Study on minor losses around the thermoacoustic parallel stack in the oscillatory flow conditions

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Results

Setup

The experimental device consists:
- two loudspeakers
- two resonators
- a regenerator.
The dual channel function/arbtrary waveform generator outputs the sine signal with fixed phase difference and frequency to drive two loudspeakers. The resonator: 28x28mm rectangular stainless steel tube with length of 400mm. The thickness of stainless steel stack and the spacing between parallel plates is 1 mm, respectively. The operating gas is atmospheric, air under 25°C.

Vortex structure under varying pressure

The ratio of the pressure drop is determined for the category of vortex patterns occurring at the end of a plate. The result is in good agreement with Aben’s conclusion.

The vortex size gets larger with the increase of pressure amplitude. In detail, the vertical dimensions of the vortices under forth working condition are larger than the one under third working condition, and the horizontal dimensions of the vortices are roughly two times larger.

Minor Losses around the Stack

The real part of minor loss coefficient exponentially increased with the ratio of hydraulic radius and displacement amplitude of oscillatory flow.

The simulation domain is 80mm long, 4mm high, 410 mm far away from the left-hand side. The mesh contains about 96019 nodes. Triangular grids are adopted at the ends of stack in order to increase the cell density towards the hydro-dynamically relevant stack areas. A mesh boundary layer is imposed near the tube walls.


Background

Conclusions

- A close agreement between simulation and experimental result is found, thus providing support for the applicability of the model.
- The vortex structures at the end of parallel stack get larger with the increase of pressure amplitude.
- The real part of minor loss coefficient exponentially increased with the ratio of hydraulic radius and displacement amplitude of oscillatory flow.

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Thermacoustic devices can achieve conversion between thermal and acoustic energy based on the thermoacoustic effect whereby appropriately phased pressure and velocity oscillations enable the compressible fluid to undergo a thermodynamic cycle in the vicinity of a solid body. Conventional thermoacoustic theory which based on first-order linear theoretical model has its limitations on the nonlinear thermoacoustic effect and phenomenon such as acoustic streaming, vortex shedding and local pressure losses caused by the abrupt change of the cross section. Therefore, the numerical simulation of mathematical equations becomes an important means to solve these problems.