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AP100

# Machine condition monitoring - linear-axis machines

## Problem

When machining a component using a CNC machine tool, the quality of the finished part, for example surface finish and adherence to tolerance, is highly dependent on the positioning and contouring performance of the machine.

Although a machine tool's accuracy is likely to have been checked by the manufacturer prior to shipment and after installation, performance can degrade over time owing to wear, settling or collisions. Poor positioning and contouring performance may cause excessive re-work or the scrapping of components, coupled with machine down-time for unscheduled machine maintenance and repairs.

As a machine tool can only earn money while it is producing acceptable components, re-work, scrap and unplanned down-time impact delivery performance and profitability.

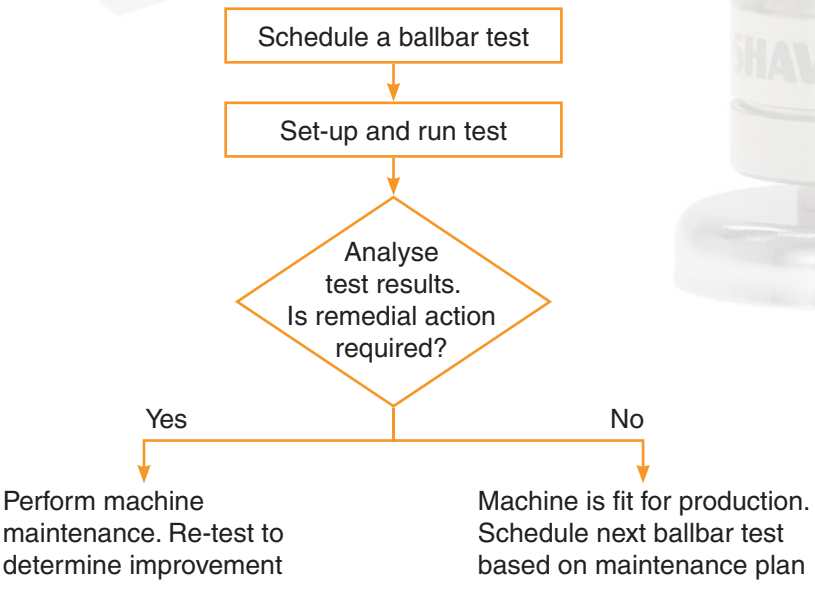
## Solution

Use a telescoping ballbar to conduct a rapid performance check as part of a preventative maintenance regime, before machine performance is compromised.

The ballbar measures minute variations in radius as a machine tool follows a programmed circular path. Associated software can display a range of numerical and graphical reports to diagnose machine positioning and contouring errors from test results.

## Benefits

- Machine positioning accuracy is established using a quick, simple test, minimising the time a machine is non-productive
- A wide range of machine errors, such as servo mismatch, backlash and machine squareness can be identified
- Capability of machine tools can be understood and used to best advantage
- Comparison of previous test results allows tracking of machine performance over time, assisting with the planning and scheduling of preventative maintenance tasks
- Proprietary software can assist in the generation of test programs, rank diagnosed machine errors and suggest possible solutions

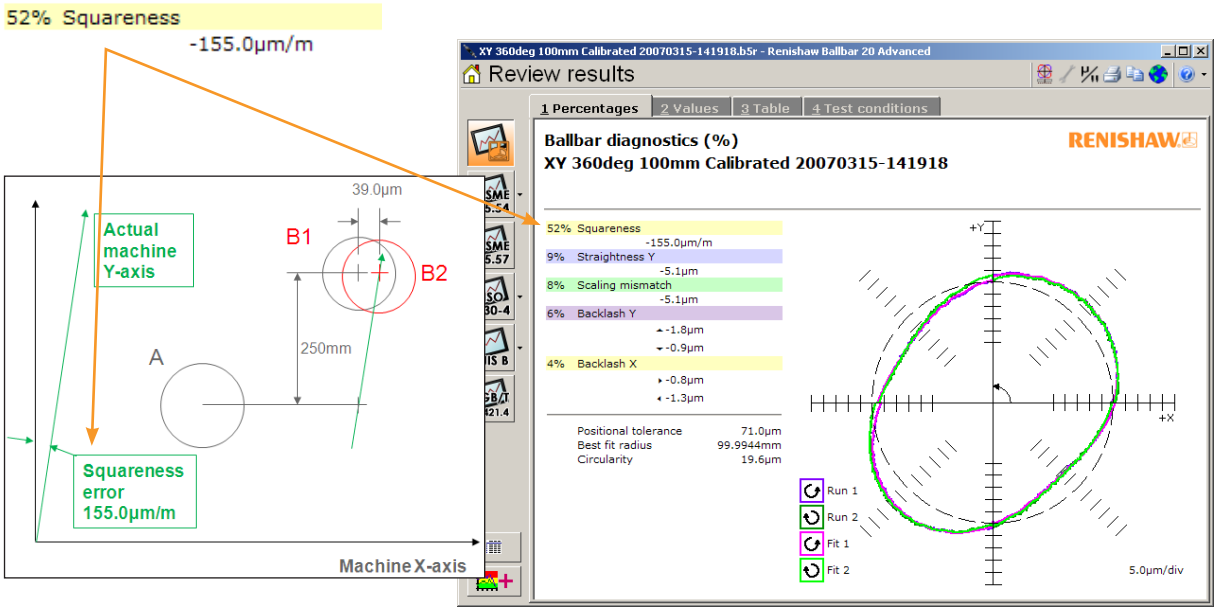



Machine condition monitoring - linear-axes

## Example 1: Machine axes are out of square

In the ballbar plot below, shown in Ballbar 20 software, squareness is diagnosed as the main error in the machine: the squareness of the Y-axis to the X-axis of the machine is -155.0 µm/m.

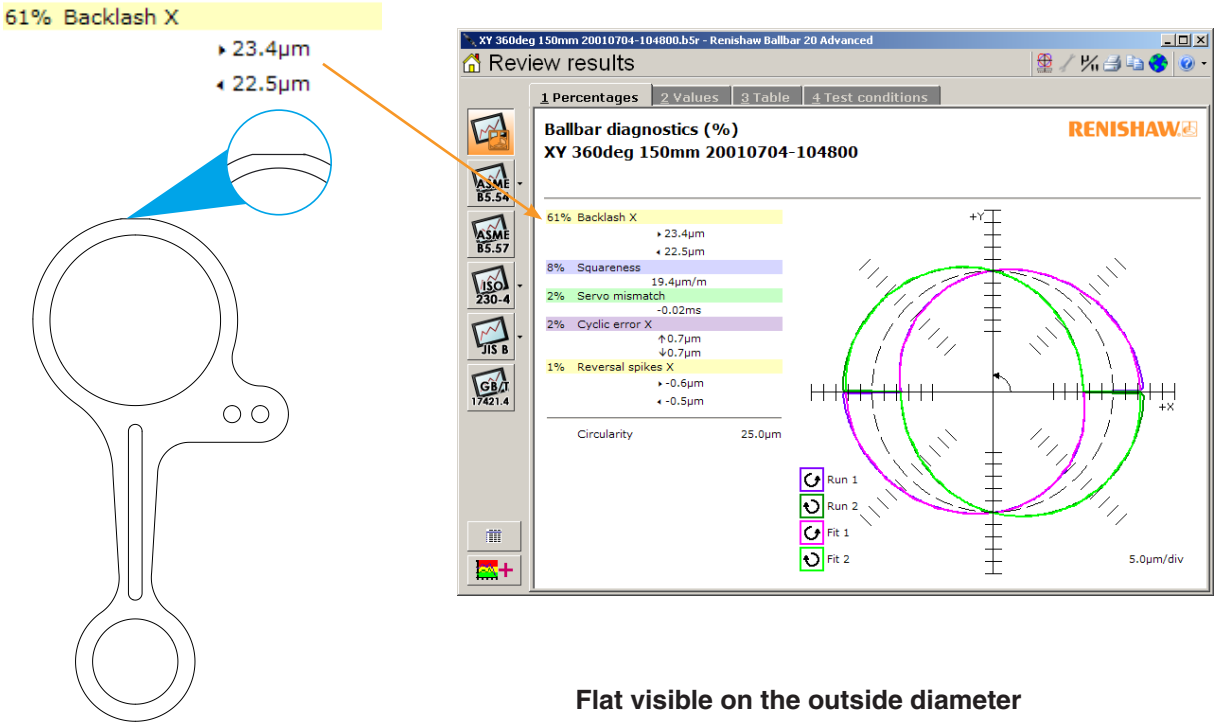
In the accompanying diagram, B1 indicates the position that a second hole should be drilled in relation to the datum hole, A. As a result of the squareness error of the machine over the 250 mm separation, the second hole would actually be drilled 39 µm to the right, indicated by B2.




**Hole is out of position**

## Example 2: Machine X-axis has backlash

In the ballbar plot below, backlash is diagnosed as the main problem in the machine. One of the effects of backlash or play in the axis positioning system, is that a flat will be produced on contoured arcs produced by the machine. For example, an interpolated 50 mm diameter will have a flat of length of over 1 mm visible at the axis reversal point due to the backlash of 23 µm in the X-axis. This could be unacceptable for either functional or cosmetic reasons.

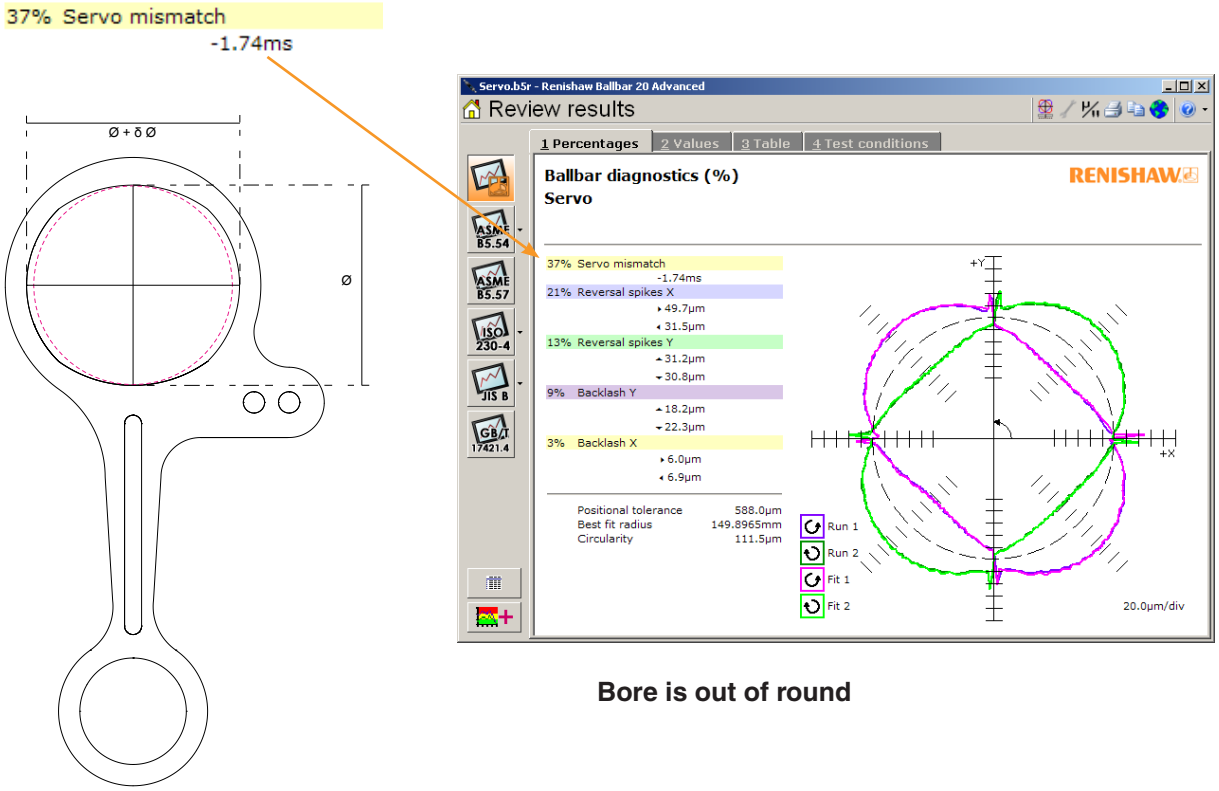



**Flat visible on the outside diameter**

*Part deformation has been exaggerated to demonstrate the affect of backlash on finished component.*

## Example 3: Machine servo mismatch

In the ballbar plot below, servo mismatch is diagnosed as the main problem with the machine. This is caused by an in-balance in the feedrates of the two axes during contouring (the X-axis leads the Y-axis). Servo mismatch results in a form error when interpolating a bore or boss.




**Bore is out of round**

*Part deformation has been exaggerated to demonstrate the affect of servo mismatch on finished component.*

## Additional machine assurance checks

In order to maximise capability and production capacity of machines with rotary axes, ballbar tests may be supplemented with AxiSet™ Check-Up. Similar to ballbar testing, use of AxiSet Check-Up provides traceability and supports scheduling of remedial maintenance before critical problems develop.

Renishaw's AxiSet Check-Up comprises software and a datum sphere for use in conjunction with a machine tool workpiece inspection probe to perform a quick health check of the alignment and positioning performance of rotary axes. Applications include the rapid assessment of rotary axis pivot points on 5-axis and multi-tasking machines as well as assessment of rotary axis performance on other machine types. See Pattern *AP101, Multi-axis machine condition monitoring* for further information.

**Renishaw plc**

New Mills, Wotton-under-Edge,
Gloucestershire GL12 8JR
United Kingdom

T +44 (0) 1453 524524
F +44 (0) 1453 524901
E uk@renishaw.com

www.renishaw.com

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## About Renishaw

Renishaw is an established world leader in engineering technologies, with a strong history of innovation in product development and manufacturing. Since its formation in 1973, the company has supplied leading-edge products that increase process productivity, improve product quality and deliver cost-effective automation solutions.

A worldwide network of subsidiary companies and distributors provides exceptional service and support for its customers.

**Products include:**

- **Dental CAD/CAM scanning and milling systems.**
- **Encoder systems for high accuracy linear, angle and rotary position feedback.**
- **Laser and ballbar systems for performance measurement and calibration of machines.**
- **Medical devices for neurosurgical applications.**
- **Probe systems and software for job set-up, tool setting and inspection on CNC machine tools.**
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- **Sensor systems and software for measurement on CMMs (co-ordinate measuring machines).**
- **Styli for CMM and machine tool probe applications.**

## Renishaw worldwide

**Australia**
T +61 3 9521 0922
E australia@renishaw.com

**Austria**
T +43 2236 379790
E austria@renishaw.com

**Brazil**
T +55 11 4195 2866
E brazil@renishaw.com

**Canada**
T +1 905 828 0104
E canada@renishaw.com

**The People's Republic of China**
T +86 21 6180 6416
E china@renishaw.com

**Czech Republic**
T +420 548 216 553
E czech@renishaw.com

**France**
T +33 1 64 61 84 84
E france@renishaw.com

**Germany**
T +49 7127 9810
E germany@renishaw.com

**Hong Kong**
T +852 2753 0638
E hongkong@renishaw.com

**Hungary**
T +36 23 502 183
E hungary@renishaw.com

**India**
T +91 80 6623 6000
E india@renishaw.com

**Indonesia**
T +62 21 2550 2467
E indonesia@renishaw.com

**Israel**
T +972 4 953 6595
E israel@renishaw.com

**Italy**
T +39 011 966 10 52
E italy@renishaw.com

**Japan**
T +81 3 5366 5316
E japan@renishaw.com

**Malaysia**
T +60 3 5631 4420
E malaysia@renishaw.com

**The Netherlands**
T +31 76 543 11 00
E benelux@renishaw.com

**Poland**
T +48 22 577 11 80
E poland@renishaw.com

**Russia**
T +7 495 231 16 77
E russia@renishaw.com

**Singapore**
T +65 6897 5466
E singapore@renishaw.com

**Slovenia**
T +386 1 527 2100
E mail@rls.si

**South Korea**
T +82 2 2108 2830
E southkorea@renishaw.com

**Spain**
T +34 93 663 34 20
E spain@renishaw.com

**Sweden**
T +46 8 584 90 880
E sweden@renishaw.com

**Switzerland**
T +41 55 415 50 60
E switzerland@renishaw.com

**Taiwan**
T +886 4 2473 3177
E taiwan@renishaw.com

**Thailand**
T +66 2 746 9811
E thailand@renishaw.com

**Turkey**
T +90 216 380 92 40
E turkiye@renishaw.com

**UK (Head Office)**
T +44 1453 524524
E uk@renishaw.com

**USA**
T +1 847 286 9953
E usa@renishaw.com

**For all other countries**
T +44 1453 524524
E international@renishaw.com



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