

# Incremental encoders help optimise the fuel efficiency of aero-engines



**Customer:**  
HAESL

**Industry:**  
Aerospace

## Challenge:

Optimise fuel efficiency of aero-engines with honeycomb seal-rings.

## Solution:

TONiC™ encoder series to improve positional stability and repeatability.

How fuel efficient is a commercial airliner? A Boeing 747 burns approximately 5 gallons of fuel per mile or a total of 30,000 gallons (98 tonnes) on a flight between London and Hong Kong - a significant cost for an airline. The honeycomb seal-ring is an extensively used component, which has been proven to optimise the fuel efficiency of aero-engines, but the measurement of these seals present difficult engineering challenges. Now, HAESL (Hong Kong Aero Engine Services Limited) believes that it has successfully solved this challenge by incorporating Renishaw's TONiC™ incremental linear and rotary (angle) encoders within its new optical Seal Ring Measurement System (SRMS).

Eric Lau, senior engineer, who has been working at HAESL for almost 20 years, and engineer Raymond Siu explain: "SRMS is a joint development system by HAESL and The Hong Kong Polytechnic University (PolyU), which has transformed the way we inspect honeycomb. Before SRMS, we used vernier callipers to measure the rings manually which is time consuming and relies heavily on the skill and experience of the operator.

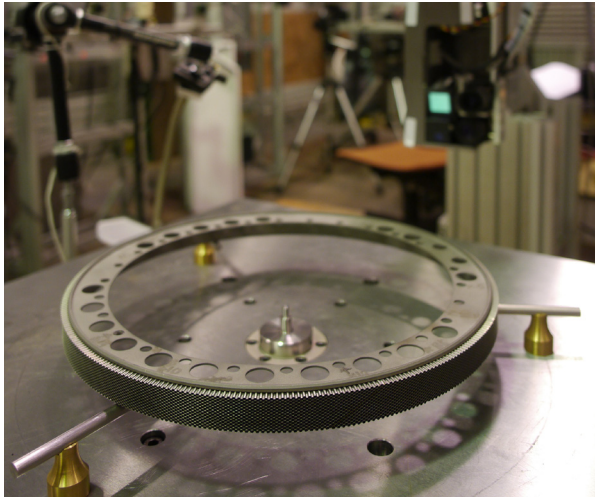
This new system has changed all of that. SRMS is not only faster, which increases work efficiency by 50%, but also maintains the consistency of the results by eliminating human error."

Renishaw's TONiC™ series encoders offer excellent immunity to dirt and its compact size and ease of installation provided us with a great deal of flexibility in system design.

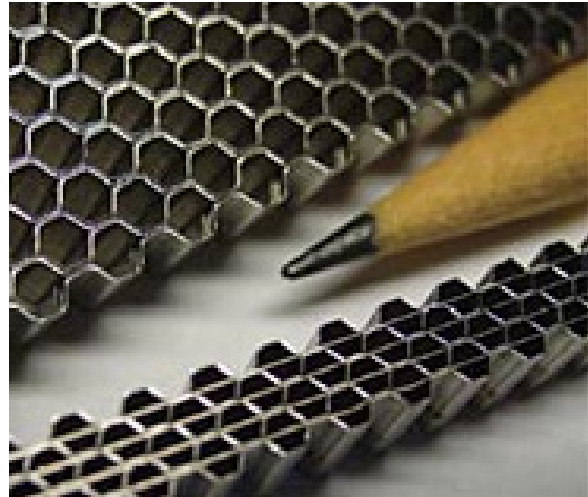
**HAESL (Hong Kong)**

## Honeycomb seal-rings

Honeycomb seals are fitted into mounting rings that are juxtaposed to the blades of the turbine. They are used to seal the radial gap between the rotating blades and the turbine wall to optimise both the fuel consumption and service life of the aero-engine. Rotor blades expand, however, as the operating temperature increases. The honeycomb seal-ring, therefore, provides a sacrificial surface that allows the rotating blades to cut into the seal and preserve the integrity of both the blades and the turbine wall. Hexagonal cell size on the ring depends on the rotor blade dimensions; cell diameter typically varies from 0.8 mm to 3 mm, while depth is up to 13 mm.



Honeycomb seal ring



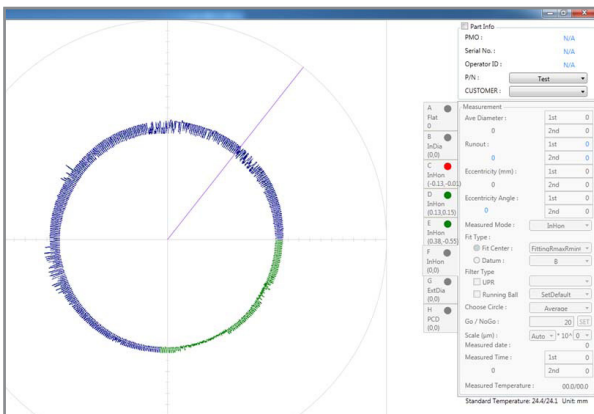
Small honeycomb

## Reliable performance

Patrick Ng is the chief designer of SRMS: “The combination of an integrated optical measurement head, ball screw axes, servo-motors and encoded rotary table create an accurate, reliable and maintenance-free system. Unlike conventional probe systems, SRMS employs non-contact and optical inspection technologies to tackle the most typical seal-ring measuring problems faced by the industry. The choice of Renishaw was straightforward. We had experience of Renishaw’s encoders from other successful projects in the past, so we knew their quality and how reliable they are. Renishaw’s TONIC series encoders offer excellent immunity to dirt and its compact size and ease of installation provided us with a great deal of flexibility in system design. Two TONIC encoders are fitted onto the linear axes of the X-Y stage on SRMS and their excellent performance is surpassed only by their exceptional support.”

Mr Ng continues: “Loading the ring in the correct position on the rotary table is critical, with a direct effect on the measurement result. We compared different brands but Renishaw’s has the best cost-performance ratio.

To ensure a smooth and stable rotation, it is important that the cyclic error is low and TONIC can achieve this.”



Software graphical user interface

Renishaw’s TONIC RESM angle encoder system offers ultra-low cyclic errors of typically  $\pm 30$  nm and a resolution up to 86.4M CPR (counts per rev) which satisfies many of the most demanding requirements. The high accuracy ring scale is designed with low mass and low inertia, allowing better dynamic performance while the readhead employs low noise (jitter) filtering optics to further improve positional stability and repeatability.

## Ease of installation

All of Renishaw’s ring scales feature a patented taper mount which minimises the installation errors and simplifies the integration. “The taper mount is one of the attractive features of Renishaw’s encoders. It saves our time and reduces the workload in correcting rotor eccentricity,” says Mr Ng. In addition, every readhead features an innovative integral set-up LED which speeds up installation and removes the need for complex external set-up equipment, or oscilloscopes.

## Avant-garde machine design

SRMS is a high precision optical measurement system which is designed for measuring the roundness, flatness and PCD (Pitch Circle Diameter) of the holes on the seal rings by switching modes on its remote control pad. This system comprises three main modules: the rotary table, the integrated optical measurement head on main console and the software console.

Mr Ng explains: “Our SRMS’ measurement head features a built-in high-accuracy class 3R Laser Displacement Sensor (LDS) and an industrial camera, which moves horizontally (X) and vertically (Y) on the main console.

“The laser takes measurements for both internal and external roundness, while the camera takes images of the holes around the PCD and provides remote monitoring of the LDS laser spot position. This results in the improvement of measurement precision which the probe system could not provide.”

The seal ring for inspection is placed by the operator on the rotary table, providing a placement tolerance of  $\pm 2$  mm through the built-in auto-centering function. The operator

then selects the corresponding ring type from the library and starts the measurement. The measurement head remains static to capture and send the data to the software console for processing. Every individual measurement reading from the head is coupled with corresponding rotary table positional data from the encoder, and then post-processed to compute a holistic geometric measurement of the sample.

## Enhancement of machine tool reliability

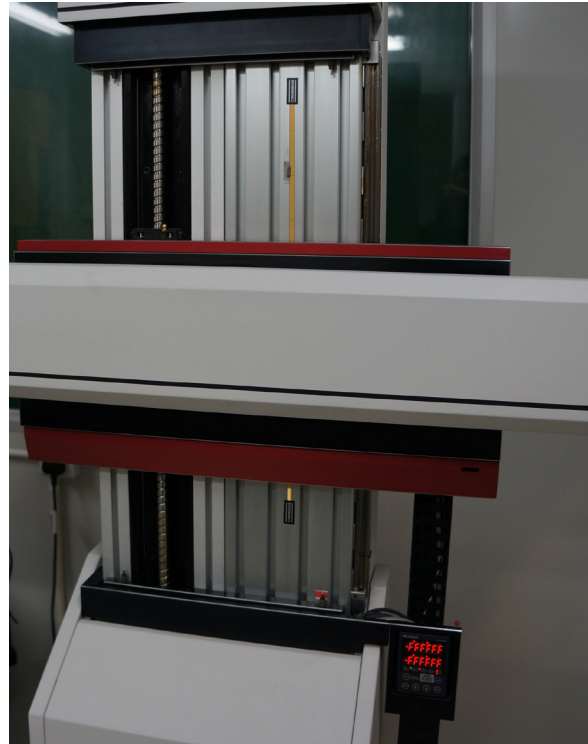
Other than SRMS, which uses Renishaw's encoders, HAESL also uses Renishaw's QC10 ballbar to assess their machine tool performance: "The ballbar allows us to track and identify problems earlier to enable preventative maintenance. This helps to minimise production downtime and ensure the accuracy of parts produced. We are currently considering upgrading this to Renishaw's latest QC20-W wireless ballbar system which offers more advanced features such as Bluetooth wireless connection, 'partial-arc' testing and single setup for three-planes testing," says Eric Lau.

HAESL also uses Renishaw's TP200 high accuracy touch trigger probe with the PH10 motorised probe head system on their co-ordinate measuring system (CMM) for part inspection. Raymond Siu explains: "Inspection is a highly important and vital process in the aero-industry. Renishaw is the undisputed market leader in CMM probing technology and is undoubtedly our first choice."

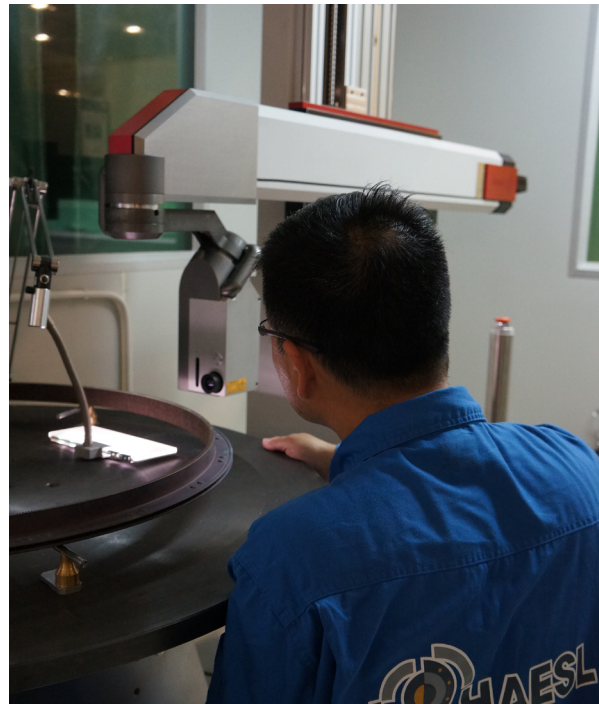
## About HAESL

HAESL, based in Hong Kong, is a joint venture between Hong Kong Aircraft Engineering Company Ltd (HAECO), Rolls Royce plc and SIA Engineering Company (SIAEC). The organisation provides world-class aero-engine repair, overhaul and component repair services for many of the world's most respected airlines that have chosen Rolls-Royce to power their fleet of Airbus and Boeing aircraft.

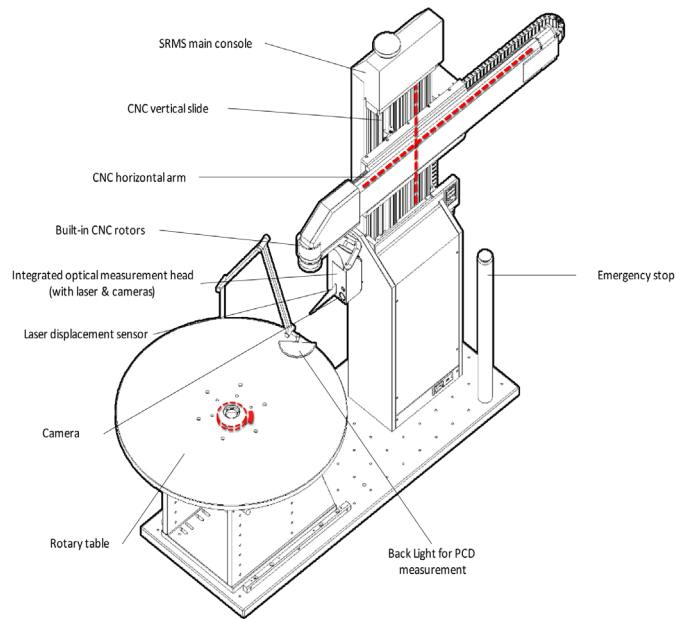
With over 35 years of experience in the field, HAESL has become one of the world's most respected engineering names for offering the highest quality and most comprehensive engine repair and overhaul services to customers worldwide. Since 2002, HAESL has been collaborating closely with The Hong Kong Polytechnic University (PolyU) on many of the joint venture projects and customized training programs for technology updates in the aero-industry.



TONiC encoder system on SRMS



SRMS inspection system



Optical Seal Ring Measurement System (SRMS)

For more information, visit [www.renishaw.com/encoders](http://www.renishaw.com/encoders)

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