A Cost Effective Bubble Detection Method for Superheated Liquid Neutron Sensor

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ABSTRACT
The bubbled are generated in the superheated liquid neutron sensor when it exposed to the neutron dose. Acoustic signal is generated during the bubble formation. The acoustic signal is sensed by the piezo-electric transducer. The number of bubble can be correlated with incidence neutron dose. The paper presents a new bubble detection method for superheated liquid neutron sensor (SLNS) using low cost condenser microphone. The piezoelectric transducer used in earlier instrumentation for SLNS is replaced with low cost condenser microphone. The microphone has more sensitivity as compared with piezo-electric transducer for bubble detection. The paper also highlights the comparison of the response of the peizo-electric transducer with the condenser micro-phone and results are presented.

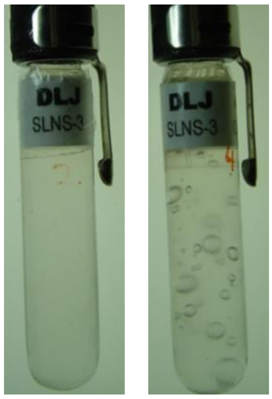
Keywords*:* Superheated liquid neutron sensor, piezo electric transducer and microphone, acoustic signal

1. INTRODUCTION
A Superheated Drop Detector (SDD) [1] is a homogenous suspension of super heated freon droplets inside a viscous elastic gel, which may undergo transitions to the gas phase upon energy deposition by incident radiation. Each droplet behaves as a micrometric bubble chamber. SDD have been widely used in neutron dosimetry [2-3] and spectrometry [4, 5, 6, 8]. They have shown to comply with ICRP 60 recommendation of measurement, real time response, low minimum detection threshold and most importantly, a nearly similar dose equivalent response.

Superheated liquid neutron sensor (SLNS) and micro-controller based acoustic instrumentations using Piezo-electric transducer have been reported by several authors [1, 2, 9]. The acoustic sensing unit designed by Apfel consists of piezo electric transducer, an amplifier, a high pass filter, differentiator, comparator and monostable multivibrator. The Improvised version of such dosimeter i.e. REMbrandt (trade mark of Apfel Enterprises Inc. Haven CT, USA) builds upon the recent hardware/software platform. The instrument uses double piezoelectric transducer configuration for a comparative pulse shape analysis of the signals from detector and noise channels. These signals are amplified and fed to analogue circuitry for amplification, rectification and low pass filtering, followed by analog to digital conversation and sampling. The microprocessor evaluates shape and amplitude of the signals, and if these meet the acceptance criteria of a real bubble formation event, a pulse is counted. Thus, vaporization bubble events are distinguished from spurious noise, both by anticoincidence and by pulse shape analysis [1, 2].

The acoustic detection technique has also been applied to bubble damage type detector produced by Chalk River Bubble Technology Industries, Canada. The acoustic detection system consists of preamplifier, conditioning amplifier, discriminator circuit and counter. A novel detection system RAISA based on bubble detector system has also been developed to meet the needs for radiation monitoring for long term space mission. The instrument has two bubble detectors, but at any time, only one of the detectors is used as the radiation sensor. When a maximum number of bubbles have accumulated in this detector, a microprocessor turns on the second detector and recompresses the first detector. By switching back and forth, the system can operate continuously.

Fig. 1 shows the superheated liquid neutron (SLNS) developed at Defense Laboratory, Jodhpur.



Unexposed exposed

Fig1. Superheated liquid neutron sensor

The Defence Laboratory, Jodhpur is actively engaged to establish this technology since beginning [7,9].

The bubble forms when nuclear radiation interacts with the superheated liquid droplets suspended in polymer matrix. During the bubble formation, an acoustic signal is generated. The acoustic signal is sensed by the piezoelectric transducer, and converted in to the electrical pulse. The pulse is processed and applied for further computation. The used transducer i.e. piezo-electric transducer is imported item and costly affair. The authors have studied the possibilities of replacement of piezo-electric transducer with easily available and cost effective condenser micro-phone using of digital techniques.

The number of bubbles formed by the nuclear radiation gives the information about the intensity of the radiation dose. Hence, it is important to find the characteristics of the bubbles such as rate of bubble formation, size of bubbles and number of bubbles formed by a certain amount of radiation dose. One of the methods currently used is to study the acoustics of the bubble formation process. It is realized that acoustic technique using commercially available Piezo-electric transducers limits the practical utility for its commercial exploitation specifically considering the cost factors. Efforts have been made in this paper to replace piezoelectric transducer with low cost microphone.

2. EXPERIMENTAL SET-UP

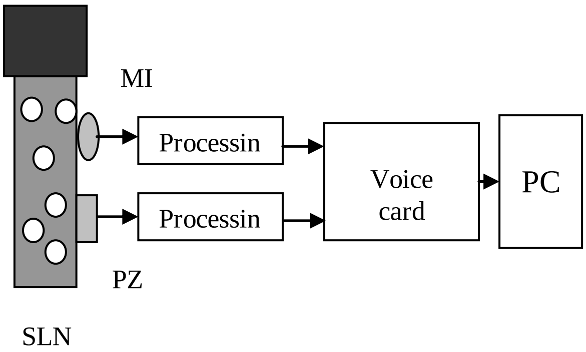


Fig.2 Experimental set-up for bubble detection

Fig3 shows the experimental set up bubble detection. Microphone (MIC) and piezo-electric transducer (PZT) is attached with superheated liquid neutron sensor. Out put signal of the both PZT and MIC are applied to the signal processing unit to improve the signal to noise ratio and eliminate the unwanted noise. The out put of the signal processing unit is applied to the inbuilt voice card of the PC. Multi Instrument (MI) software is used for data acquisition. It used as storage CRO. Experimentation was carried out for response study of MIC and PZT for bubble signal. The data were stored for 1 mR neutron dose. The acoustic activity captured by the PZT and MIC were stored on computer as a voltage vs. time signal using MI software.

3. RESULT & DISCUSSION

The experiments for bubble detection in superheated liquid neutron sensor were carried out using AM-Be neutron source. All the experiments were carried out taking the set up 1.5 meter above the ground to avoid the scattering of the neutrons. Response of the PZT and MIC for fixed neutron dose is shown in the fig.3. It indicates that MIC has registered more events than PZT. Response of the PZT and MIC for one bubble event is shown in fig.4. It indicates that amplitude of the out put of the MIC is larger than PZT output amplitude

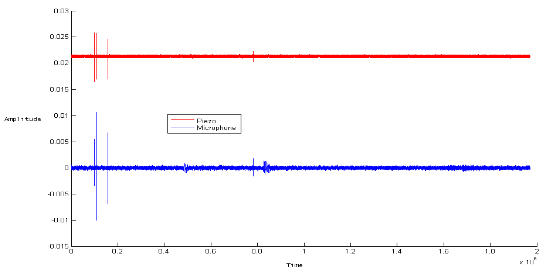


Fig.3 Response of PZT and MIC for fixed neutron dose

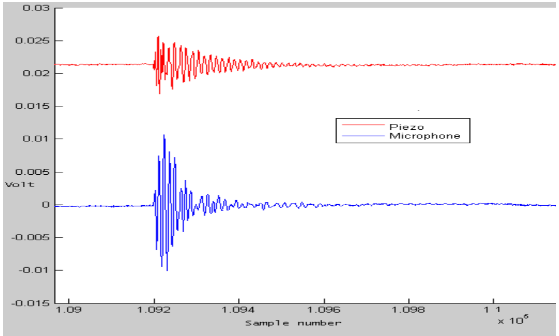


Fig.4 Response of PZT and MIC for one bubble event

4. CONCLUSION

The MIC has the higher sensitivity than PZT. MIC is easily available and cheaper in cost. PZT can be replaced by the MIC. MIC has one limitation that it is more sensitive to ambient acoustic noise.

Development of algorithm for environment noise elimination is under progress. The developed technique for bubble detection will be used in portable instrumentation based on this detector.

5. ACKNOWLEDGEMENT

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