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SupaScan surface condition monitoring: technology demonstration

As well as traditional on-machine workpiece set-up and post-process inspection, SupaScan provides the ability to monitor surface condition of flat surfaces whilst a component remains in the fixture of a machine tool.

A surface condition monitoring technology demonstration shows how SupaScan compares with a traditional off-machine inspection system.

On-machine surface condition monitoring

Surface condition errors are frequently seen on the surfaces of machined components. These errors are often responsible for cosmetic and functional failure of components and can be a significant cause of rework, so early identification and resolution during machining is critical. Use of SupaScan allows the detection of common surface defects, such as:

- periodic errors – caused by worn tooling or machine vibration, resulting in a repeated pattern on the surface;
- surface peaks – due to chipped or worn tooling;
- steps on the surface – caused by unexpected differences between cutter dimensions, tool push-off, part deflection under cutting forces, or thermal changes in the machine.

As poorly machined surfaces are often caused by worn, chipped or damaged tooling, in-process surface condition monitoring can identify tools that have reached the end of their productive life and can no longer produce in-tolerance parts. This ensures tools are not replaced before they need to be; maximising tool life and minimising tooling expenditure.

Surface condition measurement has traditionally involved the use of hand-held sensors or has required the workpiece to be moved onto a dedicated measuring machine. Using SupaScan to automate surface condition monitoring, surface condition parameters can be obtained while the component remains on the machine tool – improving measurement reproducibility and allowing corrections to be made whilst the component is still in the fixture; helping to reduce rework and scrap.

The output of the surface condition inspection is the total waviness value – W_t – which can then be passed into machine variables, for use in controlling downstream processes, or exported to a .csv file for further analysis. A complementary application – Surface Reporter – provides on-screen surface profile traces and colour-coded waviness results that clearly indicate whether a component surface is within tolerance.

Using a Ø2 mm stylus ball, SupaScan can obtain surface condition information as well as undertake other probing tasks, such as workpiece set-up and post-process inspection.

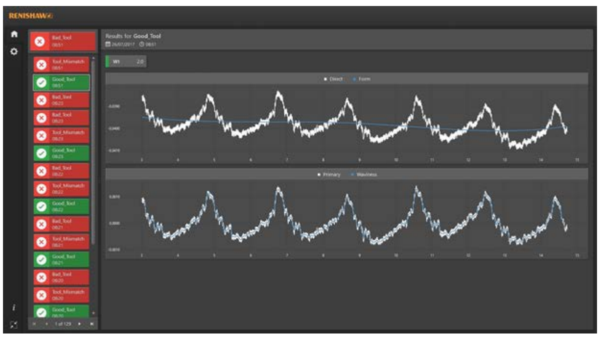


Figure 1: Surface Reporter application showing surface waviness

Surface condition monitoring for process control

Using SupaScan, process factors that influence surface waviness can be controlled. By storing the total waviness value in a machine tool variable, logic in the machine code can determine whether changes are required in machine parameters – such as tool offsets – or whether a tool is damaged and needs to be replaced by a sister tool.

After filtering out the form profile from the raw surface scan data, SupaScan software filters the waviness profile from the remaining data. Users can customise how the waviness profile is filtered by setting the value of the λ_c cut-off wavelength. A λ_c cut-off wavelength greater than 0.08 mm is recommended for process control operations.

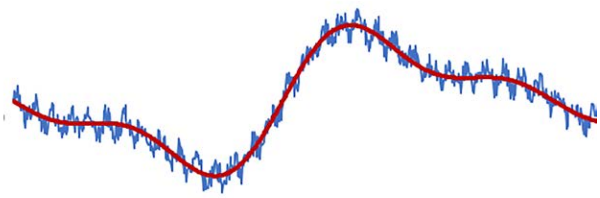


Figure 2: Filtering waviness profile (red) from primary profile (blue) using a larger λ_c cut-off value

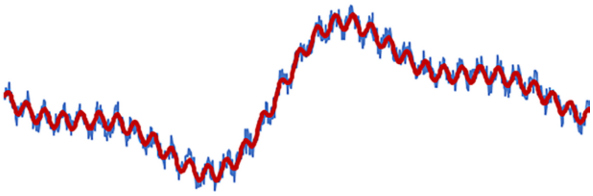


Figure 3: Filtering waviness profile (red) from primary profile (blue) using a smaller λ_c cut-off value

Technology demonstration

To demonstrate the surface measurement capability of SupaScan, Renishaw has produced an aluminium test piece showing six different levels of surface finish. Six cuts were made in the test piece by tooling with different levels of tool wear. Due to the different wear levels of the tool performing each cut, a different surface condition was produced in each section of the test piece. Section 1 was cut with a new tool, section 6 with the most worn tool.

Figure 4: Test piece with six cuts representing six different levels of surface condition

Surface waviness

The following charts show the waviness profile of each section of the test piece, as measured by SupaScan (with a Ø2 mm stylus ball at a feedrate of 500 mm/min) and by a CMM with a Renishaw REVO® RSP2 probe (with a Ø1 mm stylus ball at a feedrate of 120 mm/min). A λ_c value of 0.25 mm was used to filter the waviness profiles from the roughness profiles.

The corresponding tool images show a tool with a wear level representative of the tool cutting each section of the test piece surface.

Section 1 waviness profile

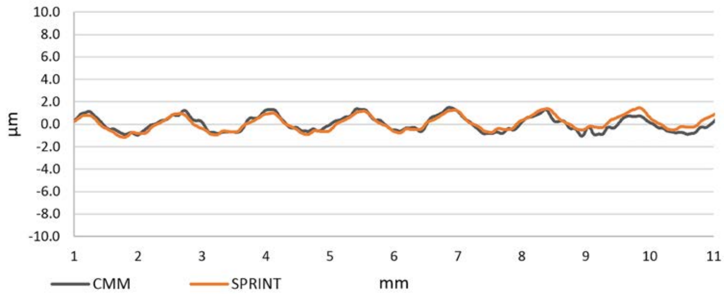
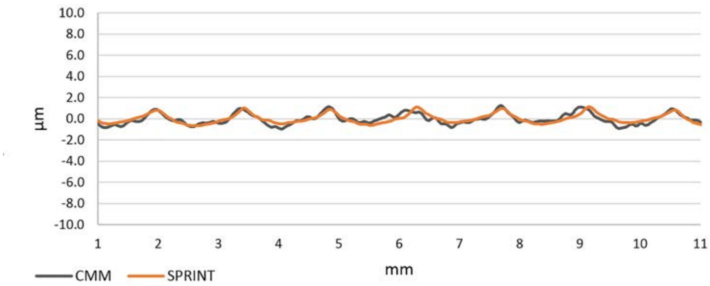


Figure 5: Waviness profile of section 1 as measured by CMM and SupaScan. Waviness values were reported as CMM W_t = 2.560 µm, SupaScan W_t = 2.575 µm

Section 2 waviness profile



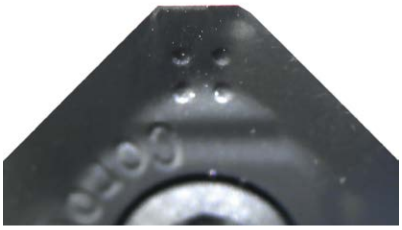


Figure 6: Waviness profile of section 2 as measured by CMM and SupaScan. Waviness values were reported as CMM W_t = 2.203 µm, SupaScan W_t = 2.086 µm

Section 3 waviness profile

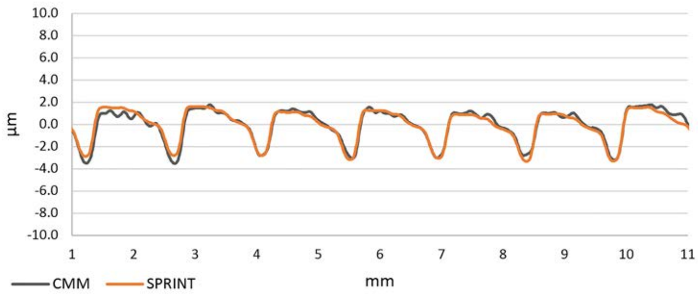


Figure 7: Waviness profile of section 3 as measured by CMM and SupaScan. Waviness values were reported as CMM W_t = 5.294 µm, SupaScan W_t = 4.985 µm

Section 4 waviness profile

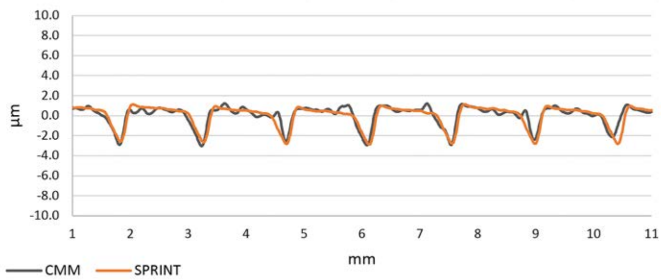


Figure 8: Waviness profile of section 4 as measured by CMM and SupaScan. Waviness values were reported as CMM W_t = 4.245 µm, SupaScan W_t = 4.109 µm

Section 5 waviness profile

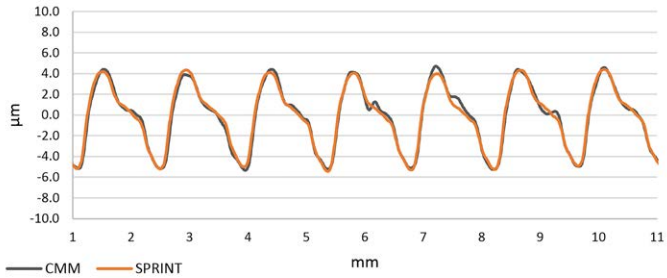


Figure 9: Waviness profile of section 5 as measured by CMM and SupaScan.
Waviness values were reported as CMM W_t = 10.028 μm, SupaScan W_t = 10.067 μm

Section 6 waviness profile

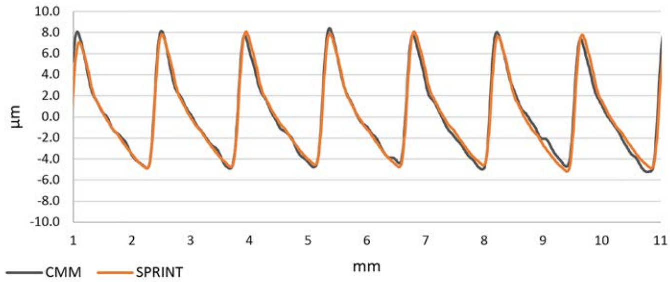


Figure 10: Waviness profile of section 6 as measured by CMM and SupaScan.
Waviness values were reported as CMM W_t = 13.656 μm, SupaScan W_t = 13.670 μm

Good correlation across the different levels of surface condition can be seen between the waviness profiles picked up by SupaScan and the CMM.

Total waviness value (W_t) correlation

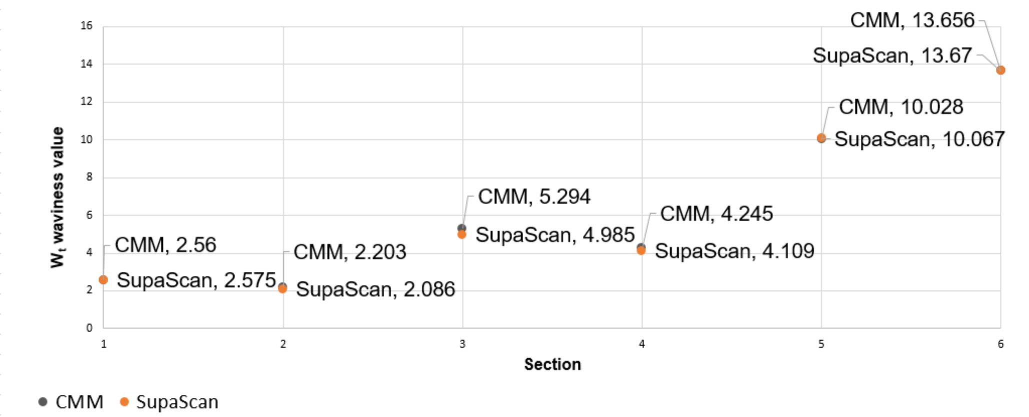


Figure 11: Correlation between W_t value for CMM and for SupaScan

A good correlation between the W_t waviness value for the CMM and SupaScan can be seen.

Surface steps

SupaScan can detect steps in surface condition data which are indicative of unexpected differences between cutter dimensions, tool push-off, part deflection under-cutting forces, or thermal changes in the machine.

As well as scanning the surface of the sections, the probe was also used to scan across the boundaries between sections detecting a step on the test piece.

The chart below shows a 140 µm step between two sections due to the difference in the depth of cut.

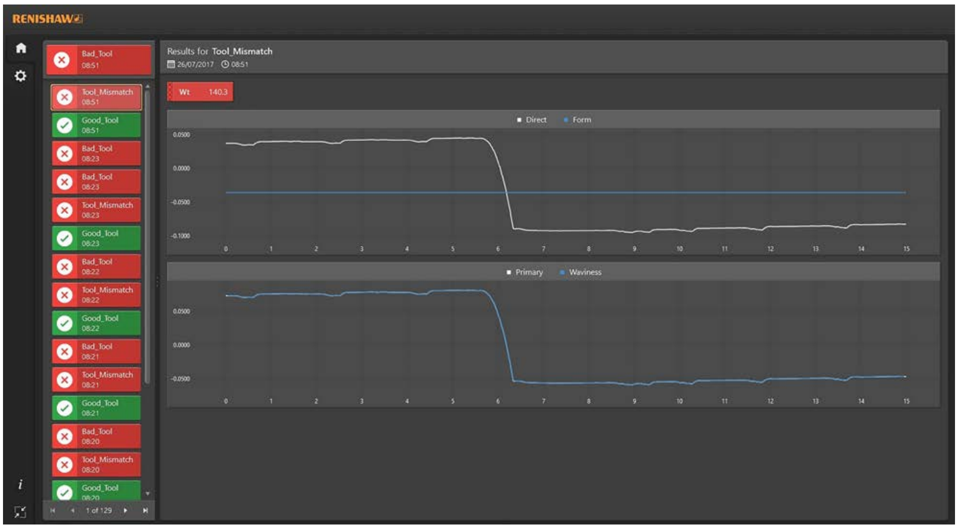


Figure 12: SupaScan measurement of a tool mismatch step of approximately 140 µm.

Conclusion

Across a variety of different surfaces, the results show good correlation between SupaScan on a machine tool and the REVO RSP2 measuring surface waviness on a CMM.

Using SupaScan, a single probe can be used for both workpiece set-up and inspection, as well as surface condition monitoring. Surface waviness of flat surfaces can be measured at high speed and in any direction – making the system a highly-versatile solution for use in a range of real world applications.

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

Products include:

- Additive manufacturing and vacuum casting technologies for design, prototyping, and production applications
- Dental CAD/CAM scanning systems and supply of dental structures
- Encoder systems for high-accuracy linear, angle and rotary position feedback
- Fixturing for CMMs (co-ordinate measuring machines) and gauging systems
- Gauging systems for comparative measurement of machined parts
- High-speed laser measurement and surveying systems for use in extreme environments
- 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
- Raman spectroscopy systems for non-destructive material analysis
- Sensor systems and software for measurement on CMMs
- Styli for CMM and machine tool probe applications

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