Ultrasound

Part I: Ultrasonic Flowmeter

Introduction

Information about the flow velocity of a fluid can be obtained by ultrasonic means. There are two different ultrasonic methods that can be used, depending on whether the fluid is “clean” or “dirty”. For a “dirty” fluid – one containing many solid particles or many air bubbles – the Doppler effect can be used. Sound waves are bounced off the solid particles, and the shift in sound frequency gives information on the speed and direction the particle is moving. It is then assumed that the fluid is moving in the same speed and direction.

For a clean fluid – like the tap water you will use today – the Doppler method will not work, since there is nothing in the fluid to reflect the sound wave. Instead, a time-of-transit method is used. For a fluid at rest, inside a pipe of known diameter and material, the time a sound wave takes to go between two ultrasonic transducers is a property of the fluid and pipe materials. If the fluid is moving, this transit time will be shortened. By measuring the transit time and comparing it to what it is for the fluid at rest, the velocity of the fluid can be calculated.

Objective

- To use an ultrasonic flow meter to measure water velocity and flow rate in a simple pipe system.
- To see how the measured flow rate varies as you open and close the faucet valve.

Pre-Lab Preparation

- The transducers have been attached (magnetically) to the cast iron pipe section in the proper locations. If they are moved, you may have to reapply the coupling gel.
- The handheld transducer reader has been set up the needed parameters (fluid type, pipe diameter, pipe wall thickness, etc.). If you need to adjust them, press the menu key – you should not need to adjust them.
- You may want to get some paper towels ahead of time.
- DO NOT attach the plastic tube from the faucet to the pipe barbed fitting initially. (You need to do some valve testing, and the tube may pop loose if attached.)

Lab Procedure

- With the faucet tube UNATTACHED to the pipe system, examine the valve at the end of the pipe system. Turn the valve so that you have some idea of how far to turn the valve so that it is ¼, ½, ¾, and fully open.

- Again with the faucet tube UNATTACHED, examine the faucet. Again, turn the faucet so that you have some idea of how far to turn the faucet so that it is ¼, ½, ¾, and fully open.
- NOW, turn off all the water and attach the tube to the barbed fitting.
- You will now take 16 measurements of the flow velocity, for different combinations of pipe valve/faucet openness. When you set the pipe valve and faucet to a given combination, wait a little while before recording the velocity, since some transient behavior has to pass (and is not of interest in this lab.) Feel free to record your velocities below.

faucet

pipe valve	1/4 open	1/2 open	3/4 open	Full open
1/4 open				
1/2 open				
3/4 open				
Full open				

Lab Report

You should submit a lab report. Your lab report should include the following information:

- Measured velocities of flow for the different combinations of faucet valve and pipe valve openness.
- A discussion of why your velocities flowing the pattern shown.

Part II: Ultrasonic Flawmeter

Introduction

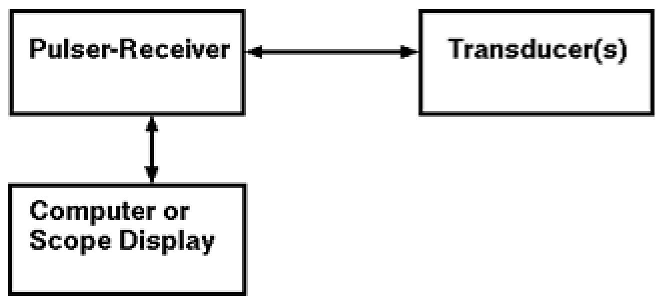
Information about material properties can be obtained by destructive tests. The disadvantage of destructive test is the loss of the sample after each testing. Either one has the sample or one has the information of the sample but not both. The goal of nondestructive identification of material properties is to circumvent this disadvantage and provide information regarding material properties while saving the sample. Identification of material properties can be done in a lot of different manners. However, it turns out that ultrasonics is a powerful tool to identify e.g Young's modulus of a material because of the direct relation between the wave velocity and the Young's modulus.

Objective

- To use a pulser-receiver and a transducer to generate ultrasonic waves.
- To use sensors to measure ultrasonic waves.
- To process data on a PC and identify material properties.

Theory

What is a pulser-receiver?
Ultrasonic pulser-receivers are well suited to general purpose ultrasonic testing. Along with appropriate transducers and an oscilloscope they can be used for flaw detection and thickness gauging in a wide variety of metals, plastics, ceramics, and composites.



The pulser section of the instrument generates short, large amplitude electric pulses of controlled energy, which are converted into short ultrasonic pulses when applied to an ultrasonic transducer. Most pulser sections have very low impedance outputs to better drive transducers. Control function associated with the pulser circuit include

- Pulse length or damping (The amount of time the pulse is applied to the transducer.)
- Pulse energy (The voltage applied to the transducer. Typical pulser circuits will apply from 100 volts to 800 volts to a transducer.)

In the receiver section the voltage signals produced by the transducer, which represents the received ultrasonic pulses, are amplified. The amplified radio frequency (RF) signal is available as output for display or capture for signal processing. Control functions associated with the receiver circuit include

- Signal rectification (The RF signal can be viewed as positive half wave, negative half wave or full wave.)
- Filtering to shape and smooth return signals
- Gain, or signal amplification

Pre-Lab Preparation

- Read the section ‘Wave propagation in elastic solids’ which is posted on cenotes.

- Find a reference with material properties (density, Young’s modulus) of concrete, cement samples and aluminum.
- What’s the difference between harmonic excitation using a function generator and a high voltage amplifier and pulse excitation using a pulser receiver?

Workstation Details

Your workstation should have the following items:

- A computer with Wavestar and Excel software
- Digital Phosphor Oscilloscope connected to PC via RS232
- Pulser-receiver
- Two ultrasonic transducers
- Couplant
- Samples (concrete, cement, aluminum rod)

Lab Procedure

Measure the thickness/length of the samples using a caliper/measuring stick. Connect both transducers with the pulser-receiver using BNC cables. Attach the transducers to the specimen using couplant and acquire the data using the oscilloscope. By identifying the propagation time of the longitudinal wave, it is possible to calculate the longitudinal wave velocity (using the thicknes/length measurement). Repeat the measurements at least 10 times for each specimen.

Lab Report

You should submit a lab report. Your lab report should include the following information:

- Image of the measured signals
- Determine the wave propagation time
- Determine the wave propagation velocity
- Determine the material properties
- Provide a statistical analysis of the results
- Compare the material properties with the material properties you found in the literature
- Discuss the results