KTH CCGEX

Vortex Meter Design for Unsteady Mass-Flow Measurement

Chris Ford

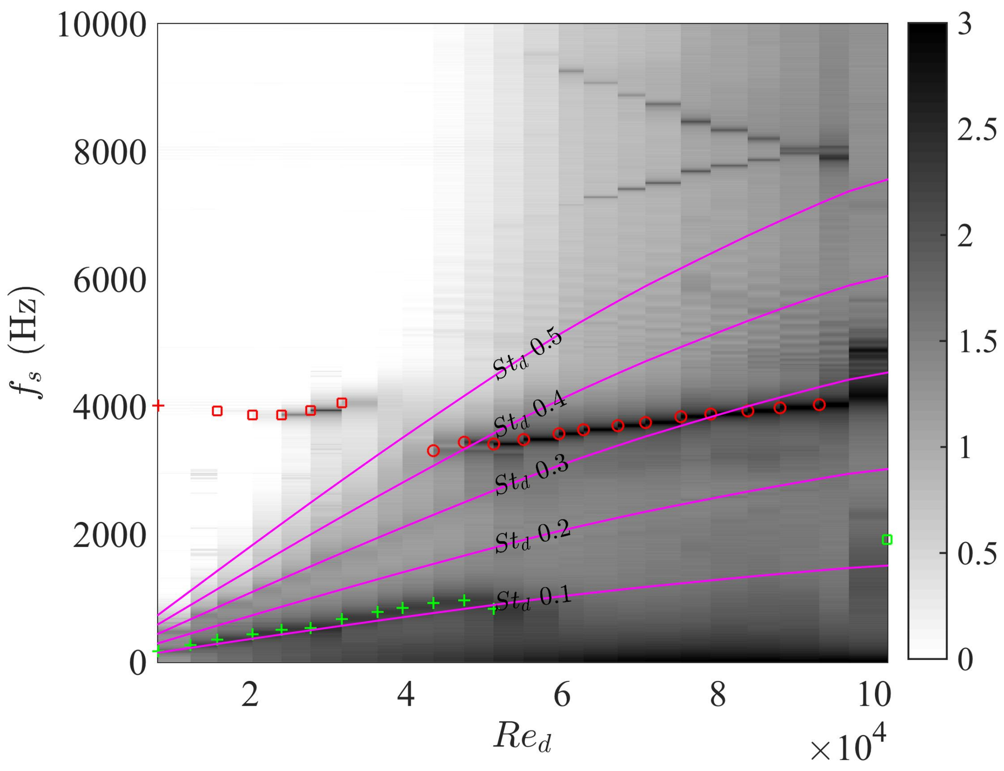
cford@mech.kth.se

An experimental investigation has explored the influence of vortex shedder (a bluff body comprising a fore-body and tail) geometry on the shedding characteristics and pressure loss for application to a vortex shedding mass flow meter. The intention of the project was to consider a parametric characterisation of the behaviour to inform design of vortex meters suitable for the intended measurement range; to maximise resolution/response rate and minimise pressure loss.

Introduction and Motivation:

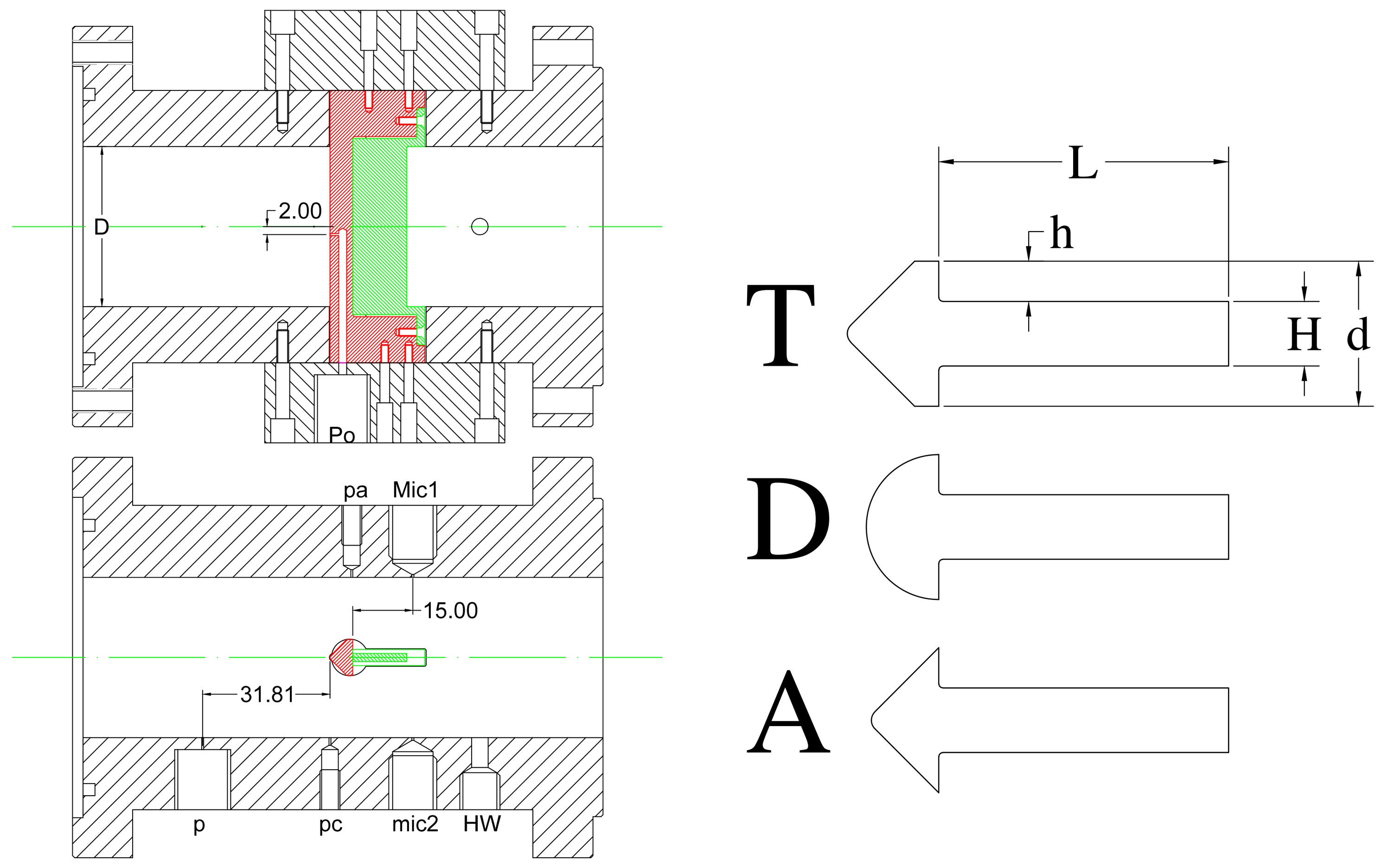
A vortex shedding meter is a simple device. It utilises the alternating wake shedding generated by a bluff body in cross flow to determine the velocity of the oncoming fluid. To measure mass flow the meter needs: 1) a method of establishing the shedding frequency and 2) a means of computing the fluid density. Pressure measurements are used to complete both of these tasks to ensure that the meter is suitable for practical flows which may contain contaminants.

Vortex meter shedding frequency characteristic as a function of Reynolds number ->



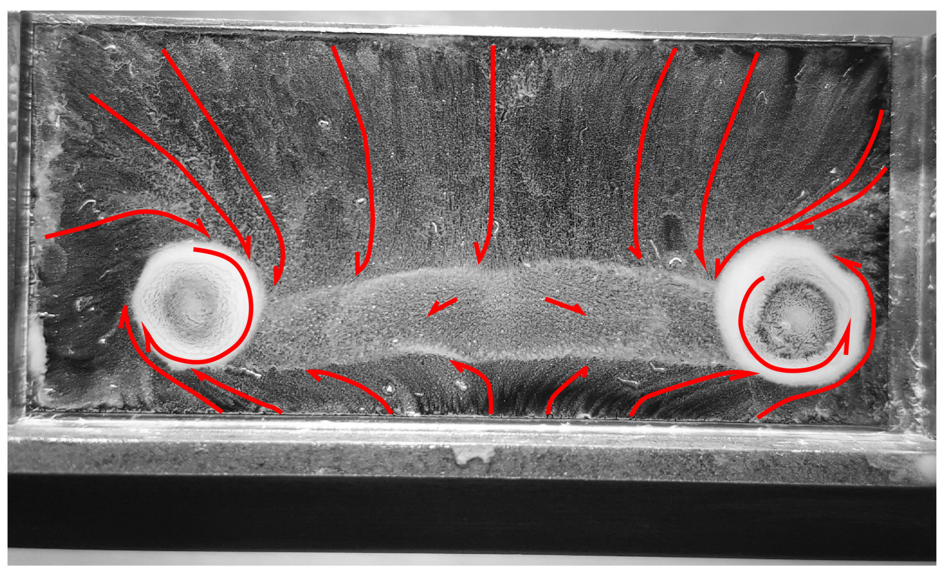
Setup:

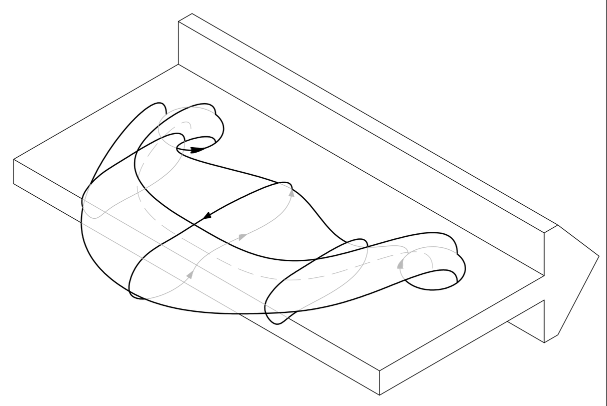
Experimental work was conducted at the CICERO pipe flow facility. The working section details may be seen below. The shedder comprised a forebody (red) and tail (green) which could be changed. Three forebody configurations (T,D and A) and 21 tails were tested with different lengths and thicknesses.

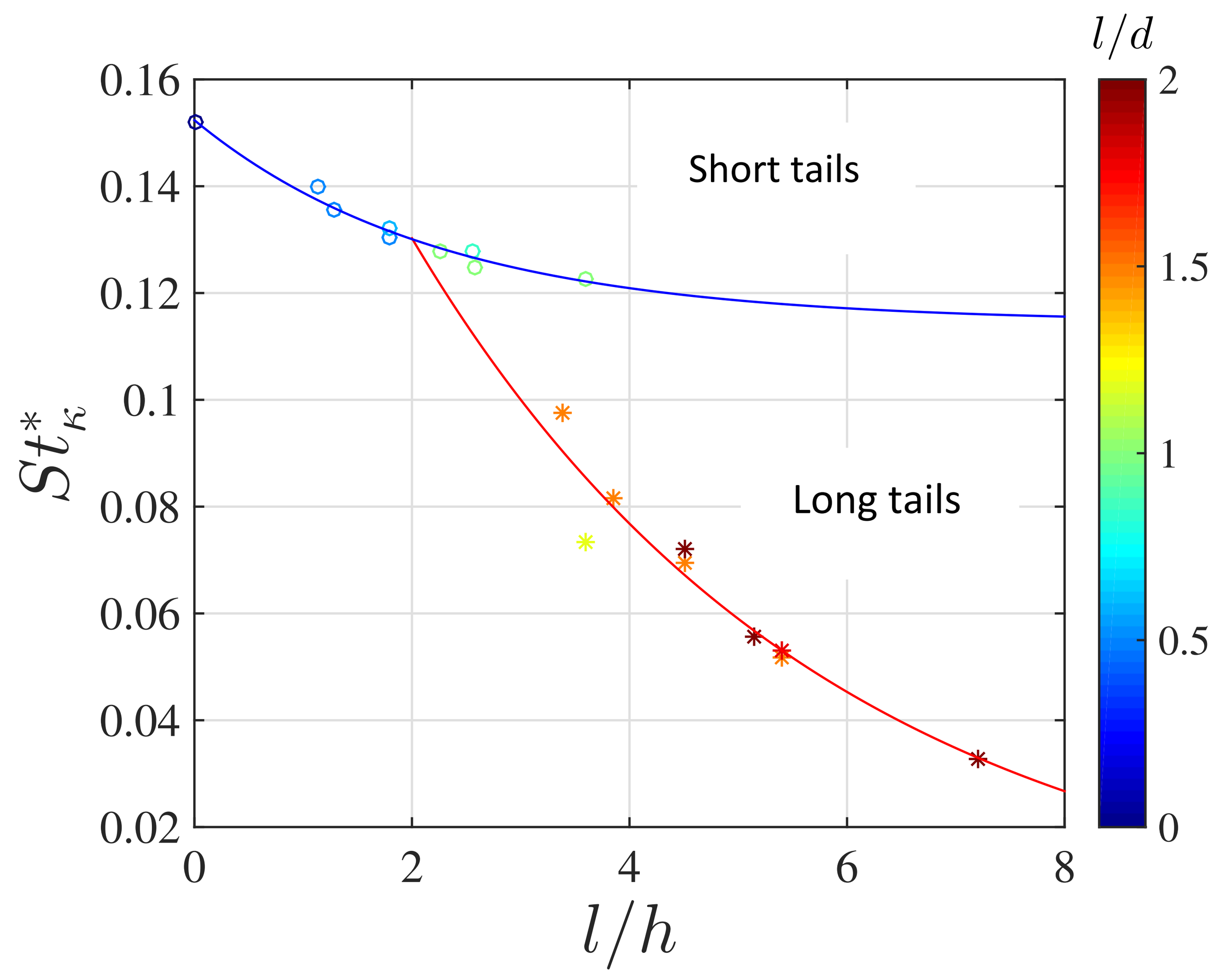


Results:

Tails may be classed into "long" or "short" based on the value of the length to diameter ratio. The flow topology differs greatly between the two. In long tailed geometries, the primary vortex length scale is proportional to the step height (h), whereas for short tails, it is proportional to d/2. The primary-vortex anchors to the tail in the long tailed geometries (see flow viz. picture), which is not possible in short tail cases owing to the vortex diameter. Resultantly, the two geometry types produce very different Strouhal characteristics (see graph). Short tails create high Strouhal numbers, long tails develop weaker, less frequent shedding. The difference in vortex scales also makes long tailed geometries more susceptible to mode interaction. A second mode occurs in the spectrum from a pipe-wall boundary layer separation. When the scale of this separation approaches the scale of the primary vortex, and the frequencies are harmonic multiple, coupling may occur. Typically this acts to "kill" the shedding mode, forcing it to lock on to the higher (mode-II) frequency.







Summary and Conclusion:

Experiments have been conducted exploring the influence of the tail geometry on the shedding characteristics of a bluff body for application to a vortex shedding meter. The selection of tail length is critical in determining the flow topology and hence the shedding characteristic. The shedding behavior may be characterized by the primary vortex scale, which is proportional to the body diameter: d/2 or the step height (h) depending on the class (short/long) of the body. The results are more subtly influenced by changes to the forebody shape.

Acknowledgement:

Co Workers: Professor P.H. Alfredsson, M. Winroth

Funding: Lars-Erik Thunholm Foundation