Test and evaluation of a fiber-optic sensor technology for in-situ and in-operando monitoring of heat exchanger tube wall thickness (GFF project number: FTI21-A-005)

FOSMON measures in-situ and in-operando the wall thickness of heat-exchanging stainless-steel tubes in harsh, high-pressure and high-temperature steam environments by applying FFT analysis to their vibration spectrum. The system uses fiber-optic interferometry, where a tightly wound single-mode fiber coil around the tube serves as an intrinsic stress and vibration sensor.

Technical specification:

Parameter	Value	Remarks
Optical Input/Output		
Number of Channels	12 (3 x 4 sensor channels x 3 optical fibers)	one transmitting + two receiving fibers per channel, 36 optical fibers in total
Input/Output Connector	MPO12 x 3	Single mode optical fiber SMF-28a
Type of Laser	DBF single mode optically isolated	Senset OLD-32122PFAB
Output Power	10 μW	Per coil (total 240 μW)
Wavelength	1311 nm	@ 25°C
Signal Processing		
Main CPU (SP-12CH)	ARM 64-bit	Amlogic S905X3 (4-core Cortex-A55)
MCU (OE-4CH)	32-bit MIPS MCU	Microchip PIC32MX795F512L
A/D Resolution	16 bit	AD7761BSTZ Analog Devices
A/D Sampling rate	max 32 kSamples/s	per channel, simultaneous sampling
Programming	Firmware written in Pyton,	Under OS Ubuntu 20.04 on eMMC 64GB module
Setting parameters	Manually, via textual configuration file	WM.INI in /WALLMON2023
Sensitivity	20.4 μm/Hz	Shifting of axial natural frequency, third mode
Data Outputs		
Spectrogram files	USB on the front panel; NoMachine; FTP; SSH via ETH LAN	One data set per day per sensor
Original photodiode signals		
Communication		
Interfaces	USB 3.0	host port, export on flash memory; to attach keyboard & mouse
	Fast Ethernet 10/100 Mb/s	RJ45 WAN, VPN Teltonika
	TEC 4-wire	Peltier 7A and thermistor 10kΩ
Power		
Input Voltage	230 V / 50 Hz	Only SP-12CH externally powered
Power Consumption	< 1 A	

FOSMON overview:

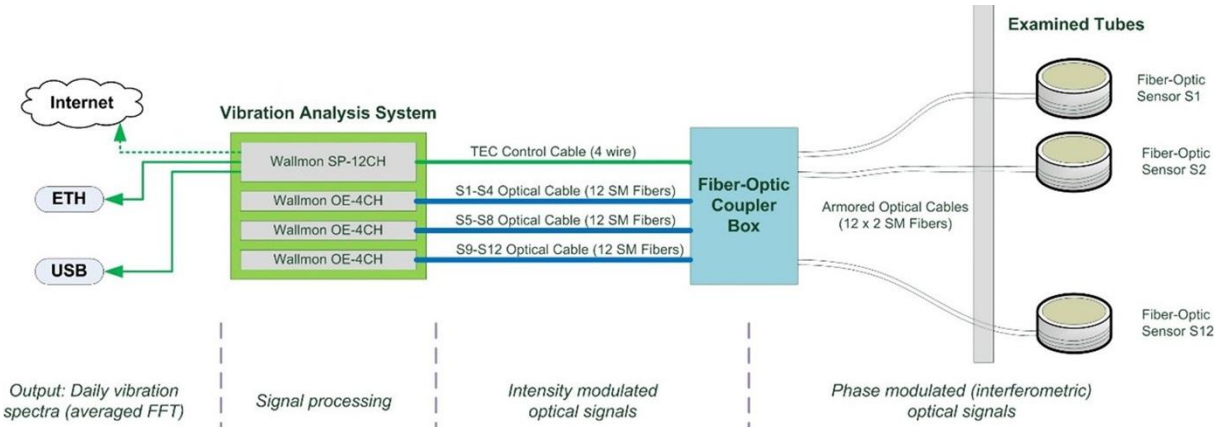

Figure 1: The vibration measuring system consisted of the FOSMON optoelectronic set, the fiber-optic coupler box, 12 fiber-optic sensing heads and connecting cables.

a) *b)*

Figure 2: a) FOSMON optoelectronic unit (OEU); b) encapsulated fiber-optic sensor for wall-thickness measurement

The monitoring display of actual wall-thickness:

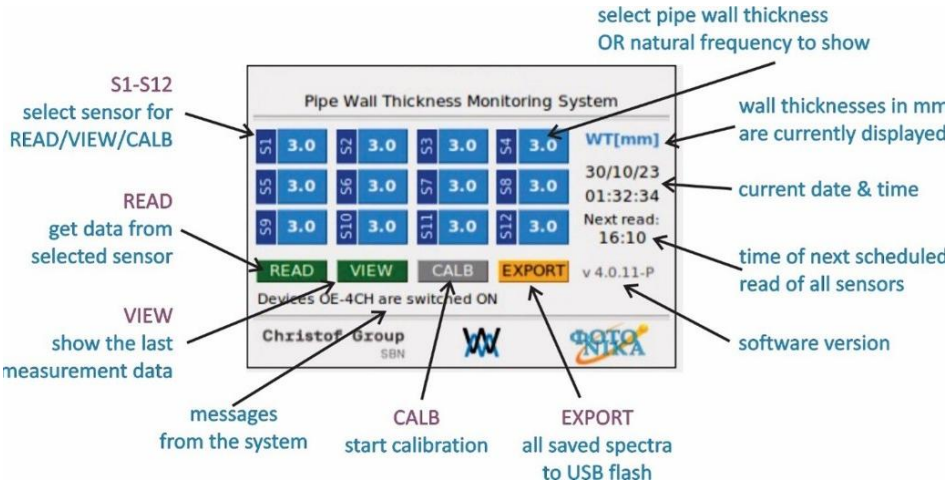

Figure 3: The monitoring and controlling display on the front panel of sensing system SP-12CH.

References:

- Z. Djinović, A. Gavrilović-Wohlmuther, M. Tomić, A fiber-optic technique for the wall thickness measurement of the industrial tubes under harsh environment, 47th MIPRO ICT and Electronics Convention (MIPRO), Opatija, Cratia, 20-24 May 2024, DOI: 10.1109/MIPRO60963.2024.1056927
- M.Tomić, A. Gavrilović-Wohlmuther, Z.Djinović, Measurement of Wall Thickness in Heat Exchanger Tubes by Simultaneous Use of Low- and Highcoherence Fiber-Optic Interferometry, 48th MIPRO ICT and Electronics Convention (MIPRO), 02-06 June 2025, DOI: 10.1109/MIPRO65660.2025.11131780
- EP000004310434B1 HEAT EXCHANGER WITH FIBRE OPTIC SENSOR FOR DETERMINING A THICKNESS OF A HEAT EXCHANGER TUBE OF THE HEAT EXCHANGER AND METHOD FOR OPERATING SUCH A HEAT EXCHANGER
- WO002024017511A1 HEAT EXCHANGER COMPRISING A FIBRE-OPTIC SENSOR FOR DETERMINING A TUBE WALL THICKNESS OF A HEAT-TRANSFER TUBE OF THE HEAT EXCHANGER AND METHOD FOR OPERATING SUCH A HEAT EXCHANGER
- ASHMOSD-I, Austrian Structural Health Monitoring System Demonstrator; FFG-BMVIT, Takeoff Program, Project No: 814579
- ASHMOSD-II, Austrian Structural Health Monitoring System Demonstrator; FFG-BMVIT, Takeoff Program, Project No: 830397, Follow up

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