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HPZ Piezoelectric Coating (HPC)

1. Scope of the Application Note

Whilst many plant assets can be monitored in situ using existing technologies, such as Ionix HotSense probes, monitoring of complex geometries or of wide areas has significant cost implications. Whilst 0-3 composites have been utilised previously for low temperature monitoring, these materials are unsuitable for use at higher temperatures. HPZ Piezoelectric Coating (HPC) is a high temperature 0-3 piezoelectric composite which can be directly bonded to a variety of metals. The coating conforms to the substrate, allowing the formation of a direct-to-shape ultrasonic transducers. HPC also allows for wide area coverage for a variety of geometries, with a low profile allowing for under insulation installation.

A feasibility study was conducted to determine whether Ionix HiT1 Piezoelectric coating (HPC) could be used for ultrasonic thickness monitoring over a broad temperature range (room temperature to 350 °C).

Highlights:

- Continuous thickness monitoring up to 350 °C
- Low profile monitoring for under insulation installation
- Wide area coverage for low cost, high volume deployment
- Potential for production of “Smart Pipe” – pre-installed ultrasonic transducers along a standard “green field” pipe

2. Methodology

Sections on a 6” P-91 pipe were prepared in three bands with a section at each cardinal point around the pipe. The sections had HPC applied and underwent heat treatment. The HPC sections were ground to 10MHz and poled. A strap was used to attach electrical connections to the HPC sections.

The pipe was cycled between room temperature and 350 °C, with a measurement taken after 1hr dwell at 350 °C and after cooling to room temperature. After 5 cycles, the pipe was maintained at 350 °C and measurements taken after 0, 1 and 16hrs. Measurements consisted of collection of an A-scan using a Sonotest Prisma.

Image 1 – Low profile transducer platform using HPC attached to a pipe section operating at 350 °C

2.1 Transducer Specification

Parameter	Value	Units	Tolerance	Comments
Piezoelectric Specification				
Thickness of Piezoelectric Layer	0.18 – 1	mm	-	Target of 0.350 mm. Minimum of 0.18mm.
Area	0.5 - 10	cm^2	+/- 1	Target 0.78 cm^2
Can send and receive an ultrasonic pulse through the test substrate	TRUE	-	-	SNR of ≥6dB
Device Specification				
Electronics temperature	Ambient	-	-	
Minimum resolution of thickness measurement	0.5	mm	-	Target resolution of 0.1mm.
Test Part Specification				
Material	P11	-	-	
Pipe Diameter	75-150	mm	-	
Pipe Thickness	Schedule 40	-	-	
SHM Testing Specification				
Measurement Type	Thickness	-	-	
Maximum Operating Temperature of Test	350	C	+/- 5	
Minimum time at Maximum Operating Temperature	16	hours	-	
Minimum number of cycles from RT to Test Temperature	5	-	-	

3. Results

Initial room temperature testing of the prototype gave a good agreement between the measured thickness using a Olympus V112 10MHz probe, 6.91 mm, and the composite sections, 6.96 mm – 7.03 mm. Room temperature testing at Doosan Babcock gave similar results, with the measured thickness of the pipe using a standard contact transducer giving 6.84mm and the measurement of the pipe thickness using the composite sections giving 6.7 mm – 6.85 mm, within the desired accuracy from the specification.

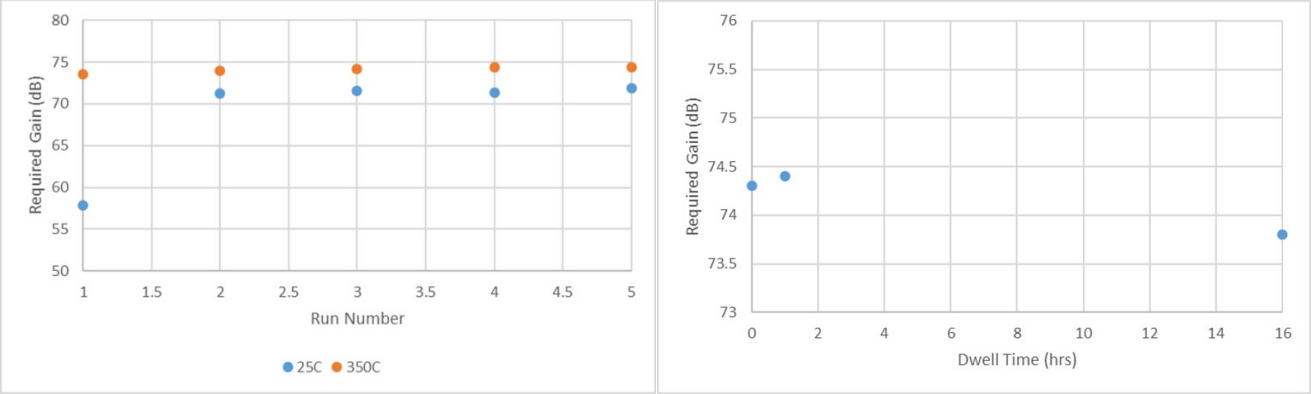

Image 3 – Repeatability of the signal amplitude on cycling between 25°C and 350 °C (left) and upon dwelling at 350 °C from 0 to 16hrs (right)

These transducers exhibit excellent repeatability of the signal amplitude on repeated cycling to 350 °C and stable performance up to 16hrs at 350 °C.

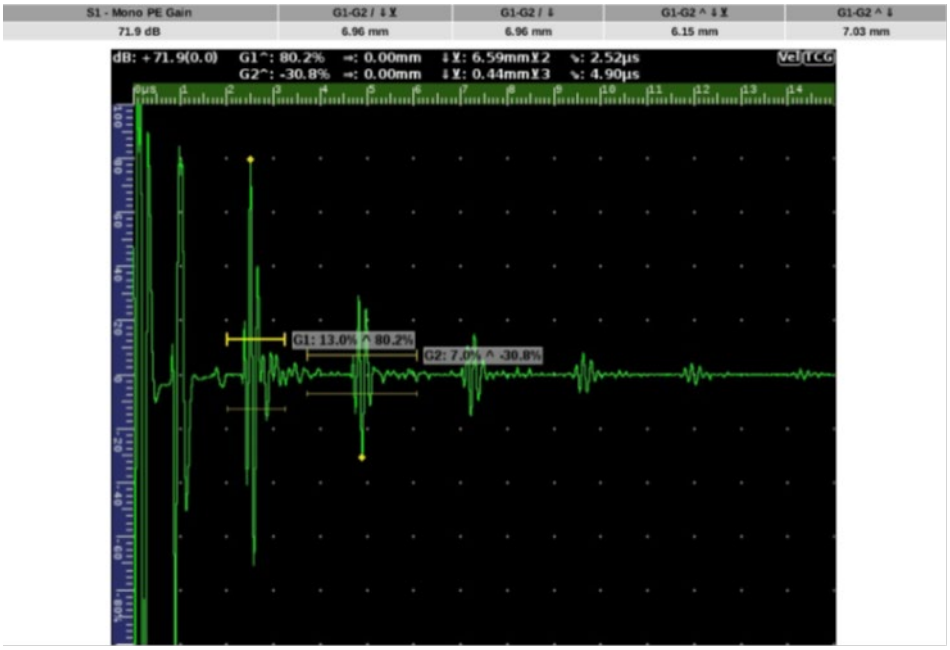

Image 3 – A-scan from a HPC transducer at 350 °C

4. Conclusions

The prototype constructed from 0-3 composite patches was operated successfully at 350 °C for 5 cycles and for 16 hours, conforming to the agreed specification. The prototype demonstrated the potential for a low profile transducer using 0-3 composite technology operating at high temperatures. The processing method for composite application has potential for scale up and could realise the potential for a wide area coverage transducer application. Both the aims of the project and the agreed performance specification were met by the prototype.

The ultrasonic signal that was produced using the direct to shape transducers could be used to make an in service thickness measurement. Key applications would be the deployment of low cost high volume transducers at multiple measurement points along a pipe installed under coatings or for coating and inspection of geometries which cannot easily be measured using standard inspection techniques.

Further development of this technology could focus on improving the operating temperature, scaling up the manufacturing capability, investigating lower temperature processing methods, modification for ATEX environments and 3D printing. Scaling up of the manufacturing capabilities could include collaborating with metal asset producing companies to integrate the transducers into their products.

Materials Application Note	
Completed by	Peter Cowin
Approved for release	