Expanding the Parameters of Almen Strip Manufacturing

AN ALMEN STRIP that meets specification parameters in flatness (prebow), hardness and thickness isn't always good enough. The following is a real-life example of strips that met specs, but failed to accurately verify the shot peening process.

Within a time frame of a few weeks, operators in shot peening facilities worldwide weren't able to reach previously attainable intensity levels. An aerospace manufacturer that uses a large number of strips conducted a comprehensive review of all the factors that influence intensity. They asked the operators about their shot peening processes. They inspected the media and questioned the manufacturers about changes in media production. They looked at every aspect of their shot peening equipment that determines intensity and OEMs were brought in to inspect their machines. They found nothing. The operators, media and equipment could not be held accountable for the failure to achieve the specified intensity ranges. Then an engineer at the aerospace facility picked up an Almen strip. "Maybe it's not the factors that influence intensity, maybe it's the intensity testing tool," he thought. He analyzed a strip and found inconsistent hardness levels and areas of decarburization. He had uncovered the problem.

Almen strips are shot peened in a custom air blast cabinet in Electronics Inc.'s test laboratory as part of EI's performance testing program.

Changing the Almen Strip Status Quo

Unfortunately, the problem didn't go away because many strip manufacturers continue to manufacture strips in the same way. These strips meet specifications, but they could have troublesome inconsistencies in hardness levels. In 2006, Electronics Inc. (EI) began research and development on a manufacturing process that would produce Almen strips that never deviated from a high standard, whether they were manufactured last month, last year or three years from now. EI formally introduced their own brand of strips in 2007.

Performance Testing Beyond the Parameters

EI started its rigorous Almen strip performance testing program in 2006. It is EI's tight manufacturing controls, backed by this testing program, that make EI's strips so dependable. EI peens approximately 2,000 strips every year in their custom air blast cabinet. The cabinet has a variable-

The Origins of the Almen Strip Grading Program

In 1995, Jack Champaigne, President of Electronics Inc., developed an Almen strip grading system to help EI's customers obtain strips that would accurately meet public and private specifications. Before the EI Almen strip grading system, it was difficult to fulfill an order for Almen strips when two or more specs were cited and the requirements were in conflict.

Electronics Inc. established a measuring system for Almen strips using an extensive sampling program that allows the sorting strips into three grades.

The grades differ in hardness, flatness (prebow) and thickness, and their ability to meet rigorous performance requirements of peening tests. EI trademarked the terms Grade 1, 2 and 3 to differentiate these quality levels in a simple manner. The grades are as follows:

- Grade 3™ - Bulk (A-3™, N-3™, C-3™)
- Grade 2™ - Standard (A-2™, N-2™, C-2™)
- Grade 1™ - Premium Grade (A-1™, N-1™, C-1™)
- Grade 1S™ - Special Grade (A-1S™, N-1S™)

speed rotary table with 26 Almen strip holders, a fixture for adjusting nozzle distance from the strips, a MagnaValve® for media flow rate control, and adjustable air pressure. The machine is configured to give a consistent exposure time to each Almen strip and assure uniform impact treatment. After the strips are peened, arc heights are measured on a calibrated Almen gage and prebow compensation is applied. The values are put into histograms for analysis.

Histograms created over the past six years exhibit nearly identical lot-to-lot arc height results, thereby verifying the uniformity of the strips. The histograms on page 14 illustrate the performance consistency of the strips as defined by nearly identical mean values and narrow standard deviations.

Traceability and Audit Program

To meet the demands of increasingly sophisticated shot peening processes, especially in aerospace, EI introduced their numbered Almen strips with Coverage Check finish in 2011. The lot numbers are printed on the strips. Electronics Inc. has developed a traceability program, represented by the strips' lot numbers, to track Almen strips back to their heat number. A heat number is a unique identification code for a piece of metal that holds information about its origins. The heat number provides a method for tracking materials and is an important part of quality assurance and control. In addition, EI audits four documents from their steel supplier:

1) Material certificate - steel composition must conform to SAE 1070 specifications.
2) Inspection records for thickness, width and length.
3) Process control charts for hardness.
4) Decarburization report that confirms zero surface decarburization.

Decarburization is a change in the structure and content of steel in which some of the carbon in the surface layer or layers of the steel is lost. If an Almen strip has decarburization, its hardness is compromised and its performance will be unreliable.

EI's steel supplier is a global industrial group with advanced steel production capabilities and they are happy to comply with EI's audit program. Most EI customers will never need to take advantage of the traceability and audit program. Nevertheless, if a supplier or manufacturer in the aerospace, automotive or medical industry faces a liability situation, they can have confidence in the completeness of information on every step of the EI Almen strip manufacturing process, and be assured that the strips were manufactured to the highest standards.

EI's Intensity Control Research Library

EI's extensive research on Almen strips and intensity control has made EI a technical support resource for the shot peening industry. Here is a sampling of the data in EI's library:

- Current lot-to-lot comparison data on EI strips
- Comparisons of EI strips to other strips
- Performance data on other strips
- Analysis on the effect of variations in manufacturing parameters - hardness, flatness (prebow), thickness

EI has become the go-to resource when their customers have questions on Almen strips and shot peening intensity variables. If EI doesn't have data on a unique situation, EI will perform tests to analyze a customer's problem or even duplicate, as closely as possible, their process setup.

For example, a manufacturing engineering associate with an aerospace facility in Poland recently sent an email to Jeff Derda, EI's Operation Manager. Mr. Derda oversees Electronics Inc.'s Almen strip production and testing programs. The engineering associate needed help reaching a required intensity range of 0.014 - 0.018A. Mr. Derda asked her for the process parameters and she gave him the flow rate, media type, air pressure, nozzle diameter, part-to-nozzle distance, part rotation speed and the impingement angle. Based on tests that EI had run with similar parameters, Mr. Derda made suggestions. The engineering associate wasn't able to increase air pressure due to limitations at the aerospace facility, but she was able to slightly alter the impingement angle and decrease the shot flow. The process time was now slightly longer but an intensity of 0.015A was achieved.

"Dear Jeff, I can find no words to describe how grateful I am for all of your advice. Without your help, I wouldn't have achieved a proper intensity," the engineering associate wrote in an email.

Due to the large amount of available data, Mr. Derda was able to solve a problem in a few short emails that had been bothering the aerospace company for several weeks.

About Histograms

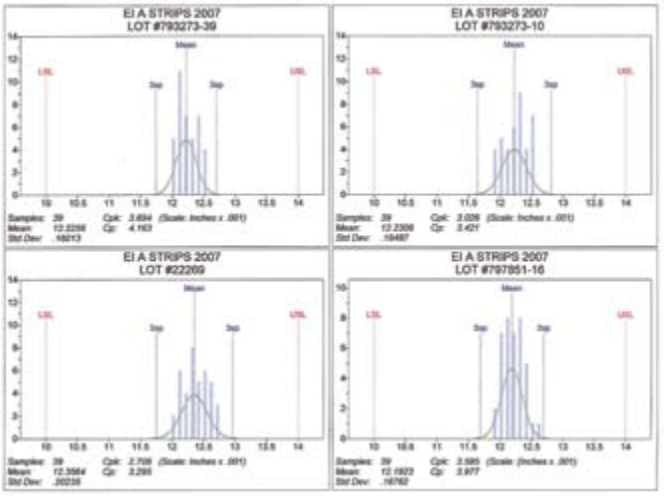
A histogram is a graphical display of tabulated frequencies, shown as bars. It shows what proportion of cases fall into each of several categories. A histogram differs from a bar chart in that it is the area of the bars that denotes the value, not the height of each bar as in bar charts.

About Mean Value and Standard Deviation

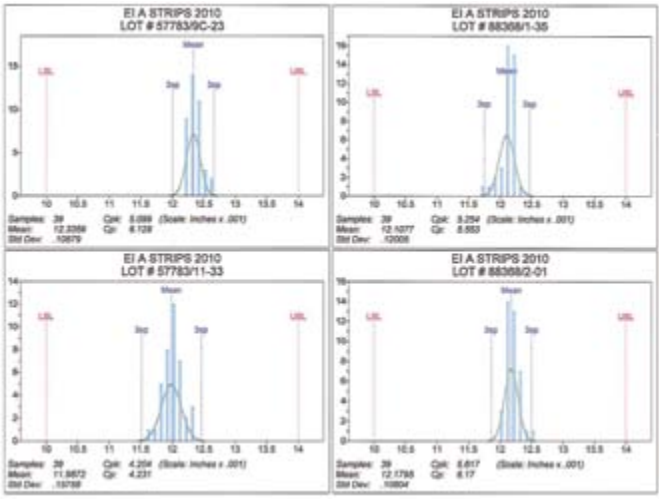
The mean is the sum of the observations divided by the number of observations. The mean describes the central location of the data, and the standard deviation describes the spread. The standard deviation is a statistic that tells how tightly all the examples are clustered around the mean in a set of data. When the examples are tightly grouped together and the bell-shaped curve is steep, the standard deviation is small. When the examples are spread apart and the bell curve is relatively flat, that signifies a relatively large standard deviation. In the case of the Almen strip testing, the tight standard deviation signifies the consistency of the arc height reading.

Electronics Inc. Almen Strip Performance Test Results

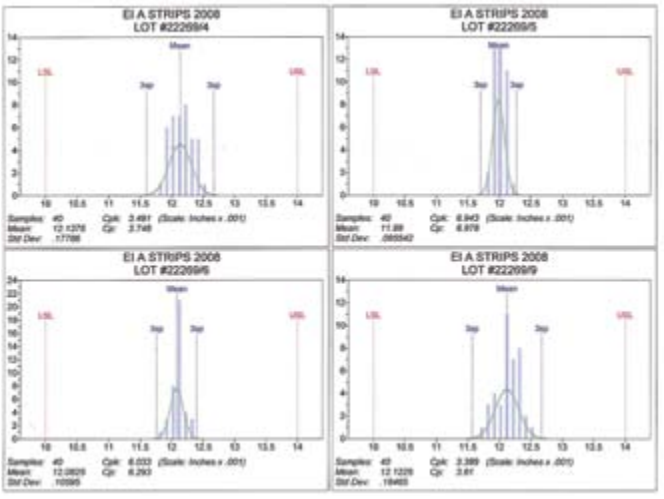
2007



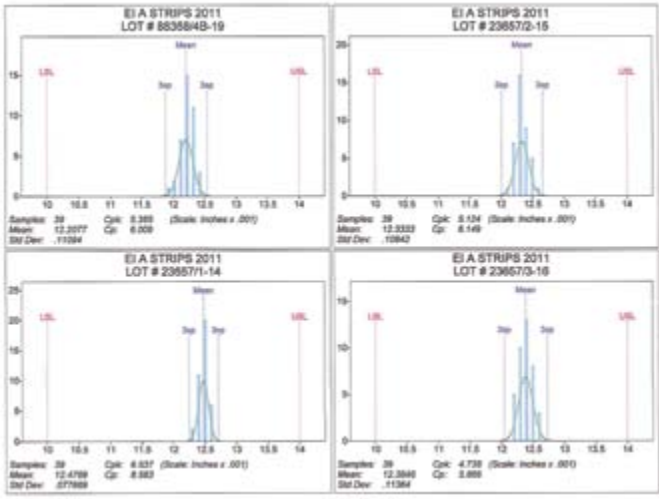
2010



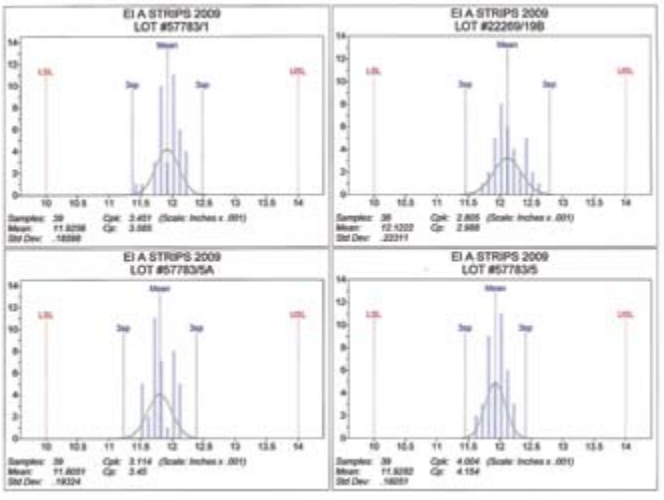
2008



2011



2009



2012