Influence of geometric layout and blockage on the performance of vortex shedding flowmeter

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Summary:

Experimental investigations are conducted on vortex flowmeter. It consists in a piece of pipe section of quadrangular section, which is placed a trapezoidal bluff body section and a force transducer with strain gauges. We have optimized the geometrical arrangement to deduce performance. There is a repeatability of 0.1% of the value of Strouhal number and assured linearity in a range of flow rate from 5 to 50 m^3/h. For flow rate measurement, the device constant Strouhal number is set up with the average velocity in the contracted section downstream of the bluff body; it is independent of blockage ratio.

INTRODUCTION

Measurements of flow rates of fluids in motion are common practices in fluid flow under pressure. The devices available in the market and the corresponding techniques are varied but generally guarantee a precision that rarely exceeds 1%. However, the current needs of certain industries (petroleum, chemical etc. ...) go beyond that figure. To meet this demand, a solution is provided by methods of measurement based on counting the vortices generated by a bluff body. The vortex path behind bodies placed in a two or three dimensional flow has been nowadays the focus of much research [1]. The current study concerns the wake downstream of a sharp bluff body in a flow. Studies of several researchers show that parameters such as the blockage ratio, the turbulence, the end effects, the geometric shape and the vibration of the bluff body affect the overall value of the Strouhal number (St1) [2, 3, 4, 5, 6 and 7].

In the flow inside a pipe, introducing the volume flow rate q_v, we obtain the following expression: $\frac{q_v}{f} = \frac{d.A}{S_t}$ = Cte, where A is the section of the pipe. This relationship shows that the flow rate is proportional to the frequency of the vortex shedding.

A technique for vortex shedding flowmeter will be used in this work and whose originality is to use a section of pipe with quadrangular cross-section and to separate the generation function from that of detection. Generation is provided by bluff body of a trapezoidal section with two parallel sharp edges, behind which vortices develop. The detection is of a surface type and is performed at some distance downstream of the obstacle. It is done via a flat plate, parallel to the flow and secured to a beam bending over which are fixed strain gauges.

We will start by describing the measurement technique and the experimental procedure. Secondly we present the optimal geometric arrangement at one hand and the most significant frequency signals on the other. Finally, we present the results and comments.

MEASUREMENT TECHNIQUE AND THE OPTIMAL GEOMETRIC LAYOUT

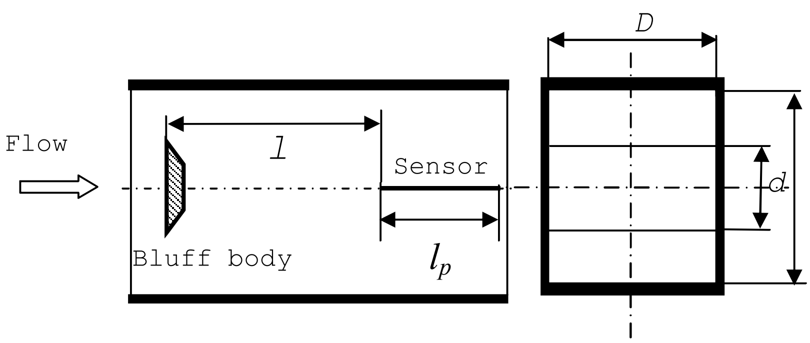

Figure 1 Geometric arrangement for the proposed technique

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The technique used in the apparatus shown (Figure1), is based on the generation and detection of vortices respectively through a generator and a sensor. To make the measurements, we use a quadrangular section (rectangular or square) which form the measurement tunnel, a two-dimensional bluff body with two sharp edges, and a flat plate collector parallel to the flow. The latter is secured to a bending beam over which are fixed strain gauges. We note that for this unit, the function of generating is separate from that of detection.

By optimizing the geometric layout, the search for a significant signal showed that it was entirely possible to have a quasi-periodic signal for all flow rates. For a bluff body of a given dimension, this optimization is characterized by the following parameters:

- a thickness of 0,7 mm for the plate sensor;
- a width of 1,5*d* to 2*d* for the plate sensor;
- a bluff body-plate sensor distance of 3,5 *d* to 4,5 *d.*

It should also be noted that other parameters can influence the signal quality such as the eccentricity of the bluff body, the material of the bending beam and finally the orientation of the latter with respect to the direction of flow.

RESULTS AND COMMENTS

Figure 2 shows the variation of the Strouhal number with the Reynolds number for different values of the blockage. The Strouhal number varies slightly with the Reynolds number. It increases with the blockage.

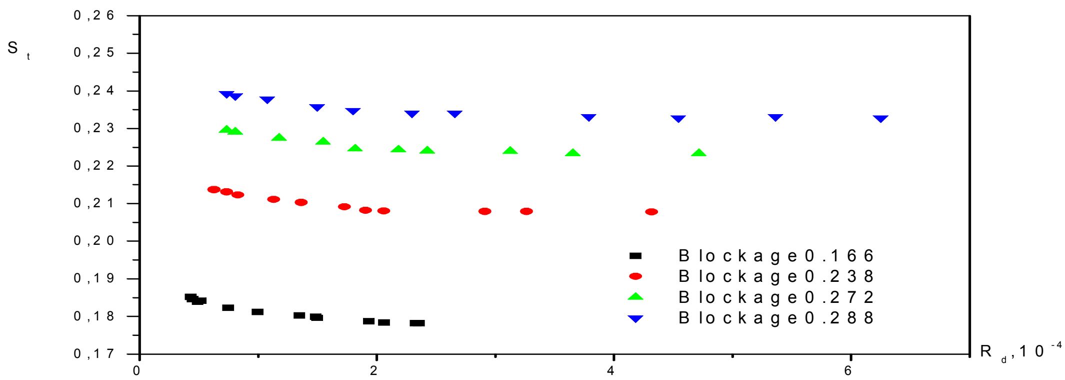

Figure 2: Variation of the Strouhal number (St) with the Reynolds number (R_{ed}) for different values of the blockage

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CONCLUSIONS

To design and implement a meter flow through the vortex street and the wake generated by a bluff body, giving a good accuracy, we recommend an optimal geometrical arrangement. The generator, the sensor and the tunnel must ensure the flow with a more symmetrical arrangement possible, prevent cavities and bumps to ensure a better quality signal possible and thus minimize errors. The device constant Strouhal number is set up with the average velocity in the contracted section downstream of the bluff body; it is independent of blockage ratio.

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