Development and Validation of an Automated Non-destructive Evaluation Approach for Testing Welded Joints in Plastics Pipes

TestPEP
TestPEP Project

- EC Framework 7
- Research for SME Associations
- Start date: 1 February 2010
- Duration: 3 years
- Total value: €3.5M
Plastics offer significant advantages over metals or concrete for many pipeline applications:
- Longer predicted service life
- Less expensive to install
- Lower leakage rates

However, their use in more safety critical applications, such as in nuclear power stations, is restricted

Reason:
- No accepted NDE techniques for welded joints
- No flaw acceptance criteria
Background

- Two main welding techniques for plastics pipes

Butt fusion

Electrofusion
Previous Work

- Ultrasonic inspection of butt fusion welds in PE pipes

Tandem

Time-of-flight diffraction

Creeping wave
Previous Work

- Ultrasonic inspection of butt fusion welds in PE pipes

TOFD image – deliberate planar flaws

Prototype inspection system
Previous Work

- Ultrasonic inspection of electrofusion welds in PE pipes
Previous Work

- Ultrasonic inspection of electrofusion welds in PE pipes

Lack of pipe penetration

Lack of fusion
Previous Work

- Development of flaw acceptance criteria
  - Minimum size of flaw / level of contamination that reduces the long-term performance of the weld
- Whole pipe & specimen tensile creep rupture tests
Project Objectives

- To develop ultrasonic phased array NDE techniques for the inspection of welded joints in polyethylene pipes up to 1m diameter
- To determine the limits of detection for the above NDE techniques
- To determine critical defect sizes and contamination levels for the above pipe sizes and joint configurations
- To develop defect recognition and automatic defect sentencing software to allow the equipment to provide a pass/fail indication
- To produce a prototype ultrasonic NDE system that can inspect welded joints in pipe sizes from 90-1000mm
- To assess the prototype NDT equipment in the field
Project Partners

- Industry Associations
  - European Federation for Welding, Joining and Cutting
  - Asociacion española de ensayos no destructivos (Spain)
  - Surface Mount and Related Technologies (UK)
  - Pipeline Industry Guild (UK)
  - Associazone Italiana Prove non Distruttive (Italy)

- Manufacturers
  - Vermon (France)
  - Isotest Engineering (Italy)
  - M2M (France)
  - Plasflow (UK)

- End Users
  - E.ON Ruhrgas (Germany)
  - British Energy (UK)

- Research Organisations
  - TWI (UK)
  - Hessel Ingenieurtechnik (Germany)
  - Kaunas Technical University (Lithuania)
  - Consorzio Catania Ricerche (Italy)

- Governmental Regulatory Authorities
  - Health & Safety Executive (UK)
Project Work Plan

Work Package 1
Project Specification

Work Package 2
Manufacture of Welded Joints

Work Package 3
Development of NDE Techniques

Work Package 4
Development of Acceptance Criteria

Work Package 5
Development of NDE Instrument

Work Package 6
Development of Scanning System

Work Package 7
Assembly and Assessment of Complete Prototype System

Work Package 8
Training, Dissemination and Exploitation
WP1 - Project Specification

- Survey of needs of the plastics pipe industry
  - Range of pipe materials, sizes; types of welds, fittings
  - Budget price for inspection equipment or service
- Preparation of the functional specification for complete UT inspection system
  - Drive unit
  - Transducers
  - Manipulator
  - Software
WP2 - Manufacture of Welded Joints

- Development of flaw insertion procedures
  - Planar flaws
  - Particulate contamination
- Manufacture of welded pipe samples
  - In materials, sizes, joint configurations defined in WP1
  - Welds containing deliberate known flaws
  - Control samples containing no deliberate flaws
WP3 - Development of NDE Techniques

- Measurement of basic ultrasonic material properties
- Development of inspection procedures for each geometry specified in WP1
- Inspection of welded samples produced in WP2
- Design and manufacture of probe wedges
- Manufacture of phased array probes
- Development of data analysis algorithms and software
WP4 – Development of Flaw Acceptance Criteria

- Mechanical testing
  - Perform short-term and long-term tests on samples made in WP2
- Determination of flaw acceptance criteria
  - Compare mechanical test results on welds containing deliberate flaws and welds containing no flaws
  - Quantify actual particulate contamination levels using X-ray photoelectron spectroscopy
WP5 – Development of Ultrasonic Instrument and Data Processing

- Miniaturisation of PC board and electronics
  - Reduce size and weight of existing instrument
  - Incorporate high gain, low noise amplifiers
  - Design to International Protection Rating IP67 (dust-tight, immersion in water up to 1m)
- Development of data collection and processing software
  - Including wireless connection to remote computer
WP6 – Development of Scanning System

- Design of modular inspection manipulator
  - Modular system to encompass full range of weld geometries specified in WP1
  - Robust system that can be used in the trench
  - Instrument and probes/wedges mounted on the manipulator
- Manufacture and assembly of scanner system modules
WP7 – Assessment of Complete Prototype Inspection System

- Assembly and testing of prototype inspection system
  - Blind trials in laboratory
  - Determine inspection reliability for each type of flaw/joint
  - Produce finalised inspection procedure
- Validation of prototype inspection system
  - Field trials
WP8 – Training/Dissemination/Exploitation

- Development of training guidelines
  - Trainers
  - Inspection companies
  - End users
- Awareness events
  - Seminars, conferences, workshops, trade shows
- Promotion and exploitation
  - Website, publications, newsletters