Pipe Internal Thread

Executive Summary

Optimet's ConoProbe sensor with a 75 mm focal length lens was used to measure pipes' internal threads. Test results indicate clearly that all parameters specified can be measured with high repeatability and certainty.

The pipes' inner screw features measured were highly accurate even with spray (used to get high quality data), implying that the method of measurement is accurate and is not influenced by spray thickness. The following features were measured:

- Height
- Pitch
- Angles

1. Optimet's Advantages over Other Technologies:

1. Collinearity –Optimet's conoscopic holography technology allows the use of a remote lens and mirror (periscope) for measurements of internal profiles with high accuracy.

2. It is not possible to evaluate the process trend using the GO/NO GO method. Optimet's method of measuring the profiles and evaluating parameters of each individual thread during manufacturing can improve the predictive trend process control and thus improve yields.

2. Application Description

- Optimet's ConoProbe Sensor with remote lens and mirror:
  - Lens: 75 mm
  - Mirror: remote; 80 mm from sensor
  - Calibrated to 14mm working range, precision better than 10 µm

- Stage:
  - THK:
    - 1 mm pitch
    - 20 µm overall position error
  - Stepper motor
    - 200 steps/revolution
    - 5%/step noncumulative error

2.1 Method

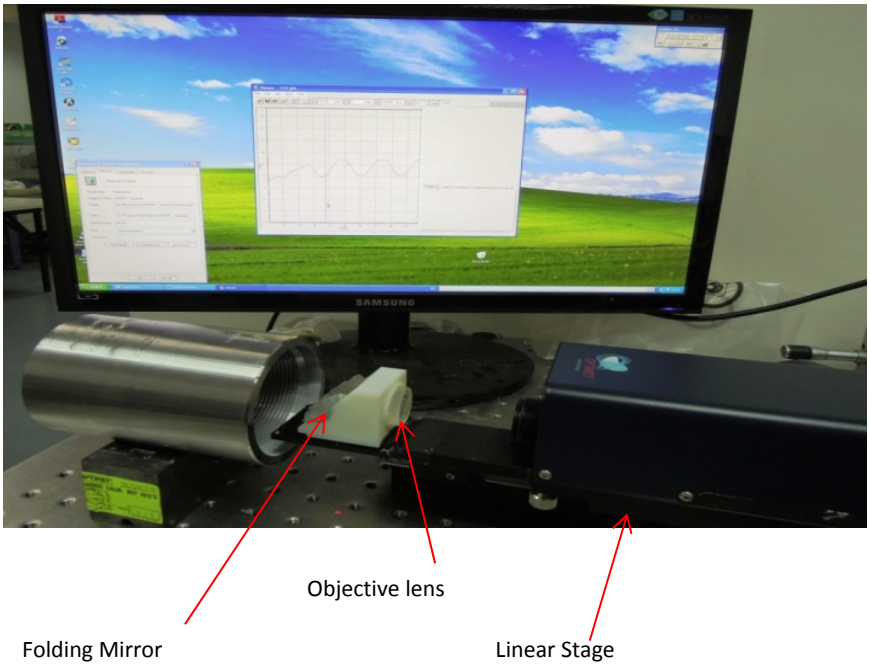


Figure 1 - Overall setup

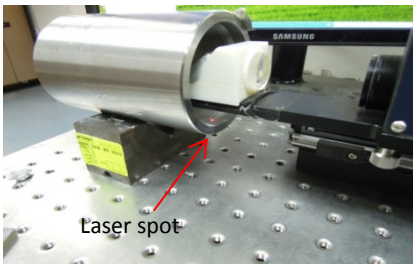


Figure 2 - Laser setup

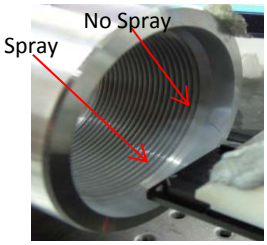


Figure 3 - Pipe

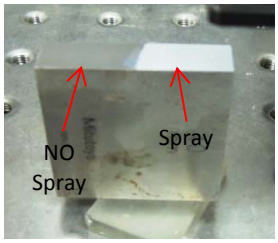


Figure 4 - Reference surface

Sensor with periscope lens and mirror (fig.1) were calibrated and checked using Optimet's standard jigs.

We performed 3 measurements:

- Side 1 - Two measurements for repeatability
- Side 2 - One measurement

Note: measurements were performed using a thin layer of scan spray around 10 µm thick. The thread was carefully cleaned from oil and metal fragments before applying the spray.

3. Results and Observations

Sensor QC Performance Testing

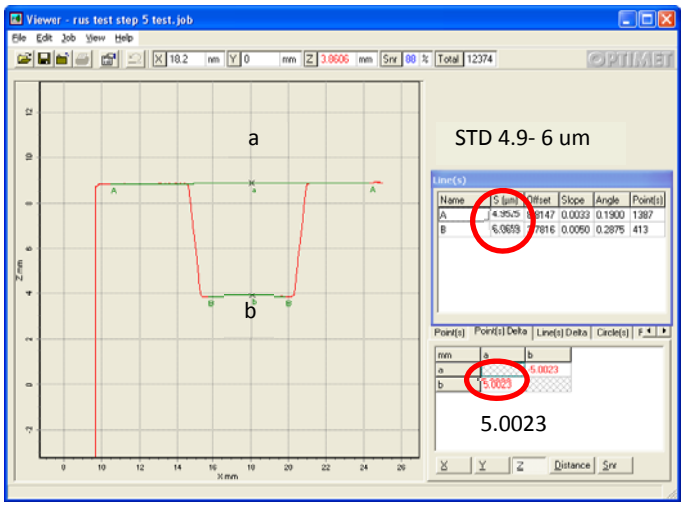


Figure 5 - Standard JIG of 5 mm step height

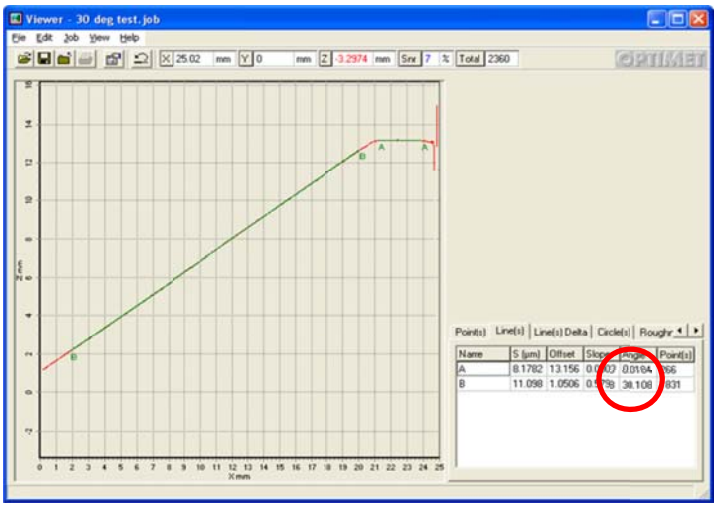


Figure 6 - Sensor Linearity Test

Explanations:

In fig. 5 the next measurements can be seen:

- 2.3 µm error (measured distance a-b: 5.002)
- 4.9-6.0 µm STD on flat surface (linear fit)

In fig. 6 the next measurements can be seen:

- Linearity and calibration error: measured 30.1° on a slope with 30.08° nominal, over 12 mm WR

Reference – Estimating Spray Coating Thickness

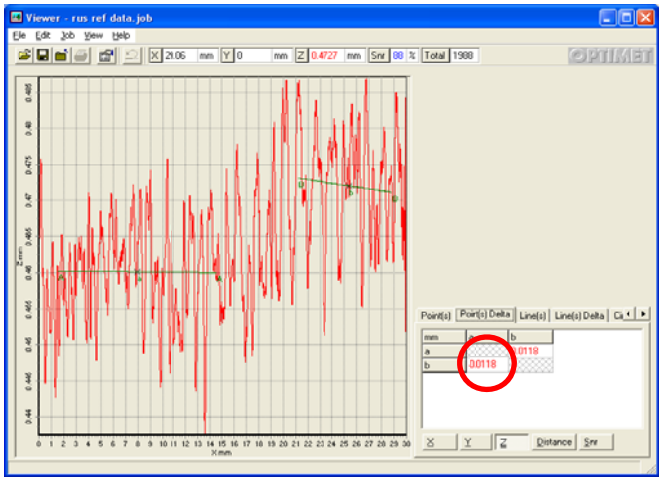


Figure 7 - Reference

- Method: Flat-surface jig half coated with spray and half without (fig.7)
- Results: Coating height is in the 10 µm range (fig. 7)

Thread Measurement – Example from Side 1

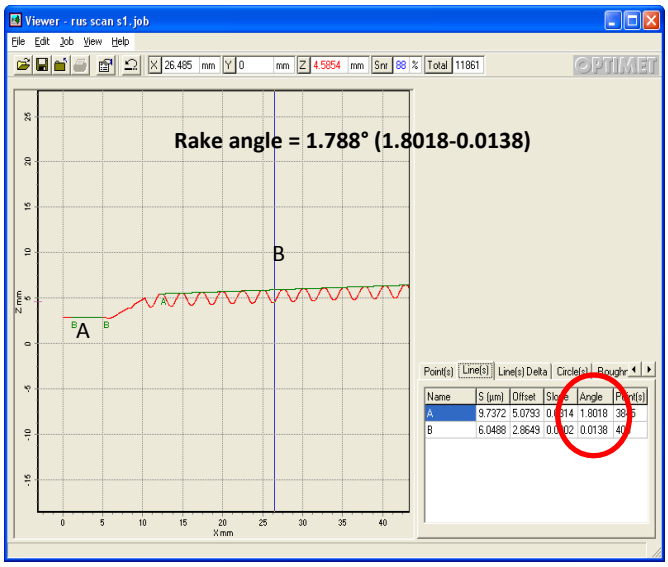
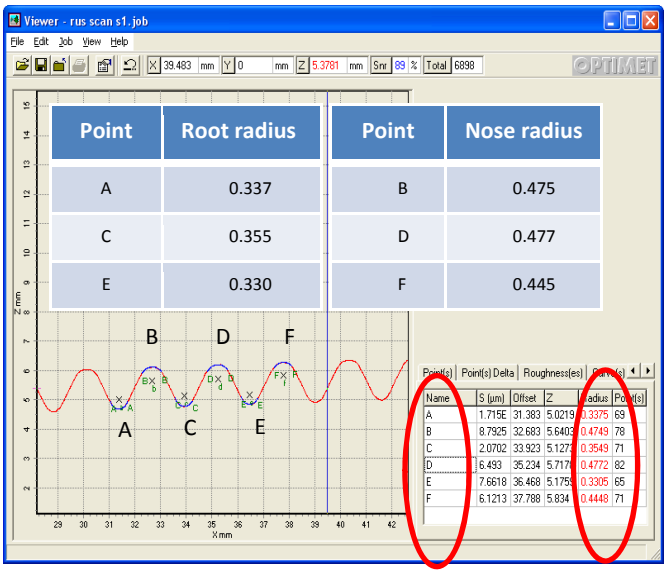


Figure 8 - Rake angle



Point	Root radius	Point	Nose radius
A	0.337	B	0.475
C	0.355	D	0.477
E	0.330	F	0.445

Figure 9 - Nose and Root Radii

Thread Measurement – Pitch and Full Profile Angle – Side 1

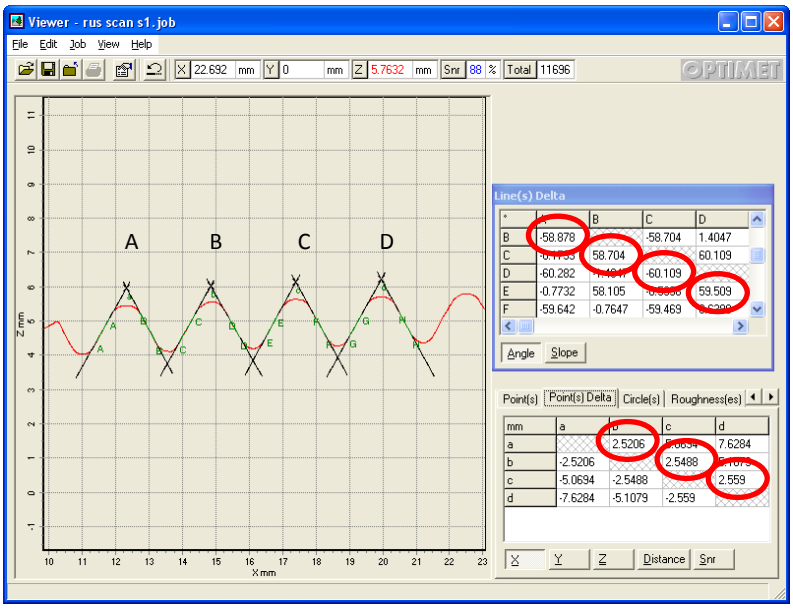


Figure 10 - Thread measurement

Points Delta	Full Angle
A	58.878
B	58.704
C	60.109
D	59.509

Table 1 - Angle measurements

Points Delta	Pitch (μm)
A - B	2.5206
B – C	2.548
C - D	2.559

Table 2 - Pitch measurements

Profile Height – Example Side 1

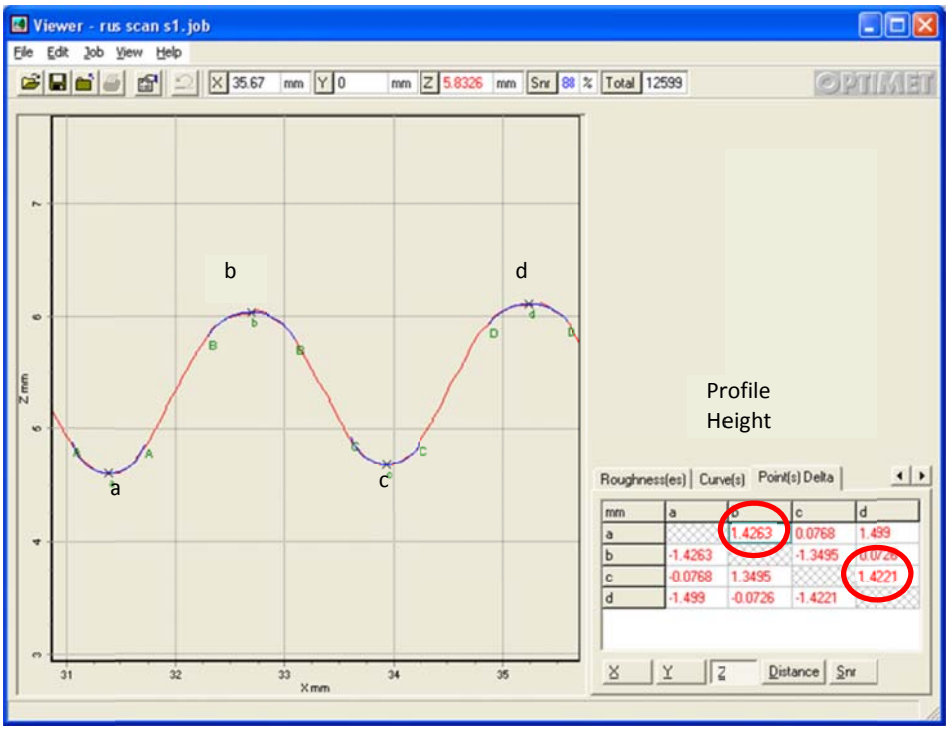


Figure 11 - **Profile height**

Repeatability-Two Scans Overlaid in Detail

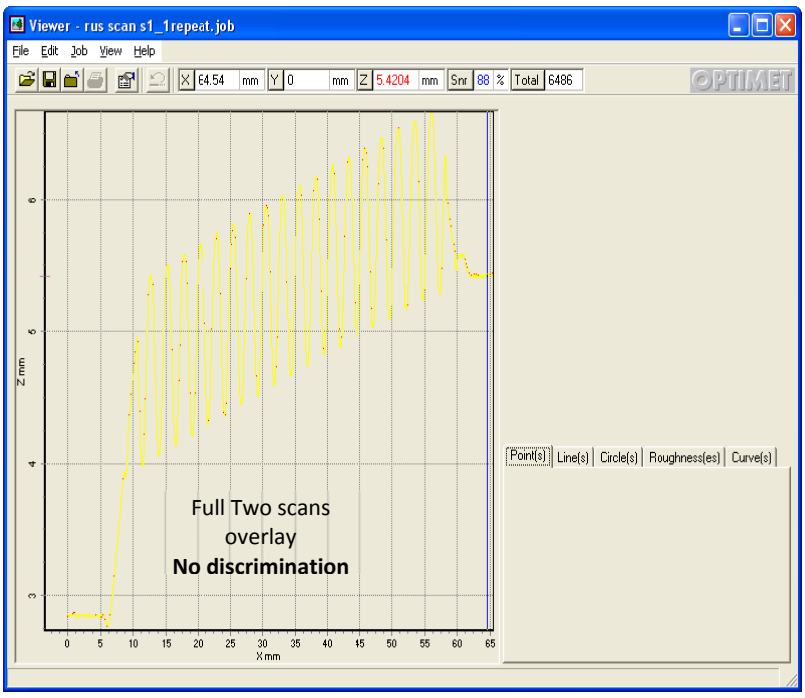


Figure 12 - **Two scans overlay**

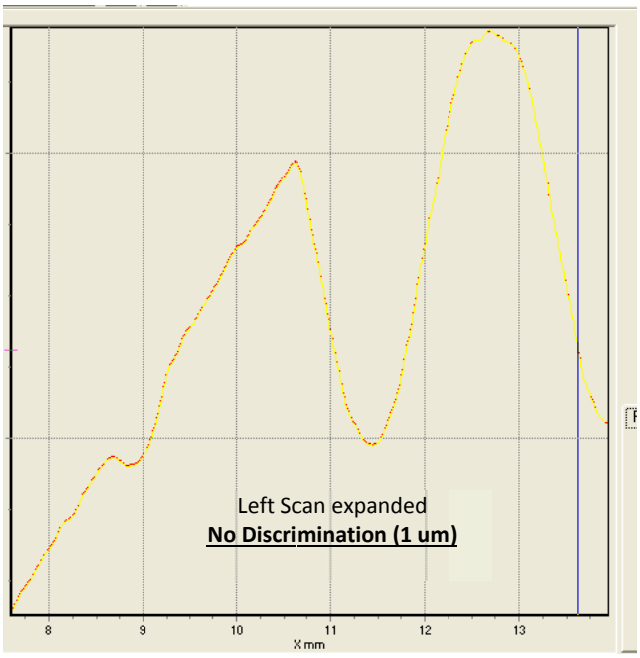


Figure 13 - **Left scan expanded**

Typical Nose Radii with Indentation in Detail

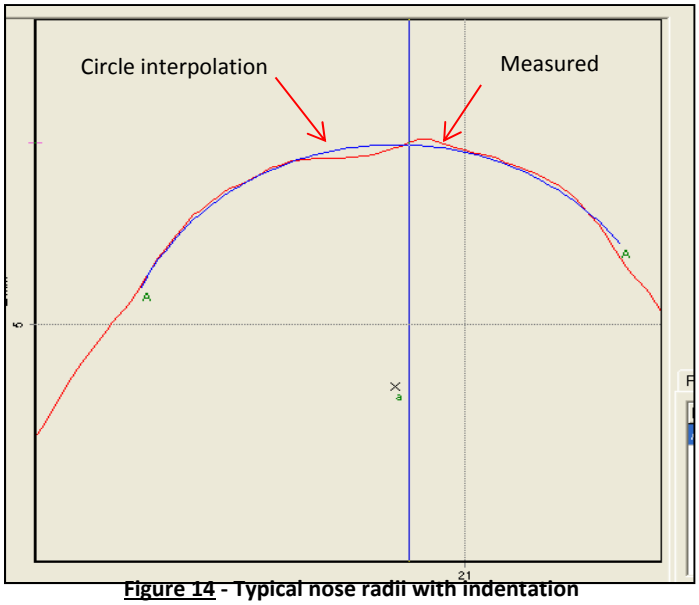


Figure 14 - Typical nose radii with indentation

Measurements Results vs. Nominal Values

Parameter	Value	Unit	Tolerance	Side 1 (average)	Deviation from Nominal	Side 2 (average)	Deviation from Nominal
Thread pitch	2.54	mm	±0.05	2.543	+ 0.003	2.545	+ 0.005
Height h1	1.412	mm	-0.1/+0.05	1.39	- 0.022	1.404	- 0.008
Height angle α/2	30	º	±1	29.484	- 0.516	29.397	- 0.603
Nose radius r	0.432	mm	-0/+0.045	0.465	+ 0.033	0.495	+ 0.063*
Root radius r1	0.356	mm	-0.045/+0	0.340	- 0.015*	0.342	- 0.014*
Rake	1.79**	º	±0.25	1.788	- 0.002	1.688	- 0.102

Table 3 - Measurement results vs. nominal values

* Probably due to profile offset caused by wear and tear on the nose Radii with some addition from the spray

** Equivalent to 1º47'24"

Observations:

- The spray thicknes.s mainly affects (around 10 µm only) the root and nose radii (fig.9) by decreasing the former and increasing the latter. It does not affect the other measured parameters.
- In order to estimate the spray alteration effect from the real values, we can use a reference (calibration) surface (fig.4) placed outside the tube and measured in the same session. The JIG is a simple flat surface half covered with spray and half without. We performed such a test and obtained around a 10 µm increase. This can, of course, be easily compensated for.
- We have found from the measurements (table 3) that the sample received shows wear and tear as exemplified by the nose radii profile (fig.14).

4. Appendix – Scan Spray

- http://www.rocol.com/products/non-destructive-testing-kit - or any talc or AlO3 + alcohol/solvent solution. Easy to clean
- http://www.directindustry.com/prod/oks-spezialschmierstoffe/mold-release-agent-sprays-29279-426351.html - mold release spray, MoS2 based
- Any dental scan spray - easy to clean - from sirona.com, drev.com, etc.
- Solution of alumina powder + isoprophil + water

5. Data:

Parameter	Value
Reflective/Diffusive/Transparent/Translucent	Diffusive
Working Range (mm)	18
Precision (µm)	10
Stand Off (mm)	65
Max. Data Rate (KHz)	9
Lateral Resolution	-
Z Resolution	-
Application Category	-