, were tested in the impact tower at room temperature. The room temperature samples were tested first, followed by the heated samples, and the chilled samples were tested last.

Each sample was placed on the Charpy block between the four securing pins to ensure accuracy and repeatability. The pins made certain the center of the sample was hit each time and that the sample did not move during the impact.

The height and mass of the impact tower was set to break the sample. This information was provided by the instructor. The software package used to record the data, Labview, was opened and prepared to collect the data. To ensure the hardware and software package was functioning correctly, the tip of the impact probe was tapped gently with a hammer. Next, several practice runs were made. Since the computer had a very limited buffer, it was essential to have accurate timing between starting the computer input and dropping the impact probe. Once set to collect data, the computer recorded all of the necessary data. Finally, the actual specimens were tested. After the end of each test, the data was saved with an appropriate filename.

Excel provided the primary tool for data reduction. The instructor made a template that creates five graphs from the data given. Those five graphs are of force, acceleration, velocity, deflection vs. time, and force vs. deflection. Please see the results section for a more in depth discussion of the five graphs.

Results

Equations Used to Obtain Results

The only equation used that was not part the instructor's template was the impact velocity equation. The equation, $v = \sqrt{2gh}$, was used to calculate impact velocity and plug the number into the template. All of the equations used to calculate total force, total energy dissipated, and used to generate all of the graphs were provided by the template.

Quantative Results

The impact velocity of each of the tests was 11.35 ft/sec for each of the eight tests.

Please see Table 2 for the maximum force seen by each sample and the total energy dissipated during impact.

Material	Maximum Force	Total Energy Dissipated (pound • ft)
Aluminum - Chilled	1611	9.979
Aluminum - Room Temperature	115	1.788

Aluminum – Heated	83	3.022
Steel – Chilled	1310	1.188
Steel – Room Temperature	4272	19.06
Steel – Heated	3434	18.47
Racquet Ball – Room Temperature	84	8.37
Racquet Ball – Chilled	440	2.77

Table 2: Total Force and Energy Dissipated by samples tested

Qualitative Results

Aluminum is more difficult to fracture at lower temperatures than it is at higher temperatures. Steel, on the other hand, is more difficult to fracture at higher temperatures than it is at lower temperatures.

Graphical Results

Numerous graphs of the data are provided in the Appendices. Each graph is self-explanatory, however, a brief additional explanation follows:

Charts 4 through 8 are the five graphs for chilled aluminum. Chart 4 is the force vs. time chart; Chart 5 is the acceleration vs. time chart; Chart 6 is the velocity vs. time chart; Chart 7 is the displacement vs. time chart; and Chart 8 is the force vs. displacement chart.

Charts 8 through 15 are the eight graphs of force vs. displacement, as requested for the laboratory memorandum. The energy calculations are equal to the area under the curve for each one of these graphs.

Interpretation of Results

Sources of Error

The primary reason for variation in the total force and total energy dissipated in the same alloys at the same temperature (i.e., variation between all of the chilled aluminum samples among the lab groups) is the samples were not impacted at the intended temperature. The materials either warmed up or cooled off between the time they were removed from the oven or liquid nitrogen and impacted. This source of error did not affect the results of this experiment because only one sample at each temperature was tested.

The second possible source of error is the limited sampling rate of the computer. Due to limitations in the computer, 33,000 samples per second is the fastest practical rate. Only seven data points were recorded for the chilled steel test. Calculating the area under the curve for chilled steel is not very practical and will lead to an inaccurate number. Being able to sample two or three times faster would improve the accuracy of the experiment.

Recommendations for Improvement

The experiment involved a single test of each sample at the given temperature. There was no repetition to ensure accuracy of the collected data. Doing multiple tests of each sample (i.e., testing the chilled aluminum alloy three times) would ensure that the collected data was representative of the material properties.

The only difficulty encountered when running the tests was the limited buffer in the computer. The one second buffer capacity made it difficult to ensure the test was started and finished before the buffer filled. One solution to the issue is to upgrade the lab computer by installing an additional 32 megabytes of memory. This would dramatically increase the buffer, allowing either more time to run the experiment or a faster sampling rate. The second solution is to have the person working the computer wait until the impact hammer has fallen half way before starting the computer. Doing so would still record all pertinent data while allowing for a longer sampling time or greater sampling rate.

Conclusion

The temperature of the samples greatly affected the way the metal samples responded to the impact test. With aluminum, the chilled sample took the most energy from the impact hammer the most, followed by the heated sample, and the room temperature sample took the least energy from the impact hammer. Steel behaved in the opposite fashion: the room temperature sample took the most energy from the hammer, followed by the heated sample, and the chilled sample took the least energy from the hammer.

When looking at the maximum force, a slightly different picture is painted. With aluminum, the colder the material the more force it takes break the sample. With steel, the colder the material the easier it is to break the sample. Even though steel is much stronger at room temperature than aluminum, the aluminum alloy is stronger at -300°F than is the steel sample. This is the reason liquid nitrogen is carried using aluminum tanks rather than steel tanks.

Bibliography

Schaffer, et. al, The Science and Design of Engineering Materials. 2nd ed. McGraw-Hill: New York, 1999.

Appendices

Please see the attached graphs.