A Technology & Innovation for Permanent Monitoring in High Temperature Applications

Dr. Aziz U. Rehman, P.Eng., CQE., NRCan/CGSB NDT Level-III, NBIC, API-510
Manager Technological Center Americas

Aziz.Rehman@Applusrtd.com
www.applusrtd.com
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• Permanent Monitoring Tool (Key Features)
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• Owners/Users (shown interest)
• Tool Configuration and A Case Study
The Need for Permanent Monitoring

• Why Monitoring is **Required**?
  
  ▪ Multiphase Piping Systems often experience localized flow-enhanced corrosion/erosion effects, and sometimes these rates are critical in certain locations:
    ○ Fluid drop-out zones,
    ○ Slugging areas,
    ○ Bends and other positions that cause turbulence within pipes.
The Need for Permanent Monitoring

- Why Monitoring is Important?
  - The corrosion/erosion phenomena is a leading cause of $\frac{1}{4}$ of all reported spills, and pipeline failures around the world
  - Estimated 60% of all maintenance costs are related to the corrosion/erosion.
The Need for Permanent Monitoring

What is needed to Accomplish Inspection?

- An inspection system designed to help user
  - In detecting metal losses,
  - by offering a non-intrusive monitoring mechanism,
  - for direct measurement/assessment of localized material loss.
Common Inspection Practices

- Traditionally
  - Monitoring of any material loss process involves manually scanning pipe-works, vessels and pipelines with an ultrasonic probe by an skilled operator
  - Inspector is also responsible for having a suitable UT probe (size, frequency, type, temperature resiliency, etc ...) and coupling medium for a specific inspection
  - For correct corrosion/erosion estimates (metal loss trends) several readings at same point on different time interval are required
Common Inspection Practices

• Traditionally
  ▪ High cost may be incurred due to the necessity of removing insulation, erecting scaffolding, shutting down plants, excavating pipelines and logistics

• What we propose?
  ▪ A surveillance system that can be installed in restricted, critical or costly to access areas and then monitored remotely or with occasional access just to download data
Permanent Monitoring Tool
(Basic Requirements)

• The first phase in the development of a permanent continuous monitoring tool is to determine needs of potential users:

  ✓ The tool should be easy to use, and data collected should be independent of the skills of the operator, i.e. anyone can operate the instrument

  ✓ The tool should provide repeatable measurements, i.e. higher reliability compared to competing techniques, which can be a significant advantage for the concept
Permanent Monitoring Tool
(Basic Requirements)

- Improved measurement reliability is considered more important than accuracy/sensitivity. However, improved accuracy & resolution would be significant plus for the tool.

- Sometimes, sensor positioning is critical for repeatability and reproducibility of data points for periodic comparison and conclusion for calculating metal loss rates and different degradation phenomena.

- Portability is also important.

- The number of sensors used may be critical to the success of inspection since each user will likely to have different configuration and sizes for different inspection locations.
Permanent Monitoring Tool
(Key Features)

• The Key Features for a Permanent Monitoring Tool:
  - Non – Intrusive Inspection
    Sensors are bonded to the inspection area permanently
  - Remote Location Monitoring
    Offshore Platforms (manned or un-manned) remote pipeline sites or inaccessible area (e.g. Power Plants, Refineries, etc...)
  - No recurring Scaffolding/Excavation Costs
    Once correctly installed no need to visit the site
Permanent Monitoring Tool

(Key Features)

- **Early Warning System**
  
  Can be utilized with a customized software to provide trending, warning and alarm information with availability of data on demand or with occasional/periodic access.

- **Operator Safety**
  
  Eliminates the need to send operator into hazardous locations and environment or remote areas to carry out wall thickness measurements.

- **Measurement Accuracy**
  
  Attainable measurement accuracy of ± 50 μm.
Permanent Monitoring Tool

(Key Features)

- Increased Asset Integrity

  The application of monitoring techniques can easily be justified by considering the consequences of the internal wall loss

  - unscheduled shut downs, i.e. loss of production and hence the loss of revenues
  - Loss of Capital Equipment
  - Hard for Personnel
  - Pollution to environment & damage to public image
  - Repair costs & optimization of maintenance schedules
Permanent Monitoring Tool

(Key Features)

- Integrated UT Sensor Solution
Permanent Monitoring Tool
(Key Features)

- Flexible UT Sensor Solution
Permanent Monitoring Tool
(Key Features)

- Operating Temperature Ranges
  - -60 °C to +200 °C
  - -60 °C to +500 °C

- Already tested on ~25 mm diameter pipes for thickness measurements

- Flexible Sensors with multiple size (footprint) possibilities, suitable for any size, shape and curvature and easily customizable for any application
Permanent Monitoring Tool
(Demo. Examples)

Erosion Monitoring at Elbow Section of a Cooling Pipe at a Nuclear Power Facility
Permanent Monitoring Tool
(Demo. Examples)

PZT-c Film on 50µm Polyimide Membrane
Permanent Monitoring Tool (Demo. Examples)

Glued FUT on Steel Pipe

Pipe thickness: 2.5mm
OD: 26.5mm
ID: 21.5mm

Apply 4MHz high-pass filter

f₁: 16.0MHz
BW: 9.1MHz
Permanent Monitoring Tool
(Demo. Examples)

- **Sensor Adoptability**
  - Sensors are customizable to produce any footprint from 3 mm² to any larger size: footprint beyond 25 mm² is possible by firing multiple sensors simultaneously as an array
  - Sensors are flexible & can be mounted to pipe/tubing down to 1” diameter
Owner/Users (shown interest)

- North American Interests
  - Canadian Nuclear Safety Commission (CNSC)
  - SHELL
  - ESSO Imperial
  - Chevron
  - Bruce Powers
  - PEMEX (S. America)
  - British Petroleum (U.S.A.)
Owner/Users (shown interest)

• European Interests
  ▪ SHELL (U.K.)
  ▪ Kronos & Taminco
  ▪ BRC, BASF & Monsanto
  ▪ TOTAL
  ▪ EDF (France)
Tool Configuration & A Case Study

Acid Regeneration Column Replacement Mid Section

Worst Corrosion Area
Tool Configuration & A Case Study

- **Problem Area Data**
  - Column Dia. ~ 1 meter
  - Annular band of 200 mm
  - Total Ares ~ 6250 cm²
Tool Configuration & A Case Study

- **3-Part Solution to the Inspection Problem**
  - Probes (Sensors)
  - Electronics
    - (Tx/Rx System with Multiplexer)
  - Visualization software
Tool Configuration & A Case Study

- Demo Tool is configured by taking into account
  - Customer requirements
  - Electronic Capabilities
  - Visualization Software possibilities & needs

Worst Corrosion Area

Acid Regeneration Column Replacement Mid Section
Tool Configuration & A Case Study

• **Sensor Configuration for Demo Tool**
  - A section is selected and sensors are configured for a coverage area of 55 mm x 280 mm (2 ¼" x 11")
Tool Configuration & A Case Study

**Sensors**

- Graphical Representation
Tool Configuration & A Case Study

• Sensors
  ▪ Actualization
- **Coverage Area**

  55 mm x 280 mm (2 ¼” x 11”)

- **Worst Corrosion Area**

  Acid Regeneration Column Replacement Mid Section
Tool Configuration & A Case Study

- Sensors Components
  - Metal Substrate
  - PZT-Film (actual sensor)
  - Top Electrode
  - Conducting Paste
  - Cable Lead (copper strip)
  - Adhesive Tape
  - Weather Protective Coating
  - Cable from Cable Lead to Electronics Box
Tool Configuration & A Case Study

- **Sensor Performance**

  - Top electrode: 15mm x 15mm
  - Top electrode: 7mm diameter
  - 12 dB stronger

- 6 Connectors
- FFA.00.250.CTA27
- 6 FUT
- 200°C Cable
- 8 Pin Connector (Two Ground)
- 8 Pin Male (Two Ground)
- 8 Pin Female (Two Ground)
- Steel Pipe
  - OD: 100 mm
  - Thickness: 4.5 mm
- 8 Pin Male (Two Ground)
- 8 Pin Female (Two Ground)

- 12 dB stronger
• **Electronic Hardware Specifications**
  - Multi Channel Conventional Ultrasonic Equipment
  - Capable of recording thickness measurements from all channels simultaneously within a pre-defined time-interval
  - Portable electronics in a box (11 x 23 x 32) cm³
  - Includes basic features of a portable flaw detector
  - Flexible to implement extra features on customer request
  - Box application is also customizable for specific requirements & needs
  - Data storage capabilities & Ethernet peripherals
Tool Configuration & A Case Study

- **Electronic Hardware Specifications**
  - 32 Channel Standard Equipment
  - Capability of expanding up to 1000 channels in one box and option to cascade multiple boxes
  - Wireless capability, with several alarming options, e.g. audible, visual for system performance, LOI or Corrosion Danger Zone can be configured
  - Connect and operate from a laptop using available Ethernet port up to a distance of 100 m
  - Spectrum Analyzer and Auto Balancing available
  - Several Filtering and rectification options included
Tool Configuration & A Case Study

**Electronic Software Application**

- Hardware Configuration Application is used to setup electronics and to download measurement data from the unit.

- Following is the list of parameters; controlled and configured using the electronic software application:
  - Transmit and Receive Setup
  - Gate 1 & 2 (start & length) & Gain
  - Data Acquisition Intervals
  - Probe configuration (dimensions & arrangements of sensors)

*All settings can be stored to and loaded from a setting file*
Tool Configuration & A Case Study

• **Visual User Interface**
  - Once the measurement data is downloaded from the Hardware box, an analysis software will be used to visualize the data
Tool Configuration & A Case Study

• In Summary
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Questions?
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Thank You !!!