HYDRAULIC TRANSIENTS LAB

PURPOSE: The main purpose is to measure the wave speed for a water pipe and to compare the measured speed with theoretical speeds. Another purpose is to measure the pressure rise generated by a sudden valve closure and to compare this rise with a theoretical pressure rise.

PROCEDURE: The setup consists of a pump which draws water through one long pipe from a tank and sends it back to the same tank through another long pipe. A valve is installed just upstream of the pump inlet. A high speed pressure sensor is installed just upstream of the valve. It is used to measure the pressure transients that are generated by a sudden valve closure. The sensor is connected to an oscilloscope. A printer connected to the oscilloscope gives a record of the transients.

REPORT: Use a sudden valve closure to determine the pipe period. Use the period to calculate the wave speed of the pipe. Compare the measured wave speed with the speed for a rigid pipe and the speed for a flexible pipe. Calculate the pressure rise for a number of flow rates and in each case compare with the theoretical pressure rise.

SUDDEN VALVE CLOSURE

Consider a pipe with a valve at its downstream end and a reservoir at its upstream end. When the valve is suddenly closed, a high pressure wave propagates up the pipe. As it does so it, it brings the fluid to rest. When the wave reaches the reservoir, there is a pressure imbalance. This causes a back flow which propagates as a wave down the pipe. As this wave moves down the pipe, the pressure is restored to its original level. When the wave reaches the valve, there is flow imbalance. This causes a low pressure wave to propagate up the pipe. As it does so, it brings the fluid to rest. When the wave reaches the reservoir, there is a pressure imbalance. This causes an inflow which propagates as a wave down the pipe. As the wave moves down the pipe, the pressure is restored to its original level. When the wave reaches the valve, conditions in the pipe are the same as they were at the instant the valve was closed. So, one cycle of vibration requires 4 transits of the pipe by pressure waves. This means that the natural period of the pipe is 4 times the length of the pipe divided by the wave speed: $T = 4L/a$. Measuring T allows one to find the wave speed of the pipe: $a = 4L/T$.

WAVE SPEED

For a wave travelling up a rigid pipe wave speed is

$$a = \sqrt{[K/\rho]}$$

where K is the bulk modulus of the fluid and ρ is its density. For a flexible pipe wave speed is

$$a = \sqrt{[\mathbf{K}/\rho]}$$

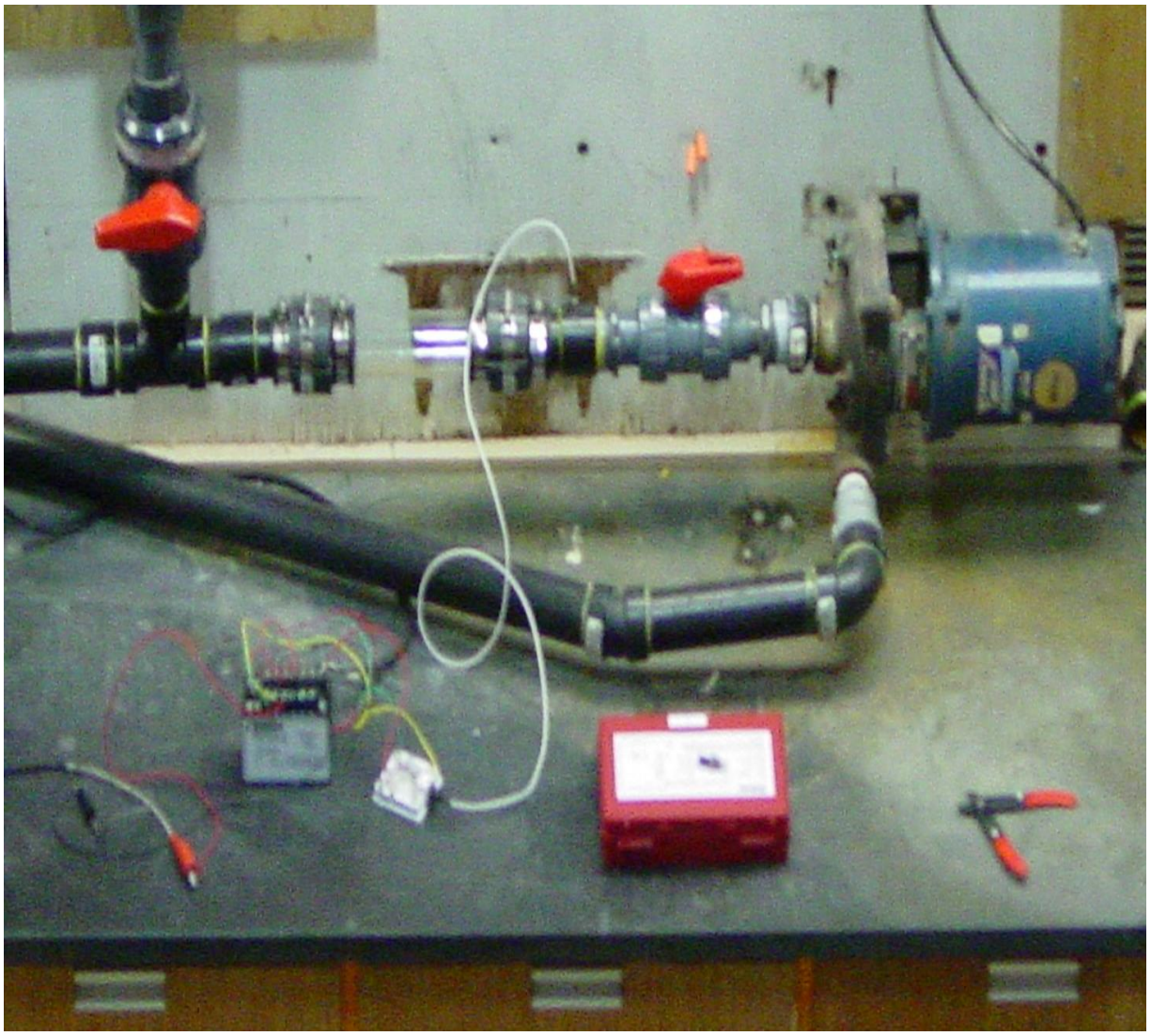
where **K** is the effective bulk modulus of the pipe

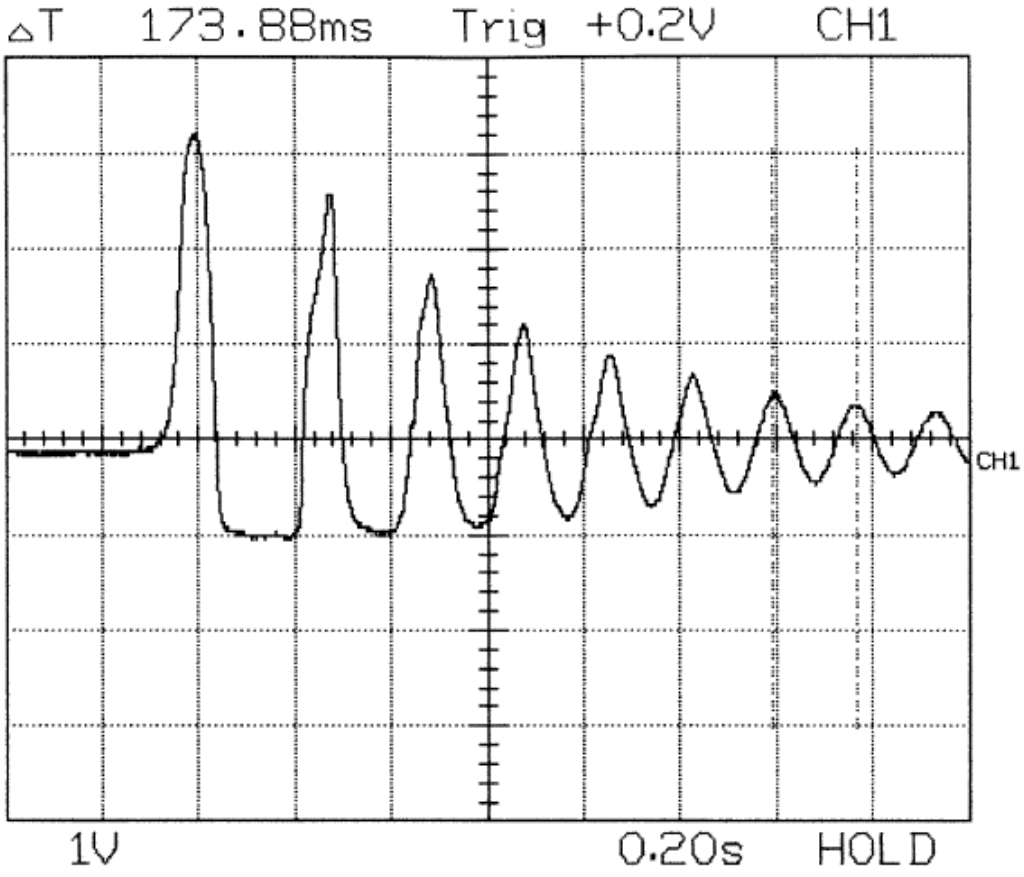
$$\mathbf{K} = K / [1 + DK/Ee]$$

where D is its diameter, e is its wall thickness and E is the Elastic Modulus of the pipe wall material.

The pressure change caused by a flow speed change is

$$\Delta P = - \rho a \Delta S$$

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