Renishaw plc

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

Tel   +44 (0) 1453 524524
Fax   +44 (0) 1453 524901
Email uk@renishaw.com

www.renishaw.com

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White paper

Renscan5 and REVO® – technology and applications

Renscan5™ and REVO™, "the most revolutionary metrology product since the invention of the touch trigger probe"

Overview

Renscan5™ is Renishaw's umbrella brand to cover five axis scanning products. It is only available using the Renishaw UCC2 universal CMM controller and forms the basis for Renishaw's future high speed scanning products.

The advantages provided by a five-axis system using Renscan5™technology are primarily the minimisation of the dynamic errors caused by the mass of the moving CMM structure, allowing significantly faster scanning speeds.

Renscan5™ is without doubt the future of scanning and as such Renishaw has invested heavily in the technology required to bring this measurement revolution to the market.

Traditionally, when a CMM is used to scan the surface using either fixed probing or an indexing head, there is a dynamic performance limit beyond which the metrology performance of the CMM becomes unpredictable. This dynamic limit governs scanning speed and hence productivity. Traditional CMM scanning is restricted to around 10 mm/sec in most cases, if accuracy is to be achieved. It is possible to scan faster, between 100 and 150 mm/sec surface speeds.

RENSCAN5™
a measurement revolution

When a five axis measuring system is used, much of the unwanted CMM dynamic error is removed because the measuring head performs most of the work. As the head is much lighter and more dynamic than the CMM, with a significantly better frequency response, it is able to quickly follow changes in the part geometry without introducing harmful dynamic errors. This allows the CMM to do what it is best designed to do – move at constant velocity in a single vector while measuring.

REVO™ system overview

The REVO™ measuring head features spherical air bearing technology in each of its two axes, each driven by state of the art brushless motors linked to high-resolution encoders to provide fast ultra high accuracy positioning.

The system comprises the following elements:

- REVO™ head
- RSP2 2D tip sense probe & stylus holders
- RSP3 3D probe range
- SFP1 surface finish measurement probe & stylus
- UCC2 universal CMM controller
- REVO™ PCI interface card (for UCC2)
- SPA2-2 servo power amplifier
- MCU5

Head technology
The REVO™ head is constructed using highly developed patented air bearing technology to provide an ultra-stiff metrology platform. Low resistance and low friction permit high accelerations and reversal in direction. The bearings, one in each axis, house high specification brushless motors which are linked to 0.08 arc second encoders, which translates to a position reading capability of under 0.1 μm at the tip of the 250 mm probe.
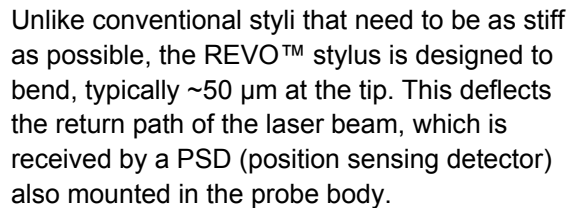
Infinite rotation is realised via hard gold slip ring contacts between the axes. This is the only part of the design where any moving surfaces are in contact. They have been tested to 50,000,000 cycles, at which point testing ceased without perceivable degradation.

This equates to a life span of over 5 years on a typical duty cycle before service is required. The slip rings are used for power only; communications is via capacitance link between the axes and is not subject to degradation.

The air bearings have an axial stiffness of 30 N per micron, which results in a stable metrology platform capable of high accelerations and surface scanning speeds of up to 500 mm/sec. The combination of these specifications along, with the features of the probe and servo control system allows, ultra fast high accuracy measurements to take place, boosting measurement throughput rates. This contributes to more efficient CMM use and reduced bottlenecks.

In addition to high speed measuring, Renscan5™ five axis systems allow rapid repositioning with the head able to move synchronously with the CMM to reposition between features. Five-axis motion also permits access to features that would previously have required complex stylus configurations and greater CMM working volume, both of which can be detrimental to cost and metrology.

Probe technology

To minimise the dynamic effects of high-speed motion on the probe mechanism, a novel probe design uses laser light to accurately sense the exact tip position. A beam of laser light is directed from its source in the probe body, mounted on the REVO™ head, down a hollow stylus, to a reflector at the stylus tip.

Unlike conventional styli that need to be as stiff as possible, the REVO™ stylus is designed to bend, typically ~50 µm at the tip. This deflects the return path of the laser beam, which is received by a PSD (position sensing detector) also mounted in the probe body.

Movement of the laser spot on the PSD is translated into a measurement output by combining it with the head and probe geometry and each of the CMM axis scale outputs. Thus, the exact stylus tip position in space can be derived. This all takes place while the stylus tip is dynamically scanning the part as the head moves synchronously with the CMM.

The REVO probe range features three types of sensor. The one described previously has been designed to be capable of measuring most features, and has a 2D-sense capability. In addition, there is a range of 3D probes based on SP25M technology, Renishaw's innovative PH10 mounted scanning probe, and a surface finish measurement probe. The probes are known as RSP2 (Revo™ scanning probe 2D), RSP3-# (Revo™ scanning probe 3D) and SFP1 (surface finish probe) respectively. The RSP2 will do most of the work with RSP3, for which a range of probes depending upon the stylus length to be carried are available, only called upon for cranked and disk styli applications. The RSP2 comprises a single probe body with stylus holders ranging in length from 175mm to 500mm from the centre of the lower axis of the head, while the RSP3 features standard SP25M stylus holders.

A probe and stylus change rack based on the popular MRS system can be configured using single ports to customise a system to the exact needs of the measurement application.
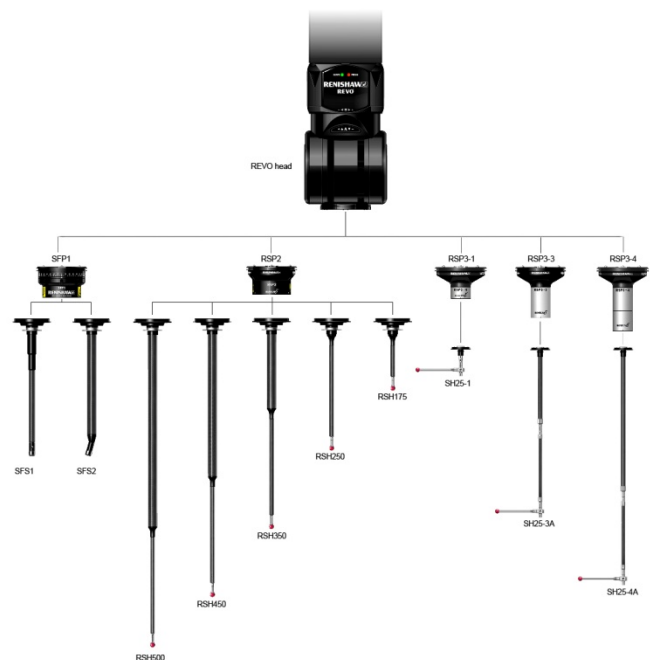
Control system technology

Renscan5™ and Revo™ are UCC2/SPA2-2 based systems. UCC2 is Renishaw's universal CMM controller for three and five axis scanning and contains the processor power to run the head and CMM synchronously. It is coupled to the SPA2-2 servo power amplifier, which, in REVO™ / Renscan5™ form, features five-axis capability.

Interfacing with the CMM controller

The primary reason for the introduction of UCC2 is to control the CMM and Revo™ head system. To synchronise the CMM and Head axes, a single processor has to be used if crucial timing and data management issues are to be overcome.

The head and probe collect data points at 4 Khz, two times the processing rate of UCC. This means that more data can be buffered and analysed post process, on areas of the part that may require it, without taking up valuable CMM time, further enhancing productivity. In context, at 500 mm/sec on a 100 mm bore which equates to ~25,000 data points per rev or one every 0.25 mm.

In addition to the challenges of data management, there are those of synchronicity to be overcome. All the information about the part surface is coming from the probe tip. While the basic geometry of the feature may well be 'known', the actual surface has to be tracked. This calls for a very responsive servo control system that permits surface contact to be maintained through changes in both of the rotary orientations of the head, as well as the motion of the CMM.

All scanning systems have to maintain surface contact using the CMM axes, but the type of scanning probes used for three axis scanning are lower frequency devices with more range than the Revo™ probes. This allows the structure of the CMM a chance of servoing accurately enough to maintain probe deflection within range but, this ultimately means that speeds are much lower.

Revo™ has a higher frequency response than traditional scanning probes, but this results in a design trade off that reduces the range of the probe. In practice, this is of no consequence as the head is capable of maintaining probe range while the CMM provides X,Y and Z axis motion. Of course, the main issue is that of synchronisation of the various inputs and outputs to permit five axis motion. Essentially the scale outputs from the head and CMM have to be combined and processed in a fashion that allows the drives of both the CMM and the head to respond synchronously to probe feedback from the part surface. All of this is achieved in the UCC2 and SPA2-2 system.

Integration with CMM application software

Renscan5™ and Revo™ integration takes place via the I++DME interface. I++DME is a common interface between application software on a range of measuring equipment. It is a client/server based connection between the measuring equipment hardware and the metrology application software used for programming.
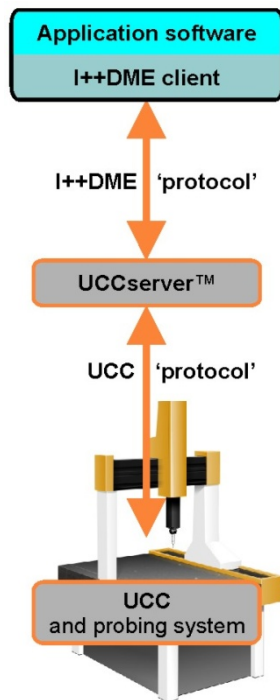
The CMM manufacturer or application software company must provide a client that is capable of communicating using the I++DME protocol. The CMM controller must have a server application capable of communicating via the I++DME protocol. In the case of Renishaw's UCC this is provided by UCCserver™.

A significant advantage of this method is that enhancements to Renscan5™ capability are available to all metrology application software packages via a single re-issue of the UCCserver™ with backward compatibility maintained.

REVO™ calibration

An essential element of using any measuring system is calibration. Traditionally, this calibration has to be done for every position on an articulating head with each probe and stylus combination to be used. Similarly, this has to be done for fixed head scanning systems and the respective stylus clusters used.

With Revo™, the calibration is used in a more sophisticated way that ultimately results in more time measuring and less time calibrating. Importantly, the calibration establishes the geometry of the head and probe. This allows all positions to be inferred from the calibration, such that any position or axis motion combination can be used accurately for measuring. This is achieved by taking the encoder readouts and associated encoder error map and combining it with the geometry calculations and the probe output to compute the exact tip position in space for all positions.

All of this is done using a routine similar to the ISO10360-4 test, which takes a few minutes; once this is complete all positions can be inferred. All that remains is for the different probe and stylus holders to be calibrated. Again this is a similar routine to the geometry calibration, but slightly shorter. A significant time saving is made which adds to the already impressive list of benefits to measurement throughput and accuracy.

REVO™ applications

Renscan5™ undoubtedly unlocks the door to greater measurement throughput on CMMs. It will also create exciting opportunities to develop applications to better meet the requirements of contemporary and future industrial technologies, and manufacturing methods.

Rapid head

Circle

Helix

Sweep

Application

Gasket

Blade sharp edge sweep scan

Round the blade
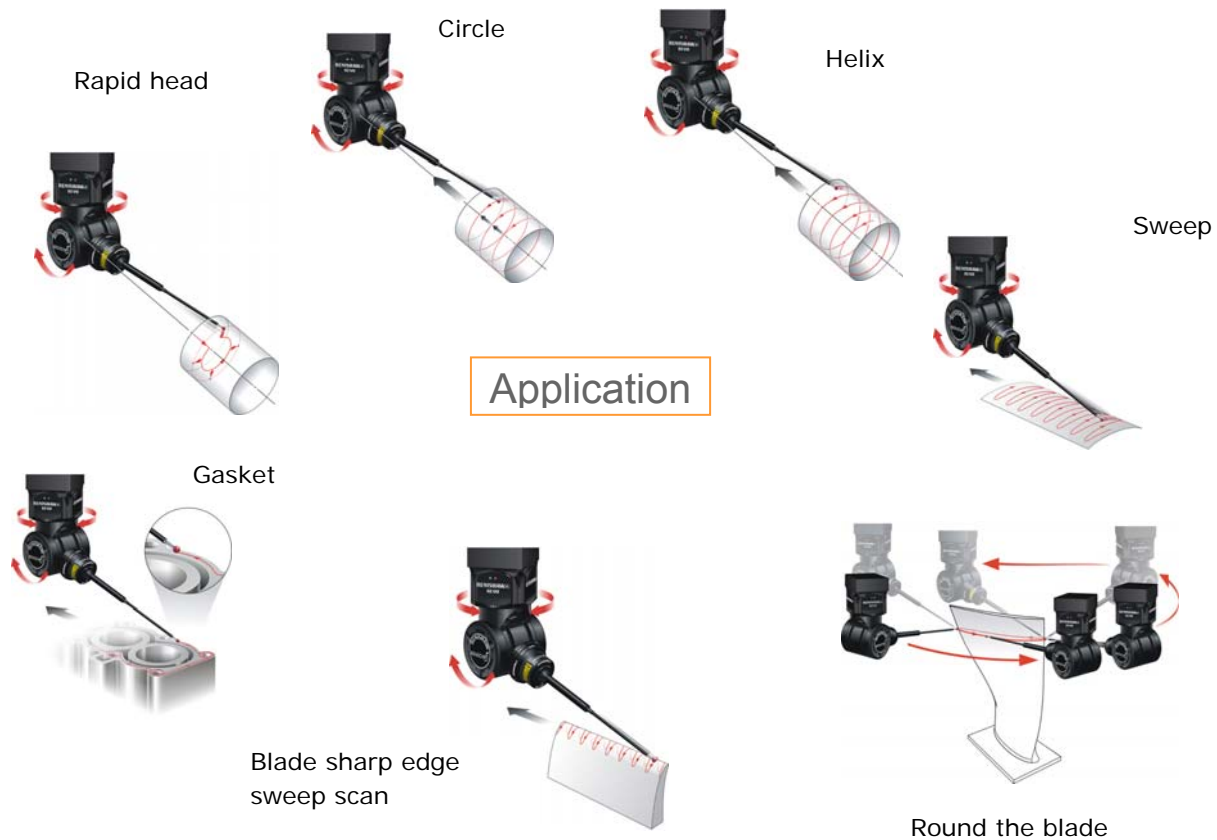
Summary of system benefits

- Incorporates Renscan5™ five axis scanning technology minimising CMM motion and the associated CMM dynamic errors.
- Increased measuring speed, up to 500 mm/sec. resulting in increased measurement throughput.
- High data collection rates up to 4,000 points per second.
- Infinite positioning and five axis motion reduces unproductive transitions between features
- Minimal stylus wear due to extremely low scanning forces
- Infinite positioning and five axis motion aid access to difficult features
- Rapid calibration with all positions inferred means more time measuring
- Maximum reach up to 500 mm with maintained effective working length
- Continuous rotation capability easing part programming challenges.
- Standard M2 styli for convenience.
- Interchangeable probe technologies to allow surface finish measurement on CMM as part of the inspection program.