Pocket guide:
An explanation of CMM sensor technologies

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CMM technology guide

A guide to CMM sensor technology – the heart of any CMM

CMM technology guide

an explanation of CMM technologies

Pocket guide contents

This pocket guide provides an overview of the different sensing technologies available from Renishaw for in co-ordinate measuring machines (CMMs). It will help you select the right equipment for your CMM to get the very best out of your investment. It will be particularly useful when specifying new CMMs or considering upgrades or retrofits.

"…boost inspection throughput by as much as 50 times."

See section 6
5-axis measurement – Renscan 5™

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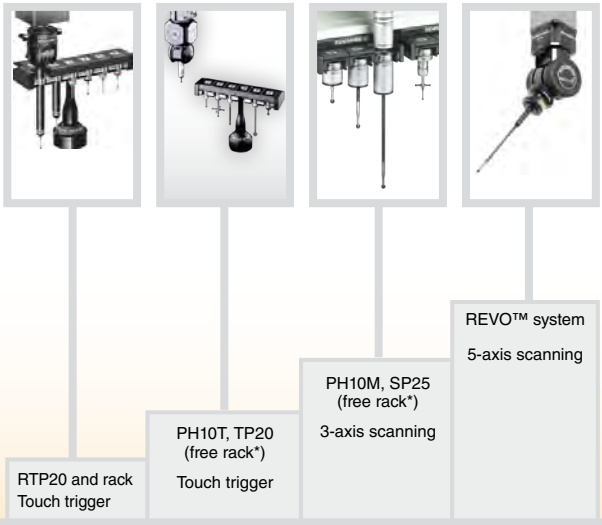
The range of automated probing at a glance



*** see section 7**

Touch trigger probing –
an introduction

Renishaw invented the first touch trigger probe back in the early 1970s and since then, has constantly developed the technology to offer ever-increasing levels of accuracy and flexibility.

The job of a touch trigger probe is a simple one: to act as a highly repeatable, sub micron, switch giving a trigger signal when a surface to be measured is contacted.

This type of probe is best suited to applications where a few touch points are sufficient to define each feature of a component. Examples include prismatic parts with easily defined features such as flat faces, pockets, bores and bosses.

Touch trigger probing – with entry level auto-indexing and stylus changing

RTP20 – 'round the pole' head

The RTP20 head is a novel hybrid between a manual and a motorised indexing head and uses the CMM motion (not in-built motors) to automatically index to a range of positions at 15° increments (see picture sequence to right). The industry standard TP20 probe body is integral to the head and it can carry the full range of TP20 modules, giving an overall reach of up to 155 mm when a 60 mm stylus is used. The TP20 modules can be automatically changed using the MCR20 change rack included in the low cost kits. This is a popular choice with those taking their first step into automated inspection with a CMM.

For more advanced applications requiring longer extensions, more precise indexing or ultra precise probes, the PH10 head is the natural choice – see section 4.

Stylus module changing

Unlock

Re-orientate

Lock

Measure

Touch trigger probing – advanced

PH10T indexing head and TP20/TP200 probe (with free change racks*)

Always choose touch trigger probes with detachable magnetic stylus modules; they are no more expensive than older fixed types, and have significant time saving benefits and extra crash protection (e.g. TP20 and TP200).

RENISHAW changers

*End users buying a PH10 head (or PH9 – PH10 upgrade) through participating OEMs receive a free MCR20 or SCR200 change rack - see section 7, 'changers' promotion for full details

The PH10 range of motorised heads represent an auto-indexing solution which can carry up to 300 mm extensions and orientate probes to a wide range of angles at 7.5 ° increments (we know from over 20 years of experience that smaller increments compromise durability). It is a proven and robust system with full repair back up if accidents occur – see section 11, service and support.

PH10T with the industry standard TP20 probe is the most common head/probe combination used on CMMs worldwide. The flexibility of PH10's auto-indexing combined with TP20's automatic stylus changing with the FREE* MCR20 change rack is what makes it so popular.

By combining PH10T with the TP200 strain gauge probe, users still get automatic stylus changing, using the FREE* SCR200, and even higher repeatability with the capacity to carry longer (up to 100 mm) or heavier stylus configurations.

3-axis contact scanning

Renishaw's high accuracy award winning SP25M is the most compact 3-axis scanning probe available, allowing it to be fitted to the PH10M/MQ indexing head.

SP25 is two probes in one - a high accuracy scanning probe and a touch trigger probe, giving added flexibility.

3-axis contact scanning offers significant speed advantages over touch trigger data capture.

3-axis scanning operates in a different way from touch trigger probing, by constantly streaming data as the stylus 'scans' in contact with the measurement surface (2000 – 6000 points a second is typical). The X, Y and Z axes of the machine provide all the movement during 3-axis scanning.

SP25M high accuracy indexing scanning probe

SP80 ultra-high accuracy fixed scanning probe

This type of system is suitable where features need large amounts of data to define their form, but maximum throughput is not top priority. Good examples include taking batch samples of propeller blades, aerofoil sections or automotive cylinder bores.

In these cases a few touch points don't give enough information to accurately measure the form.

The SP25M is the most recent 3-axis scanning probe of this type and is mounted using the autojoint connection on PH10M or PH10MQ heads.

The PH10M is a shank mounted head, whilst the PH10MQ is directly mounted within the quill of a CMM.

The SP80 is an ultra-high accuracy 3-axis scanning probe with some unique features - it can carry up to 800 mm long styli, and operates without the need for counter-balanced styli configurations. The addition of in-built crash protection means this high performance is protected from accidental damage.

Gear inspection is 30 times faster

It now takes Meltham Mills Engineering (MME) only eight minutes to inspect every critical feature on a typical gear component; 30 times faster than previously. Simultaneously, data is gathered on the form of features, the first time MME has had this automated capability. This has been made possible using Renishaw's SP25M scanning probe fitted to a new CMM, allowing continuous measurement data to be captured along 3D profiles.

5-axis measurement – with Renscan5™

Renscan5™ is a revolutionary new CMM technology giving unrivalled speed and accuracy to boost inspection throughput by as much as 50 times.

The 5-axis technology can run identical routines to those commonly used with conventional touch trigger or 3-axis scanning probes, but also has additional time saving features for users to exploit.

Even before measurement begins, the technology reduces set-up time because Renscan5™ probe heads (eg REVO™) only require a single 20 minute calibration routine to be accurate at all angles of their infinite rotation. This replaces the conventional multiple calibration procedure that can take many hours.

Where simple touch points are all that is required, they can be gathered 'on the fly' at very high speed using an infinitely positional 2-axis servo head. For a series of points around a bore, the head's axes revolve to the required position then 'flicks' the stylus out, taking the touch points.

Calibration

Rapid touch points

Sweep scan

Helix scan

This novel technique can also be used to take very rapid points on flat and freeform surfaces. The machine's axes guide the head parallel to the surface and the 'tip sensing' probe flicks down to take points without the machine slowing down (although scanning could be even quicker in many applications).

Most modern components are designed in CAD where designers have much more freedom to produce complex forms. When the finished components are inspected, it takes far too long using touch trigger probes or even 3-axis scanning. It is here where 5-axis scanning is invaluable with its ability to gather the huge quantity of accurate inspection data that is required.

When attempting to use traditional 3-axis scanning at high speed, large dynamic errors result from the machine frame flexing under the loads of movement.

5-axis measurement – with Renscan5™ continued

Renscan5™ uses novel techniques to eliminate dynamic errors from scanning results:

By fixing the machine's X, Y and Z-axes, whilst the 2-axis servo head scans the surface with a 'tip sensing' probe, no machine accelerations or decelerations are present to create dynamic errors.

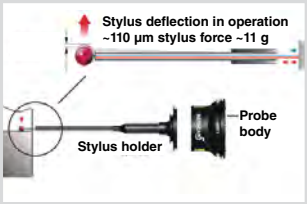
In certain applications it isn't possible to measure components with the machine axes fixed. Instead the axes are moved in a vector (at constant speed) resulting in a smooth motion with minimal acceleration or deceleration, enabling the servo head and 'tip sensing' probe to scan accurately.

REVO™, the first head to use Renscan5™ technology manages to avoid the biggest limitation of 3-axis scanning (low speed) by breaking through the traditional speed/accuracy barrier. Although 3-axis scanning can run at speeds of up to 80 mm/sec, accuracy is severely compromised. Typically 15 – 20 mm/sec is required for accurate results.

REVO™ can achieve speeds of up to 500 mm/sec **and** maintain accuracy.

It is difficult to identify one typical application for the Renscan5™ technology as the range of benefits are so varied. Some customers justify the investment on calibration set up time alone, whilst others make best use of the ultra high scanning speeds. In either case the result is the same; large increases in inspection throughput.

Renscan5™ uses 'tip sensing' a novel method of taking measurements very close to a component's surface with ultra high speed and accuracy.



Renscan5™ systems are offered by CMM suppliers on new machines or as retrofit packages.

'Tip sensing' – how it works:

The 'tip sensor' is attached to a 2-axis servo positioning head which can orientate to infinite angles, and to the untrained eye looks like an ordinary carbon fibre extension rod with a stylus at the end. However, there are some important differences:

The carbon fibre stylus holder is hollow, allowing a laser beam to be fired down its centre to a reflector positioned immediately behind the stylus tip. The reflected beam returns back up the stylus holder and is focussed onto a position sensitive detector (PSD) in the servo head.

When the stylus tip comes into contact with a surface the stylus holder bends slightly, causing the laser beam to move on the PSD. The system then adjusts all 5 axes (3 machine axes and 2 rotary head axes) to maintain a constant deflection of 110 µm.

Stylus and probe change racks – ‘changers’ promotion

The wide range of features and components measured in a typical factory means that manufacturers need a flexible measuring solution. A single sensor and stylus configuration will not be sufficient in most cases.

Stylus and module changing

Unless you are constantly measuring one simple component, you will need to change your stylus configuration to suit different measurement tasks. This can be done manually by swapping styli using the threaded connection, but takes time and requires a recalibration after every change.

Probe systems like TP20 are available with repeatable, automated means to change styli without the need to recalibrate each time. This greatly increases flexibility by allowing you to access features that demand long or complex styli, as well as using different styli types (sphere, disc, cylinder). It reduces operator intervention and increases measurement throughput.

The MCR20 module changing rack is completely passive and has the capability of storing up to 6 TP20 probe modules for automatic changing under measurement program control.

RENISHAW changers

Changers promotion
Under the ‘changers’ promotion auto-change racks are offered free of charge* to customers purchasing new PH10s (including PH9 – PH10 upgrades) from participating OEMs.

Rack	Probe	Cost
MCR20	TP20	FREE
SCR200	TP200	FREE
FCR25	SP25M	FREE
ACR3	various	(50% DISCOUNT)*

The MCR20 (free under the ‘changers’ scheme) is designed to securely hold the stored probe modules for automatic changing and to protect them from airborne contaminants which may be present in the working environment.

When using the TP200 high precision strain gauge probe, the SCR200 change rack provides automatic, high speed changing of up to six TP200 stylus modules. The SCR200 is powered by a separate interface and provides features to facilitate safe stylus changing.

Most Renishaw probes, including Renscan5™ heads, have the ability to automatically interchange styli configurations, giving a more flexible solution.

Probe change racks

There are situations where the whole probe needs to be changed automatically, for example when using both contact and non-contact probes together on the same machine. In these cases a probe changing system like ACR3 is essential – these are discounted by 50% under the 'changers' scheme. The ACR3 probe changer safely stores the probes and because these each use a repeatable 'autojoint' there is no need for calibration after each change.

SCR200


FCR25


ACR3

Styli selection – good practice

All Renishaw styli use high accuracy grade 5 balls as standard - look for the Renishaw logo on every stylus.

What type of styli should I choose?

General notes on stylus selection:

- Keep styli short; the shorter and stiffer a stylus the better the accuracy
- Choose the largest ball possible as this maximises stem clearance and minimises the effect of component surface finish
- Use as few joints as possible as they introduce potential points of bending and deflection which adversely affect accuracy
- Star styli allow up to 5 styli to be used in a cluster, and are useful when measuring internal features such as circlip grooves in bores.

In addition to the general features above, the following three areas should be considered:

1. Stylus ball grade

To achieve good accuracy most CMMs are supplied with grade 5 stylus balls. When purchasing replacements it is essential that lower grade (grade 10) styli are not chosen, as it is common for them to cause the loss of up to 15% of overall machine accuracy.

Saving money on a stylus is false economy when it can compromise the accuracy of your quality assurance system. For exceptional accuracy Renishaw can offer ultra-accurate grade 3 styli on special order. For more information ask for Renishaw's 'Ball grading' document, part number H-1000-3001.

2. Stylus ball materials

• Ruby

This is the industry standard material, is very hard and wear resistant, and is used in the vast majority of applications.

• Silicon nitride

This is preferred to Ruby where aluminium is being scanned in a heavy-duty cycle, as it resists a phenomenon known as 'adhesive wear'

• Zirconia

When scanning cast iron in a heavy-duty cycle, this material is more resistant to 'abrasive wear'.

3. Stylus stem materials

• Steel

Most styli with a ball diameter greater than 2 mm and a length of up to 30 mm use non-magnetic stainless steel stems. A one-piece construction gives the optimum weight-to-stiffness ratio. This is the most common choice of stem material.

• Tungsten carbide

Where the ball diameter is less than 1 mm or the stylus is up to 50 mm long, this material offers the best stiffness.

• Ceramic

Where the ball diameter is greater than 3 mm or the stylus length is over 30 mm, this material offers the stiffness of stainless steel but is a lighter option than Tungsten carbide.

• Carbon fibre (Renishaw GF)

This specially developed grade of carbon fibre is not only light, but also offers excellent stiffness when very long lengths are required (up to 800 mm with the SP80 scanning probe).

For more information on stylus selection, ball and stem materials, plus the full range of styli ask for Renishaw's 'Styli and accessories' guide (part number H-1000-3200).

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