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NASA TECH BRIEF

Studies Reveal Effects of Pipe Bends on Fluid Flow Cavitation

The problem:

To determine the conditions that cause incipient cavitation in liquids flowing in pipes curved in one plane. Pipelines containing suction ducts and small bend radii are conducive to cavitation at high volumetric flow rates. Although considerable data are available on cavitation occurring in fluid flow over bodies of various shapes, little has been published on cavitation in pipe bends. Cavitation can cause erosive action in the bend areas and a loss in flow efficiency.

The solution:

The results of a series of tests using water as the working fluid, in a Reynolds number range of 4 x 10^5 to 2 x 10^6 and at pressure ratios of 0.04 to 0.40, in pipe bends curved in one plane and made of a transparent plastic are as follows:

1. Cavitation was affected by the pipe bend radii and the pipe diameters, and little, if any by pipe bend angles ranging from 60° to 120°. The critical cavitation index (i.e., the index computed for flow just entering cavitation) was greater for smaller ratios of bend radius to pipe diameter.
2. Critical cavitation indices decreased with increasing Reynolds number and pressure ratio (i.e., the ratio of liquid vapor pressure to upstream dynamic pressure).
3. Increasing the bulk liquid temperature lowered the mean critical velocity at which cavitation occurred.
4. An empirical relationship, taking into account the effects of bend radius and pipe diameter, was derived for the determination of the critical cavitation index.

How it's done:

Transparent pipe elbows having bends of 60°, 90°, and 120° in one plane, pipe diameters of 1.5, 2.0, and 4.0 inches, and bend-radius-to-pipe-diameter ratios of 0.7, 1.0, and 1.5 were subjected to varying water flow rates from a raised, open-top reservoir. The flow rate was regulated by replaceable orifices near the bottom of the downcomer below the test section. A three-probe pressure pickup arrangement was used to measure the average upstream static pressure. Single pressure measurements, directly opposite one another, were made in the bend. All pressures were recorded electrically.

For computing the volume flow rate, the water reservoir was filled to a predetermined level and timed through a measured fall of such magnitude that steady flow conditions could be assumed to be established in 5 seconds and that the pressure-head differential would be negligible. With a given orifice size, test elbow, and reservoir liquid level, a shutoff valve was opened and a test was run. The orifice size was increased until cavitation was visually observed in the elbow. For each run, maximum, minimum, and mean values were determined for the pressure at each probe position. The water temperature was varied from 70° to 130° F in steps of approximately 15° F.

Notes:

1. No consideration was given to the effects of dissolved gas, surface tension, rate of bubble growth by diffusion, surface roughness, and water cleanliness.

(continued overleaf)

2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10228

Patent status:

No patent action is contemplated by NASA.

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