Add hardness values to SPC procedures

Trevor Sidaway . . . high quality of product sustained over the long term

The idea of including hardness measurement in statistical process control is no longer a novel concept. Growing experience in total quality management has shown that hardness is often an important factor in determining product quality.

The move has been encouraged by the emergence of Rockwell-type testing machines well able to deliver the performance and analytical capabilities essential for effective SPC.

RHP integration

The Knottingley plant of RHP Bearings contains a good example of how such a tester can be incorporated into computerised networks to produce SPC data.

Used for testing heat-treated components for ball and roller bearings, the machine is supported by special SPC software verified to meet specific quality requirements. The test results are processed on the shop floor by an SPC-dedicated computer, which is linked to a PC with hard-disk storage and printer in the quality control laboratory. Details of every component to be tested are entered through an operator keyboard.

The hardness tests are initiated by a keypad depressed by the operator. If any one of the three tests typically specified is outside the preset limits, the test procedure is halted until an 'event' is entered to show the cause. The information is displayed on screen at the testing station, the software containing 40 possible causes ranging across heat-treatment and quenching times to incorrect component and faulty tester calibration.

The routine requires the operator to check all charts and print-outs to ensure that process and testing procedures have been performed correctly. If the cause cannot be identified at this stage, a note to this effect is entered for the attention of the quality manager or metallurgist, who will make further checks of displays and charts.

Clearly in this instance, the application of hardness to SPC produces more than the simple Rockwell value. In fact, Rockwell figures in themselves may not reveal a part that is right for hardness but defective because of a combination of variations in the process. For this reason, RHP sends all rejects to the quality control lab for full metallurgical analysis and further examination.

The application demonstrates how the integration of hardness into SPC reduces faults through operator intervention, pinpoints aberrations in heat treatment, stores and analyses data, and keeps heat treatment under tight control.

The overall effect is a high quality of product sustained over the long term at minimum cost.

Stable standard

As the RHP case shows, a well-conceived and executed programme is vital for consistent process monitoring for hardness, with a stable hardness standard as the central element. Tight process control is impossible without it. To achieve a stable standard, there must be consistent measuring methods and consistent performance from the testing equipment.

A gauge repeatability and reproducibility study could be of value in this area. An R&R study shows if a testing machine can measure consistently to within a fixed percentage of component tolerance under different operators. It evaluates the consistency of machine performance. Test blocks of proven quality should be used for R&R studies. Reputable testing machine makers can provide NAMAS test blocks consistent to 0.2 HRC units.

The study should also be based on reasonable production tolerances, not the test-block tolerances. If a modern, well-maintained Rockwell-type tester is available, it should be expected to perform well within 10% of component tolerance with a ±2 point HRC tolerance.

Fig 1 The latest Rockwell-type machines can analyse and communicate test data in a way compatible with effective SPC

Traceable

If an R&R study shows that the machine is suitable for monitoring hardness in the process, a stable hardness standard should be chosen against which the tester can be verified.

With the close correlation of calibration by IMGC and NPL, there is no need to adopt an in-house master hardness system, although some companies do so for essentially internal reasons. A secure, stable and traceable standard will be provided by test blocks calibrated by a NAMAS-accredited organisation.

This is important. Tenths of a Rockwell point may not count for much in a part's overall quality but they can have a significant influence on a process controlled to close Cpk figures. It may be necessary to seek machines with a measuring resolution around 0.01 HRC units simply to satisfy R&R studies.

Fortunately, machines of such precision and sophistication are becoming more readily available. The latest models — launched in May 1993 — have narrowed resolution to the requisite 0.01 Rockwell divisions, a tenth of that previously available on standard machines. This particular tester, which uses touchscreen technology for control and data handling, also provides a comprehensive SPC capability in its own on-board software. This can save much time and trouble in putting together a suitably compatible network.

Verification

With a stable standard established, a daily verification regime should be instituted. Up to five tests should be made daily on test blocks on each hardness tester integrated into SPC. The average and range should be plotted for comparison with control limits on X-bar and R charts. Thus, any drift in accuracy and repeatability will be identified immediately.

Without this daily verification, it is extremely difficult to prove that the hardness process is under control. Periodic calibration is not good enough, there being no certainty that the machine will remain within limits until the next calibration. ▶

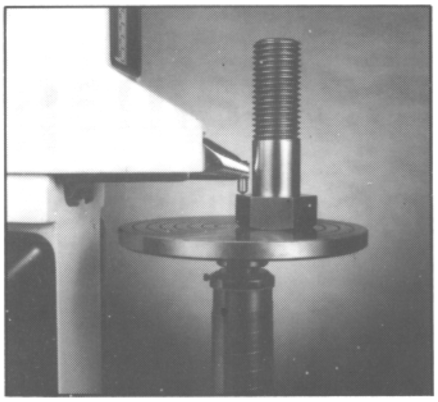

Fig 2 Hardness is often seen as being as important as fit and finish in establishing product quality

The problem is, however, eased by the microprocessor technology of the latest Rockwell-type machines. In some of them, built-in software tracks the testers' accuracy and repeatability on test blocks. Serial number, hardness value and control limits can be stored for up to three test blocks per hardness scale. Reminders can also be programmed to alert the operator that daily verification is required.

Each verification is reported and stored in memory. An X-bar and R chart is also printed.

Transmitting statistics

The next step is measuring the hardness of the production parts. Again, an X-bar and R chart provides an easy means of monitoring results against controls. Readings

```
SCALE HRC    (HV *)    11:44    29 Jan
 59.5 (  691)    59.5 (  691)    59.7 (  695)    59.5 (  691)
 59.6 (  693)    59.6 (  693)    59.6 (  693)    59.5 (  691)
 59.7 (  695)    59.6 (  693)

     N      10                     USL    60.1 (  703)
  Xbar   59.58 (  693)             LSL    59.1 (  682)
     R    0.20 (    4)             Max    59.7 (  695)
    SD    0.07                     Min    59.5 (  691)
 * SSD    0.08                     +NG       0
 *  Cp    2.08                     -NG       0
 * Cpk    2.00                      P%       0
```

Fig 4 Example of a statistical print-out on Rockwell testers connected to printers. More complete SPC can be provided when the machine is linked to a PC or data network

Fig 3 Touchscreen on the latest Rockwell-type tester. A full alphanumeric keypad enables highly detailed identifying data to be stored and analysed

can be stored in the tester's memory for statistical reporting and transmitted to the process computer through the machine's RS232 port. This direct link thus enables hardness tests to figure directly in real-time process control, underlining the significance of proper calibration and verification procedures.

Training

Having decided to integrate hardness monitoring into SPC, the training of operators must not be forgotten. Efficient and confident operators are as vital to hardness process control as versatile, well-engineered machines.

Although some testing machines are largely automatic, proper setting-up and usage are clearly essential. Operators should also, of course, be familiar with the need for calibration and verification procedures.

The machines themselves must be inspected and serviced regularly, daily verification routines should also signal impending faults and defects. Test-block results moving outside control limits, for example, will highlight the need for investigation.

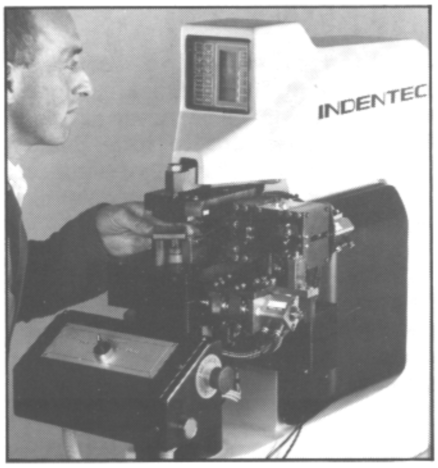

Fig 5 Modern hardness testers can be engineered for use in unmanned test cells, providing data automatically for the host computer

Changes to a machine can also affect performance. A highly standardised tester can drift outside control limits when a diamond indenter is replaced. Nonetheless, the stable hardness standard should prevent an incorrect indenter finding its way on to a production-monitoring machine.

In some testers, a means of electronic calibration is available to maintain accuracy to test-block standards. The adjustments are usually made through a password to prevent tampering.

Indentec Hardness Testing Machines Ltd, Lye Valley Industrial Estate, Bromley Street, Lye, Stourbridge, West Midlands, DY9 8HX, England.

Reprinted from
'Wire Industry'
December 1993 issue

Printed in England by Chandlers Printers Ltd, Bexhill-on-Sea, East Sussex