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ALMEN STRIP PROCESS CONTROL

by Jack Champaigne

The Almen test strip is one of the greatest contributions to shot peening process control. It provides a means of determining process consistency. Proper use of the Almen strip will demonstrate the condition of a process which has many variables. John Almen's intention was to provide the tool for a new process that would be reliable and repeatable. There was no other means available to determine "how long" and "how much" shot peening was performed.

The new process of shot peening highlighted the classical manufacturing problem:

What is the correct process?
How do you perform the process?
How do you measure the process?

To understand how the Almen strip evolved into a standard tool, we should peak into the history books to see what happened. According to legend, General Motors Corporation was constantly testing valve springs due to high failure rates. Several machines were in use and the program required a large number of springs to be tested. One of the test technicians complained about the dirty condition of the springs as they were received from heat treating.

Because of the large quantity of springs involved, individual cleaning was not practical. Someone suggested blast cleaning the springs in a Wheelabrator tumble blast machine. This was done and the springs were not only clean, they also had different performance. The cleaned springs had achieved a significantly higher life expectancy on the fatigue testing machines.

As John Almen got involved with this laboratory curiosity, it became apparent a new process would be available and it needed some method of consistency control. Defining the benefit as a result of adding surface compressive stresses answered the question, "What is the correct process?" The next steps, performance and measurement, took several years to refine. In June of 1944, Almen received U.S. Patent 2,350,440 titled Shot Blast Cleaning.

The original gage described in the patent was later refined and became Almen #2 Gage (see THE SHOT PEENER, Volume 1, No. 1). By this time, a consensus had developed that allowed consistent data collection, namely the description of the terms intensity and saturation.

Meanwhile, progress was being made in the aircraft industry. Noble[1] reported that Aeronautical Materials Specification 2430 was first issued in September of 1943. Rocker arms were the first parts to be shot peened on a production basis, and the process rapidly spread to many more critical components.

Today's manufacturing environment pays special attention to product quality and consistency. We spend a great deal of effort focusing on:

Product uniformity
Adherence to standard practices
Real time process control

We all desire product uniformity. We (try to) adhere to standard practices. However, real time process control is difficult for shot peening. If we were measuring size, weight, temperature, etc., we could perform classical statistical process control chart methods. But how do you measure peening quality?

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Measurement of surface stress is not difficult, but it doesn't adequately describe or relate to peening benefits. Fatigue testing machines can test a part until failure, but this destroys the part. By default, we turn our attention to (you guessed it), the Almen strip.

Use of the Almen strip falls into two categories:

Process Qualification
Process confirmation

The qualification process requires the use of several strips, each subjected for a longer exposure time. The measured value of arc height is recorded and displayed on a graph. The intensity of the shot stream is then inferred from the graph. Its value is determined by estimating the first occurrence on the curve where its height does not increase by 10% when the exposure time is doubled. This description appears in MIL-S-13165 U.S. Government specification on shot peening and also SAE J442 by the Society of Automotive Engineers.

The confirmation process occurs after the machine has been certified to be operating at a blast intensity within the specification range required as determined above. However, the confirmation process usually does not repeat the above qualification procedure; an abbreviated procedure using one or two strips may be used.

The one strip procedure requires exposure of the strip at the same time that saturation occurred for the qualification procedure. The arc height must fall within the specification range.

The two strip method requires performing the one strip process plus exposing a second strip at the doubled exposure time. Now the fun begins. What arc height is required of this second strip?

a. Any value within the specification range.
b. Within 10% of the first confirmation strip.
c. I don't know.
d. None of the above.
e. All of the above.

My own view is choice (a). The reason I have trouble with choice (b) is due to lack of statistical data. The use of Almen strips is actually an exercise in probability theory where average events are expected to occur with amazing accuracy.

A purist might even insist that the confirmation procedure should be identical to the qualification procedure. A single point does not constitute a graph for Almen strip intensities. Many lines could go through that point and the true intensity may be significantly different that the intensity implied by that single point. Almen strip performance is influenced by many factors. It is conceivable that one or more of these could change yet the single point test may be within the allowed specification.

Even my preference of choice (a) carries assumptions. This is usually addressed by saying, "It's probably OK to do this." The key word here is "probably." The Almen strip is a probability experiment. The question is "How comfortable" or "How confident am I in this assumption?"

I would suggest the following approach:

1) Perform qualification process using multiple exposure times, plot and read intensity.

2) Later, repeat qualification tests, as in Step 1, each time a confirmation test is also required.

3) Blast five (5) strips at the same exposure time that saturation was achieved in Step 1, and

4) Run five (5) strips at double the exposure time in Step 3.

5) Keep a record of these data items and plot them (histogram). Observe the data scatter and determine which method of confirmation you are comfortable with, either full qualification procedure or one-step or two-step confirmation.

6) Send me your conclusions.

This last part is most important. We need to know how people are performing the measurements and if this experiment confirms or repudiates the methods used. Please indicate whether or not we should include your name with your comments in the next newsletter.

[1] *Shot Peening Applications and Techniques in the Aircraft Industry by J. H. Noble, SAE Div. XX Presentation, 10/1/53*