NIST Charpy V-notch Testing

Problem Description

What do we know about it?

A Charpy test, after Augustin Charpy (1865-1945), is an impact test that uses a swinging pendulum to assess the resistance of a material to brittle fracture, as measured by the absorbed energy (in Joules). The Charpy test is often specified as an acceptance test for the toughness of steels used in bridges, buildings, pressure vessels, etc.

The American Society for Testing and Materials (ASTM) Standard E 23 requires the annual verification of Charpy V-notch impact machines using verification specimens that have a certified absorbed energy value. Three master machines owned, maintained, and operated by National Institute of Standards and Technology (NIST) are used to establish the certified value. At NIST, the certification of a lot of verification specimens is done using 100 pilot-lot specimens that are divided into 3 groups of 25, with one group tested on each of the master impact machines. The extra 25 are held in reserve, or can be tested in another machine.

What is the question or uncertainty that we want to answer?

A pilot lot of High-Energy material has arrived for certification as Standard Reference Material 2096-High-Energy. Following the Charpy V-notch Test Verification procedures three groups of 25 specimens each were tested on the 3 master machines (Tokyo, Tinius 1, and Satec), and their absorbed energy values (Joules) were recorded. However, one of the Tinius 1 specimens had an apparent flaw in the fracture structure and was not included. In addition, 25 specimens were tested on a new machine (Satec 2) that will eventually replace one of the older, master machines.

The certified energy value for a production lot of verification specimens is defined as the grand average of the 75 specimens tested on the 3 master machines. The standard deviation is the pooled estimate of the 3 standard deviations from the 3 master machines. The required energy specification for the SRM 2096 specimens is 88 Joules to 136 Joules.

Some questions of interest:

- Is the average absorbed energy similar for the 3 master machines?
  - What is the certified energy value for this lot?
- Is the absorbed energy variation the same for each the 3 master machines?
  - What is the pooled standard deviation for this lot?
- Where should you expect 99% of absorbed energy values to fall with 95% confidence?
  - How does that compare to the required energy specification of 88 to 136 Joules?
- Are the analysis assumptions met?
  - Any unusual observations?
- How does the performance of new Satec 2 machine compare to the 3 master machines?