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Memorandum

Denver, Colorado

TO : Head, Hydraulics Research Section

DATE: June 13, 1975

JAS 6/16/75

FROM : R. A. Dodge

SUBJECT: Vortex shedding flowmeters

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Purpose

This survey was made to determine whether vortex shedding flowmeters should be studied in the laboratory.

Conclusions

Based on information provided by two companies the following were concluded:

1. The possibility of applying vortex shedding for measuring flow has been known for 58 years but has been slow in developing.

2. A flowmeter using vortex shedding is readily adaptable to digital counting-type electronics.

3. Data supplied by one company indicate a potential accuracy of about ± 1 percent.

4. Head loss is similar to that of orifice meters having a beta ratio of 0.7, or about 4.3 approach velocity heads.

5. One company claims a 1:100 range of discharge measurement. However, this large range is at the expense of large head losses.

Recommendations

Because of the head loss characteristics for high velocities and limited use of orifice-type meters in Bureau measurement structures, no laboratory tests are recommended until there is positive evidence of need for further information beyond that supplied by manufacturers.

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Survey Procedure and Sources of Information

Early in this study NTIS and SSIE searches were made to guide further action. Neither of these searches produced information related to use of vortex shedding flowmeters. Thus, the only materials available

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for information in this memorandum were provided by two manufacturers. Eastech, Incorporated, provided two papers 1/, 2/. Fischer Porter Company provided some catalog-type information.

Principle of Meter Operation

The vortex generating flowmeter is based on the principle that obstructions placed in flows generate vortex trails at frequencies that are uniquely related to the obstruction shape and flow velocity. The frequency of shedding has been generalized by Strouhal and Reynolds numbers.

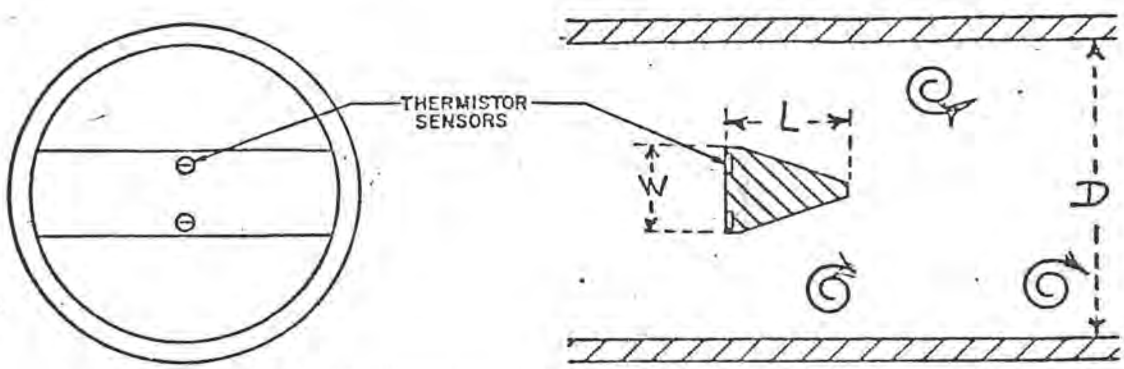
$$S = \emptyset(N_R)$$

The Strouhal number is defined as $(\frac{fD}{v})$ where (f) is frequency, (D) is a length, and (v) is velocity. The frequency at which the vortices are shed can be sensed and counted in developing a flowmeter. Although the shedding frequency is well known for cylinders, the cylindrical shape does not produce a linear velocity-frequency relationship for a wide range of flow. One of the investigators in 1/ claims to have developed a shape, illustrated in the figure, that produces a constant Strouhal number over a large range of Reynolds numbers or flow range and

$$S = \frac{fD}{v} = \text{constant}$$

or

$$f = KV$$



PAIR OF THERMISTOR SENSORS ON FRONT FACE OF FLOW ELEMENT.

Figure from ref. 2/

1/ White, Rodely, and McMurtrie, "The Vortex Shedding Flowmeter," Paper No. 2-16-187, 1971 Symposium on Flow - Its Measurement and Control in Science and Industry.

2/ Rodely, A.E., "Flow Measurement by the Vortex Shedding Technique," Eastech, Inc., sales engineering publication. Undated.

The blunt obstruction shown has a width (w) that is one-third the diameter of the pipe and a length (L) that is (1.3w). This geometry was designed to provide stable vortices that reinforce or interact with each other on each side of the blunt obstruction. This obstruction leaves a flow area that is about 58 percent of the pipe area.

The shedding vortex oscillations are sensed in different ways such as by thermisters, pressure cells, or magnetically picking up the oscillation of a shuttle ball in a chamber that has each end connected to piezometer ports at sensing positions on the vortex shedding flow element.

Advantages

Purported advantages applicable to both Eastech and Fischer Porter flowmeters are:

1. No moving parts

2. Calibration by dimensioning and tolerance that is independent of pressure and fluid properties.

3. Adaptable to electronic digital counting and capable of totalizing widely fluctuating flow.

4. Possible to verify that installation is correct or that conditions have changed by examining amplifier output.

5. A portable form of the vortex generating element can be installed through a stuffing box into a pipe.

Uses

The vortex shedding flowmeters are claimed to have been used for highly fluctuating gas or liquid flows and can tolerate dirty flows and slurries. The specified temperature range of operation is -320° F to 360° F for Eastech and -40° F to 250° F for Fischer Porter flowmeters.

Installation

Installation requirements for vortex shedding flowmeter are similar to other measuring devices in regard to sufficient approach conduit length after bends, valves, or protruding gaskets.

Performance as Specified by Companies

Eastech claims calibrations can be kept to within 0.25 percent by machine tolerance, linearity to within ± 0.5 percent for Reynolds numbers greater than 10,000 and repeatability to within ± 0.1 percent. This performance was contingent upon yearly maintenance. Fischer Porter claimed accuracy of ± 1.0 percent and repeatability of 0.15 percent of rate.

Head Losses

Head losses were claimed by Eastech to be equivalent to beta 0.7 orifice plate meter. Beta is defined as the ratio of orifice diameter (d) to pipe diameter (D). Beta could be considered the square root of the ratio of the orifice area (a) to pipe area (A). Thus $b = \frac{d}{D} = \sqrt{\frac{a}{A}}$.

Using the geometry description of the Eastech vortex generating element having width of about (1/3 D), the calculated equivalent circular (b) is 0.75. Using orifice information from HYD - 202 it can be shown that a 0.7 beta orifice meter has a head loss equal to 4.3 times the velocity head of the approaching flow.

Minimum velocities can be calculated for different sizes of flowmeter based on the company specified minimum Reynolds number of 10,000. The following table gives these minimums for the diameters of Eastech flowmeters mentioned in 1/ and 2/:

Flowmeter diameter (inches)	Minimum velocity (ft/s)	0.7 B Head loss (ft) water	
		Minimum	Maximum (1:100)
2	0.720	0.04	355
4	0.360	0.01	84
6	0.240	-	38
8	0.180	-	28
20	0.072	-	3.5

Head losses were computed for both the minimum and maximum velocity as determined from the 1:100 meter range claimed by the Eastech. The head loss range for the same diameter range for 1:50 flow range is from 0.85 to 89 feet water. For a 1:10 range of flow the loss is 0.03 to 3.6 feet water. Fischer Porter claimed a pressure loss of 7 feet at capacity for 2- to 6-inch meters. However, their meter velocity range was 1:15.

R. A. Dodge

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