Visualization of Pulsating Low-Speed Flows from a Basic Annular Jet

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Abstract

Flow in the initial region of a pulsating low-speed annular water jet issuing into a quiescent water reservoir was visualized by means of a dye. The objective of this study was to characterize the different flow regimes as a function of pulse frequency. The blocking ratio was fixed at 0.7. The Reynolds number was varied from 59 to 155 and the Strouhal number from 0.133 to 1.90. For the experimental conditions considered, two different flow regimes were observed.

Motivation

- Transient flow behavior associated with pulsating jets is known to affect entrainment, mixing, and spread rate characteristics.
- Pulsating jets can also produce large-scale coherent structures, i.e. trains of toroidal vortices.
- Annular jets flows often provide a better description of the flow associated with nozzles used in engineering applications.
- The flow phenomena associated with pulsating annular jets are still not fully understood.

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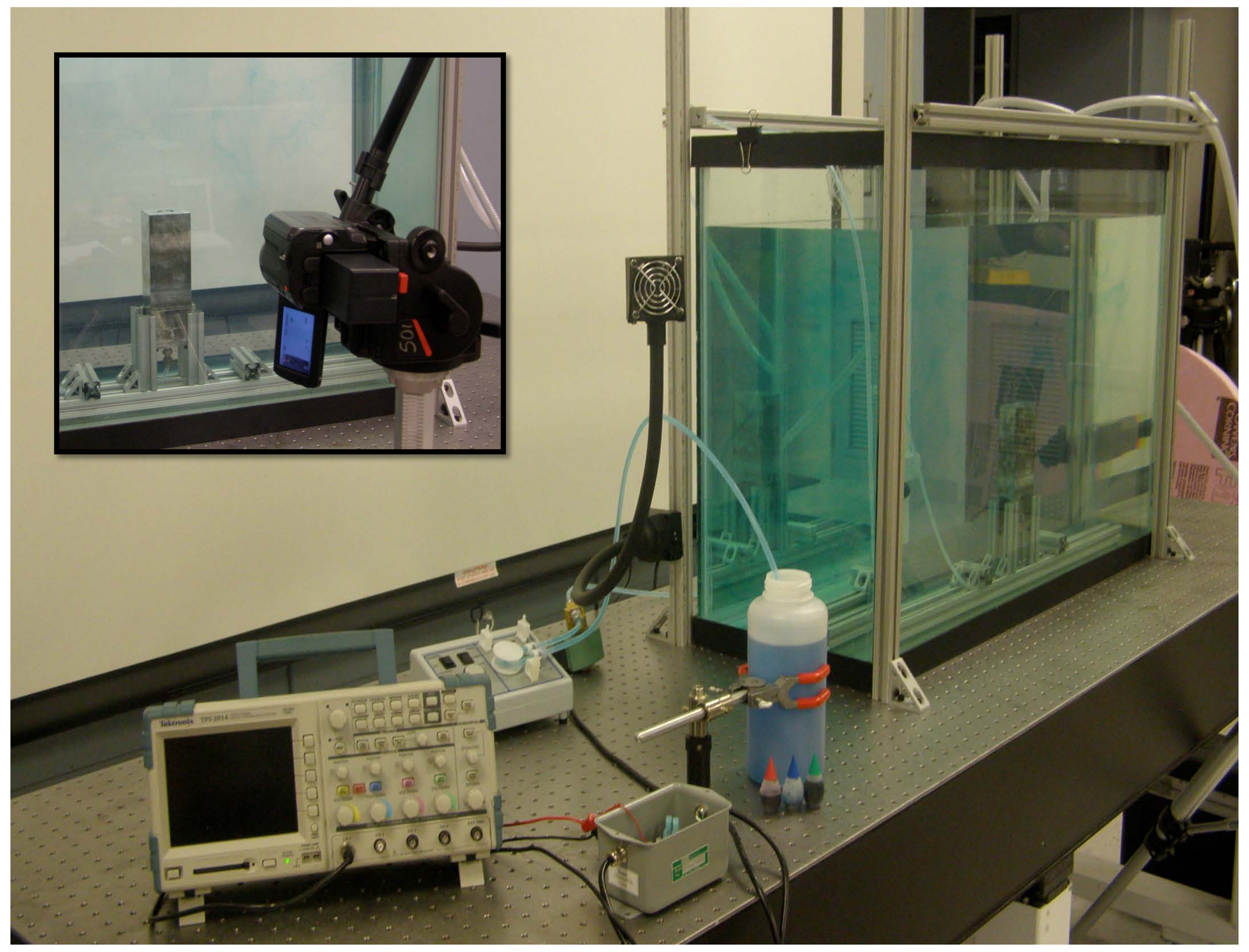
Experimental Apparatus

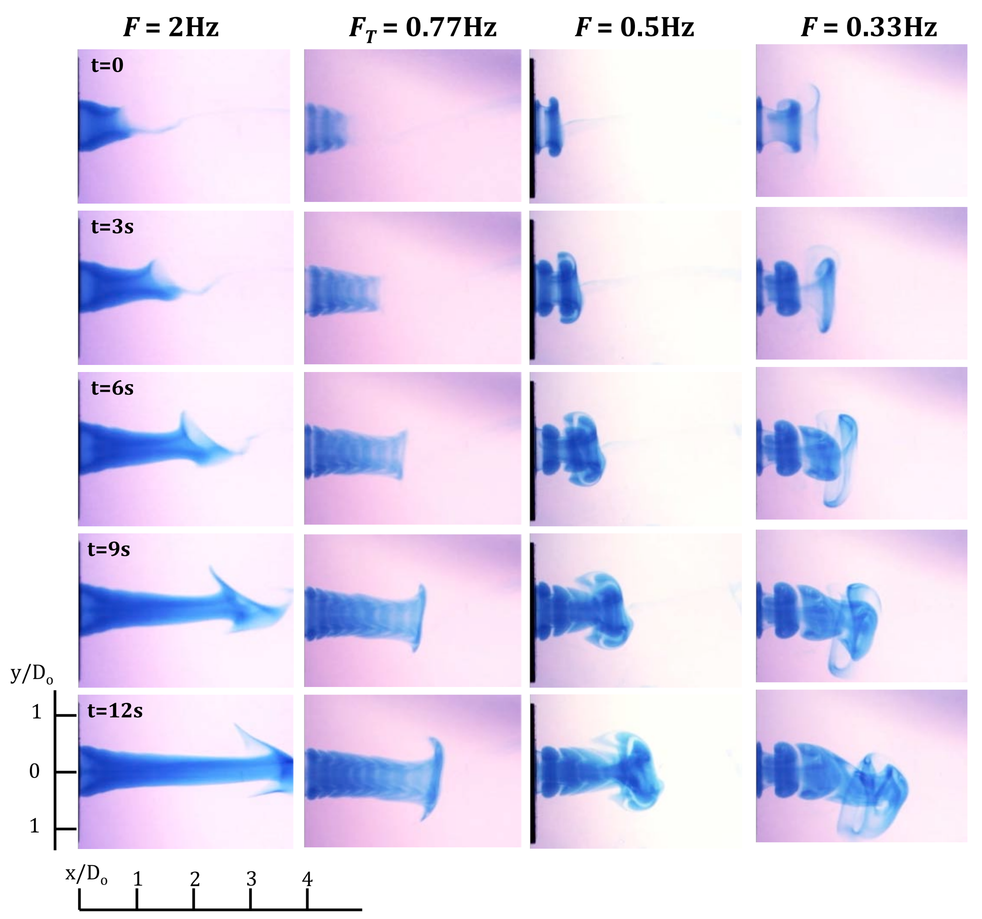
- Jet flow visualized by means of dye.
- Frequency varied through the use of a programmable solenoid valve.
- Blocking ratio of 0.7 (D_i= 1.78 cm, D_o = 2.54 cm).
- Reynolds number based on hydraulic diameter.
- Still images obtained from video recording (2020 x 1140 pixels).



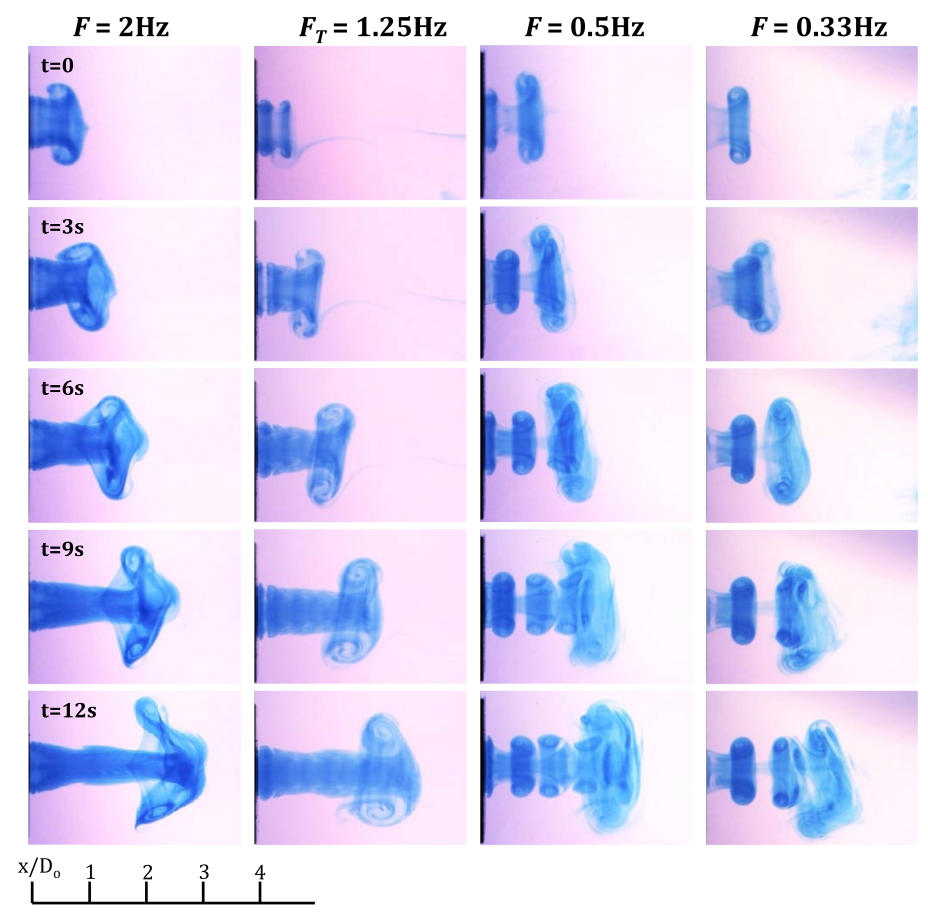
Experimental Apparatus

Results

- At higher frequencies the jet resembles that of a steady jet.
- At lower frequencies the jet consist of a structure composed of several vortex rings, which are generated by every pulse.
- The frequency when the jet starts to deviate from the steady jet is defined as the transition frequency (At Re = 97 F_T= 0.77Hz, at Re = 155 F_T= 1.25Hz).
- Size of leading vortex was proportional to Reynolds number.
- At frequencies below F_T, the vortex rings generated by every pulse are larger for the higher Reynolds number jet.

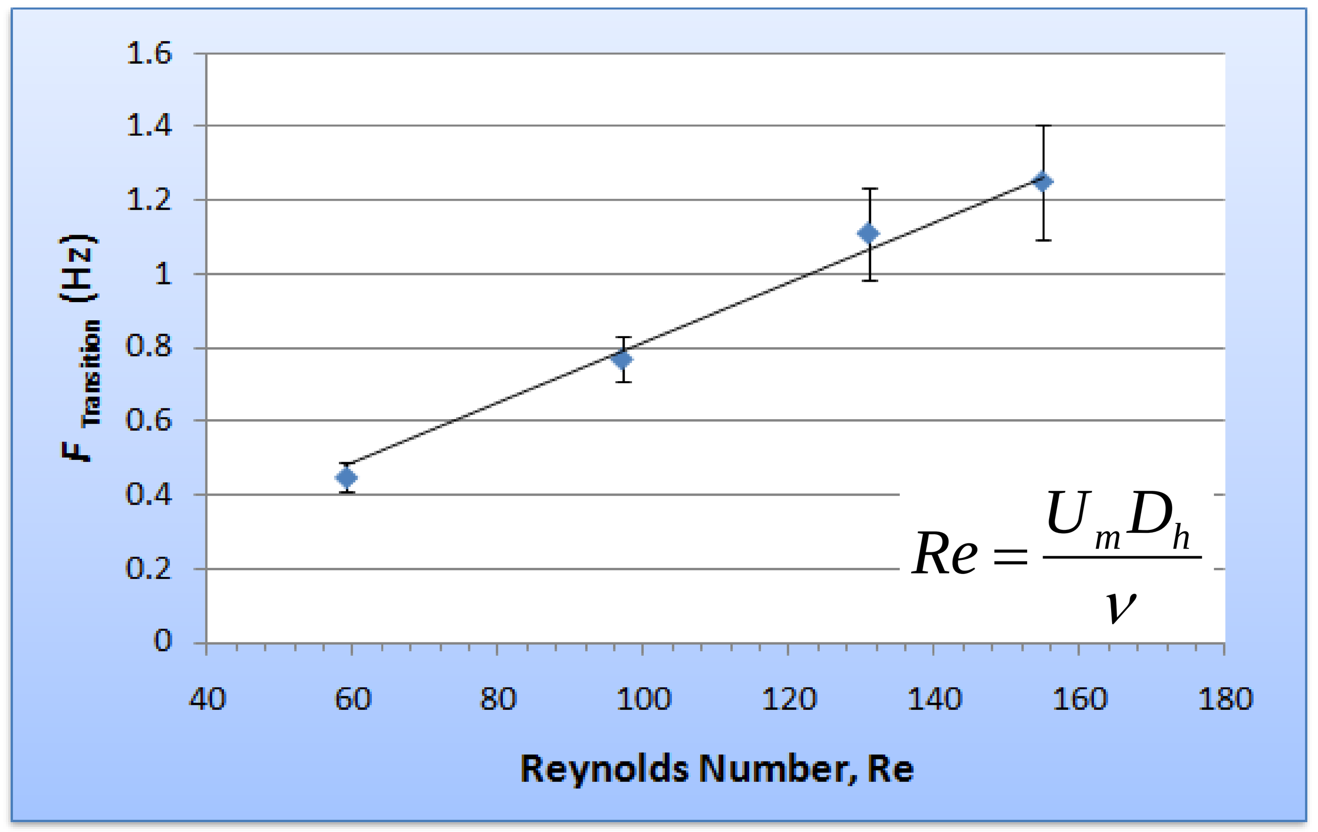


Flow patterns of the pulsating jet at Re 97.

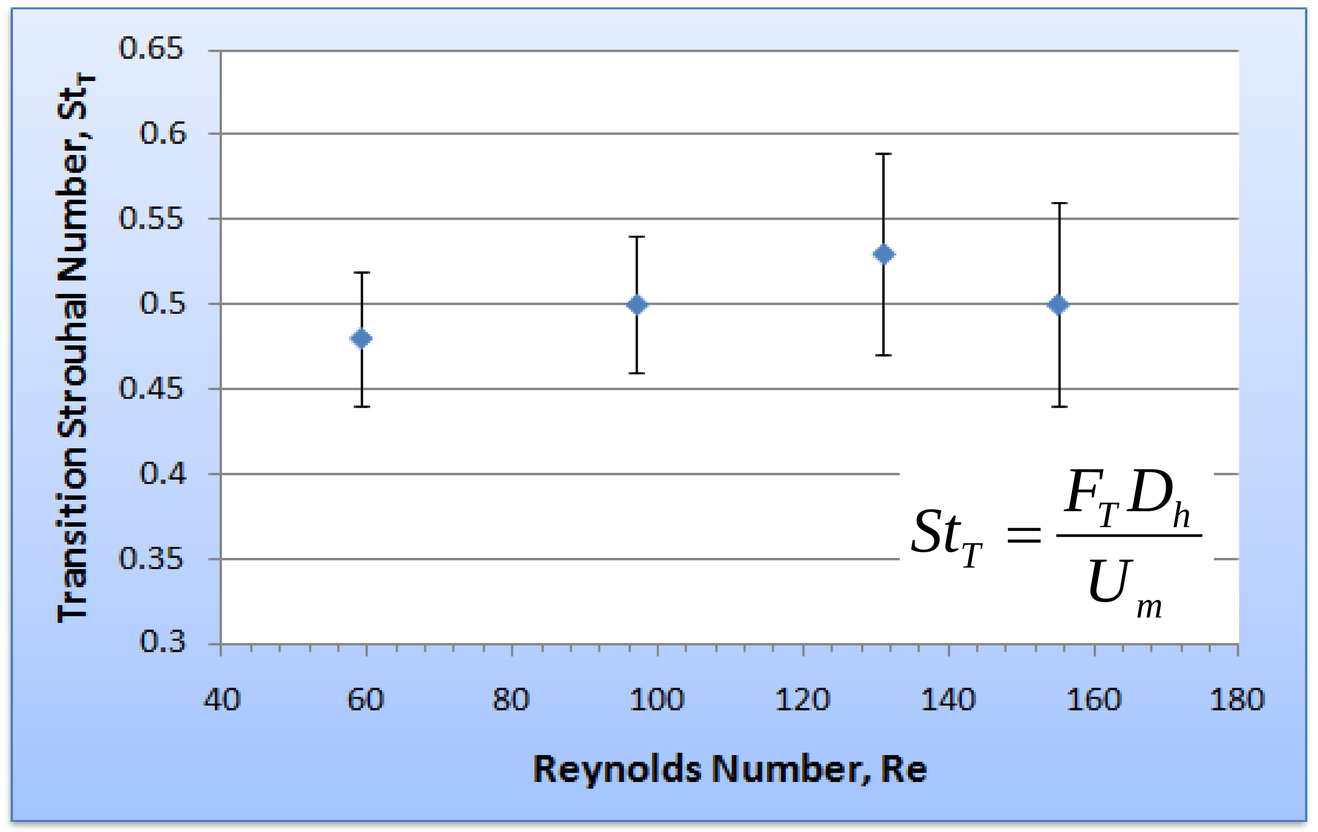


Flow patterns of the pulsating jet at Re 155.

Results (continued)



Transition frequency as a function of Reynolds number.



Transition Strouhal number as a function of Reynolds number.

Conclusions

- Two different flow regimes were observed.
    1. At high frequencies, the flow field resembled that of the steady annular jet.
    2. At low frequencies, the flow field is composed of a train of toroidal vortices, i.e. vortex rings.
- The frequency at which transition occurred was proportional to the Reynolds number.
- The Strouhal number at which transition occurred appears to be independent of the Reynolds number.

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