In-Service Monitoring of Steam Pipe Systems at High Temperatures

This system can be used by utility companies for steam pipe systems incorporating multiple manholes.

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An effective, in-service health monitoring system is needed to track water condensation in real time through the walls of steam pipes. The system is required to measure the height of the condensed water from outside the pipe, while operating at temperatures that are as high as 250 °C. The system needs to account for the effects of water flow and cavitation. In addition, it is desired that the system does not require perforating the pipes and thereby reducing the structural integrity.

Generally, steam pipes are used as part of the district heating system carrying steam from central power stations under the streets to heat, cool, or supply power to high-rise buildings and businesses. This system uses ultrasonic waves in pulse-echo and acquires reflected signal data. Via autocorrelation, it determines the water height while eliminating the effect of noise and multiple reflections from the wall of the pipe.

The system performs nondestructive monitoring through the walls of steam pipes, and automatically measures the height of condensed water while operating at the high-temperature conditions of 250 °C. For this purpose, the ultrasonic pulse-echo method is used where the time-of-flight of the wave reflections inside the water are measured, and it is multiplied by the wave velocity to determine the height. The pulse-echo test consists of emitting ultrasonic wave pulses from a piezoelectric transducer and receiving the reflections from the top and bottom of the condensed water. A single transducer is used as a transmitter as well as the receiver of the ultrasonic waves. To obtain high resolution, a broadband transducer is used and the frequency can be in the range of 2.25 to 10 MHz, providing sharp pulses in the time domain allowing for higher resolution in identifying the individual reflections.

The pulse-echo transducer is connected to both the transmitter (function generator), which sends electric signals to generate the elastic wave, and the receiver, which amplifies the attenuated reflected waves that are converted to electric signals. To avoid damage to the receiver, the large signal from the generator is blocked by an electronic switching mechanism from reaching the receiving circuitry. To assure the operation of the transducer at the required temperature range, the piezoelectric transmitter/receiver is selected with a Curie temperature that is much higher. In addition, the system can be improved by introducing a heat sink between the transducer and the steam pipe, reducing the temperature requirements on the transducer.

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In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to: Innovative Technology Assets Management JPL.

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