Clamp-on Ultrasonic Guided Wave Flow Measurement in Thin-walled Pipes

With climate change on the rise, water security is becoming ever more important. Billions of litres of water are leaked from the network every single day in England. [1,2] Consequently, water supply companies have been set leak reduction targets by the government. Since the condition of England's water pipe network is not well understood, additional capacity for detecting leaks is required. [2,3] Smart water metering provides ability to detect leaks and inform people and businesses about their water usage patterns, allowing them to reduce wastage. However, current technology requires cutting into existing pipelines which is expensive and slow, inhibiting the rollout on a large scale.

Clamp-on ultrasonic flow measurement is valuable in this circumstance as it is non-invasive, so the pipeline can remain in-tact which reduces installation time and costs. However, existing technology does not work effectively on small, thin-walled pipes such as those used in domestic water supplies due to the formation of guided waves in the pipe wall. Using novel sensors developed at the University of Warwick [4], clamp-on flow measurement has been achieved on the 15 mm copper pipes that are ubiquitous in water supply plumbing. [5] The complexity that is introduced when guided waves are formed in the pipe wall is best illustrated by looking at the received signal, an example is shown in figure 1.

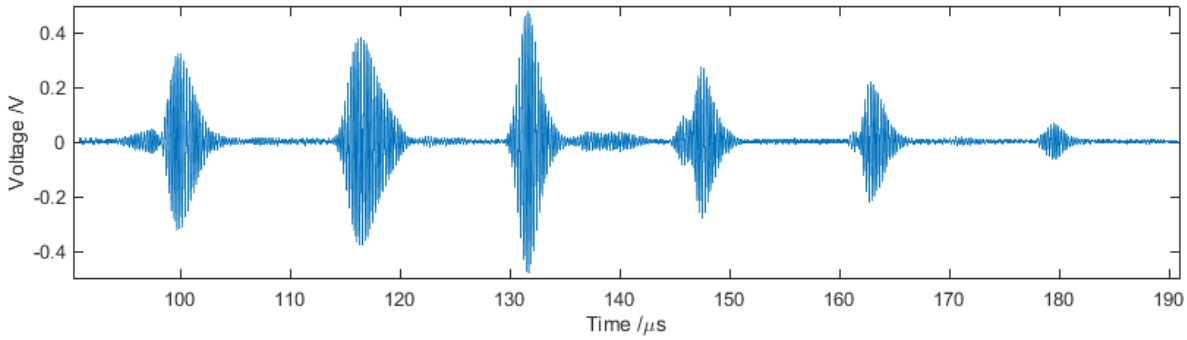

Figure 1: Example received signal from a clamp-on ultrasonic meter on a thin-walled pipe.

A single five cycle burst at the transmitting transducer produces six much longer arrivals at the receiver. Via modelling and experiment, an understanding of wave propagation in the system has been developed which allows transit time difference flow measurement to be made using all six of these arrivals.

Currently, research is being conducted to refine the design of the transducers, account for temperature changes in the water, and determine which coupling mechanisms work best for long term installation of the sensors. The electronics for making measurements and performing the flow rate calculation are being miniaturised into a low-cost, low-power microprocessor based unit. Future work will include utilising machine learning to analyse water usage patterns, enabling the automatic identification of leaks and producing more intuitive information to be sent to the consumer about their usage.

[1] Great Britain. DEFRA., (2008). *Water Strategy for England – Future Water.* London – Department for Environment, Food and Rural Affairs.
[2] Great Britain. National Infrastructure Commission., (2018). *Preparing for a Drier Future – England's Water Infrastructure Needs.* London – National Infrastructure Commission.
[3] Bakker, K. (2001). Paying for water: water pricing and equity in England and Wales. *Transactions of the Institute of British Geographers.* **26**(2), 143-164.
[4] Li, Zhichao, Smith, Luke D. and Dixon, Steve M. (2021) Design of miniature clamp-on ultrasonic flow measurement transducers. IEEE Sensors Letters, **5**(6).
[5] Steve Dixon, 2021. Clamp-on measurements of fluid flow in small diameter metal pipes using ultrasonic guided waves. Available at: https://dx.doi.org/10.21227/5fr9-6x03.