Overview

Because automated mechanical testing is here to stay, ASTM must come to terms with the use of automation and should waste no time addressing standardization issues associated with this technology. This was the thinking of ASTM Committee E-28 when we first decided to hold a symposium on the subject of automated testing. Two years later, the attendance, presentations, and discussions at the resulting symposium confirmed that automation is definitely a topic of interest.

Background

The 1990s can, for our purposes, be considered the second decade of automated mechanical testing. During the 1980s, test machine manufacturers first began to supply significant numbers of tensile test machines equipped with PCs and specialized hardware and software for control of the testing and handling of specimens. By now, it is widely accepted that automated testing has many benefits to offer, and many labs, particularly those running large numbers of similar tests, have implemented automated test systems to reap these benefits.

As often occurs with emerging technologies, there has been an initial flurry of activity, during which it was difficult for standardization efforts to keep up with the fast-breaking developments. Such was the case for standards under the jurisdiction of Committee E-28. Many labs jumped at the first opportunity to cut costs and improve repeatability and reproducibility through automation, even if they had to use nonstandardized procedures to do so. This has complicated the task of standardizing, because no matter what is balloted, there is a good chance that it will contradict a procedure already in use and will therefore draw negative votes.

Hopefully, the initial flurry of activity has now subsided enough that the '90s can be a decade of maturing and standardization of automated test procedures. To help achieve this goal, we present in this STP nine technical papers on the automation of mechanical testing. The first five form a primer for those preparing to implement automated testing. These papers consist of information obtained "the hard way"—from experience with automation projects. Beginning with the fifth, which fits into both categories, the papers focus on specific technical issues and topics, many of which affect or need to be addressed by ASTM standards.

What Do We Mean by Automation?

We begin with a paper from Ruth which discusses what the term "automation" actually means. The author points out that this term has been applied over the years to many hardware advances that have decreased human involvement. (For our purposes, an automated test is loosely defined herein as one that is computer-controlled and that uses specialized hardware and software to ensure that little operator intervention, if any, is required.)

Ruth's paper is a good introduction to the subject in that it discusses the different levels of automation, pointing out the advantages of each. Taking expense and effort into account, the author indicates the approximate testing levels at which the various levels of automation become viable options. He then reviews an aluminum manufacturer's step-by-step automation of a production tensile testing laboratory, offering observations of what made this particular effort a success. Readers who are preparing for (or involved in) such an endeavor are advised to take note.

Additional Considerations

Next is Gebhardt's general discussion of robotic testing. He, like Ruth, has been involved in many automation projects, and his paper resembles Ruth's in that it points out many considerations that have proved to be of great importance. However, Gebhardt's paper focuses on robotic testing as a production system and stresses the importance of project strategies and functional specifications. He also discusses maintenance and support, which definitely need to be kept in mind when purchasing robotic systems. (The more complex a system, the more opportunity there is for something to go wrong; and the more one relies on a single machine for throughput, the more significant any outage of that machine will be!) For examples, Gebhardt refers to an integrated steel mill's automation project.

Several of Gebhardt's attachments will be of particular interest to the reader considering automation. One, for example, shows approximate test times associated with various levels of automation. Another shows the times that various types of robotic systems can be left unattended, and a third shows the corresponding depreciations.

The State of the Art

The third paper, by Mumford, discusses the state of the art, identifying many ways in which the advent of the PC and other developments have greatly changed mechanical testing in the last 20 years.

Topics of this paper include:

- The revolutionizing of test machine design due to PCs
- Enhancements in accuracy of measurements
- Calibration considerations
- Advantages of PC controlling
- Robotic and automated feeding systems
- Standardization of report formats
- Data storage issues
- Use of mathematical models.

This discussion should be useful to the reader who is struggling with the many details associated with automating—whether he is evaluating commercially available systems or developing his own.

A Case Study

Next is the first of two case studies. Carter and Gibbs provide a detailed description of the progress that has been made at Los Alamos National Laboratories.

First, the details of acquiring data from many different types of mechanical tests, some of which are quite complex, are discussed in depth. Then the authors describe the Mechanical Testing Systems Network. This network has become very complex and powerful and currently incorporates over 30 PCs and workstations, a central file server, and a variety of output devices—all linked together via thickwire ethernet and connected to the rest of the world via Internet. Finally, the Los Alamos data analysis software is described by working through an example in which the raw data for a simple tensile test are reduced to provide meaningful results.

This paper shows how far automation has already been taken by those who committed to it early and who have put considerable effort into it. For those who are just now "getting their feet wet," the prospects may be a bit overwhelming, but we can all definitely learn from this experience!

And From the Editor's Experience

We then move to the Heberling paper. This case study gives an end-user's account of the complications and issues that were encountered in the course of purchasing an automated tensile test machine and linking it to a Lab Information Management System.

General topics of the paper include:

- ASTM issues (those related to existing standards)
- Other technical issues and details
- Benefits of semi-automatic testing
- Plans for the future.

Although much general information is provided, the thrust of the paper is to point out many areas in which ASTM can make the task of automation more straightforward—by revising its standards. (Many revisions are, of course, being developed or balloted at this writing.)

While on the Subject of Standardization

The next paper, by Khan, focuses on a point made in the editor's paper: that ASTM standards should define properties in definitive mathematical terms. Khan's paper takes this a step further and suggests the best way to define the properties is to standardize the algorithms used for their determination. (Software used to analyze raw tensile test data, Khan believes, should employ particular logic in doing so.) The paper also presents several algorithms developed by Khan and his company for consideration by the reader and by ASTM.

Unlike most of the papers in this STP, this one includes examples and terminology taken from the mechanical testing of plastics. This should not diminish the usefulness of the paper to those involved in metals testing, for one could easily rework the terminology and details and apply this work to the testing of metals. As such, this paper should be food for thought for all ASTM committees involved in the standardization of mechanical testing.

Elongation at Fracture

The seventh paper, by Scherrer, compares automatically determined elongation at fracture to percent elongation determined by piecing together the broken halves of a tensile specimen and measuring the final distance between gage marks.

The paper reports that the two results agree quite well, that elongation at fracture results are generally the more conservative of the two, and that there seems to be slightly less variation in elongation at fracture results, as compared to a well-controlled procedure for measuring percent elongation. Scherrer also notes that best fit linear regressions can be effectively used to predict percent elongation based on the automatically determined elongation at fracture.

Since manual percent elongation measurement requires operator intervention, fully automated systems have used elongation at fracture for some time now. Only at this writing, after four years of effort, are revisions finally being made to E 8 and E 8M to explicitly permit use of automatically determined elongation at fracture in place of manually measured percent elongation—a bit of convenient timing for this STP!

Determination of Yield Point Elongation

Next is a paper by Young on the calculation of yield point elongation (YPE) by automated test systems. Some fairly complicated mathematics are involved in this because it is very difficult to create software sophisticated enough to detect the slightest hint of YPE *and* to correctly differentiate between YPE and noise. (Although some may not have realized this, the operator has been doing some fairly sophisticated visual analyses all these years in looking for and measuring YPE from *X-Y* recorder charts!)

This paper also touches on a theme that has been mentioned in other papers. Specifically, Young notes that he first had to settle on a definitive mathematical definition of YPE, because such a definition is not provided in ASTM standards today. (Until this is done, a multitude of approaches can be attempted, because the task at hand is not clearly identified.) Clearly, something must be done in this respect. Fortunately, something *is* being done; task group E28.04.10 is currently balloting new definitions for a number of mechanical properties, including YPE.

Bandwidths and Data Rates

We close with a highly technical paper by Nicolson on event criteria for determining bandwidths and data rates to be used in automated tensile testing. This paper shows that, for the measurement of slopes and peak values of waveform events to a given accuracy, the required bandwidth and data rate can be estimated by using convolution of the impulse response with various waveshapes.

This paper should be of much interest to electrical engineers and parties involved in the design of test equipment. Others, such as end-users, may have a difficult time with some of the concepts. Nevertheless, reading through the paper will certainly help the reader gain some understanding of the kinds of technical details that are involved in the automating of mechanical testing, though details such as these are generally dealt with by the test machine manufacturer. Also of use to the end-user is the paper's demonstration that improper selection of bandwidth and data rate can have drastic effects on test results.

The papers outlined herein contain much useful information on the automation of mechanical testing, as provided by experts from test machine manufacturers and R&D facilities and, in the case of the editor's paper, from a previously inexperienced end-user who has become somewhat experienced out of necessity! I gratefully acknowledge the efforts of the authors, reviewers, and ASTM personnel that have made the symposium and this publication possible.

Enjoy!

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