西安交通大学《Numerical Heat Transfer》课程大作业(1)

(20221129)

渐扩-减缩圆管中的周期性充分发展层流对流换热

使用本课程的教学程序研究以下稳态周期性充分发展对流换热问题。

1. 假定：（1）渐扩渐缩圆形截面通道，壁温为常数（图 1）；（2）流体物性为常数；（3）流动为层流。
2. 给定条件如下：（1）$L_{cyc}/D_{\max}=1.51, 2.29$; （2）$\theta=10^{\circ}, 14.8^{\circ}$ ；（3）**Pr=0.7，5.0**； （4）Re= 100, 600 , 1000。
3. 求：选定一个 $L_{cyc}/D_{\max}$，一个倾角 θ ，一个 **Pr** 数，在三个 **Re** 数下一个周期通道（图 2）的平均 **Nu** 数。
4. 数值求解建议：
   （1） 采用区域扩充法处理不规则求解区域，对略大于一个周期的区域进行计算；
   （2） 关于周期性充分发展的流动与换热数值计算可参加教材节 11. 2. 1，及 **11.2.2.2**；
   （3） 建议对略大于一个周期的区域（图 3）进行计算，便于实施周期性边界条件的实施（及将 **AA-BB** 及 **CC-DD** 进行计算结果的交换，以获得周期性充分发展的结果）。
   （4） 特征尺度取为：$D_{eq}=A_{cyc}/\pi L_{cyc}$, 其中 A_{cyc} 是一个周期的对流换热面积；
   （5） 将数值计算结果与文献[1]作比较。

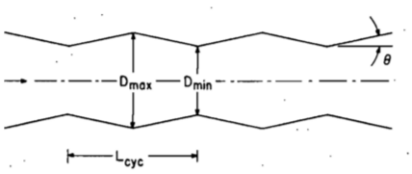

图1

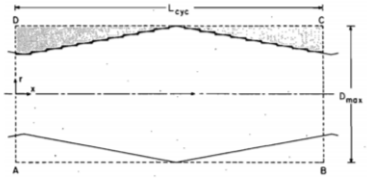

图2

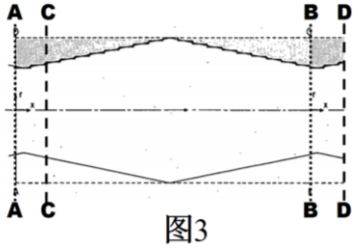

图3

5. 参考文献

[1] E M Sparrow, A R Prata. Numerical solutions for laminar flow and heat transfer in a periodically converging-diverging tube, with experimental confirmation. Numerical Heat Transfer, Numerical Heat Transfer, vol. 6, pp. 441-461,1983

[2] 陶文铨编著. 数值传热学（第二版）. 西安：西安交通大学出版社，2001. pp.488-492.

Project Assignment of Numerical Heat Transfer course of Xi'an Jiaotong University (1) (20221129)

Periodic-fully developed laminar heat transfer in a converging-diverging tube

Please use the teaching code of this course (available for download on http://nht.xjtu.edu.cn/) to calculate the following steady heat transfer problems:

1. Assuming:（1）Diverging-converging tube with circle cross section and constant wall temperature (Fig. 1)；（2）Constant physical properties；（3）Laminar flow.
2. Giving following conditions:（**1**）$L_{cyc}/D_{\max}=1.51, 2.29$; （**2**）$\theta=10^{\circ}, 14.8^{\circ}$ ；（**3**）**Pr=0.7， 5.0**；（**4**）Re= 100, 600 , 1000。
3. Finding: The Nusselt numbers of one cycle (Fig.2) at three Reynolds numbers for a selected value of $L_{cyc}/D_{\max}$， θ and Pr.
4. **Recommendations:**

(1) The domain-extension method may be adopted to deal with the irregular domain;
(2) For the numerical method of periodic fully developed flow and heat transfer Section11.2.1 and 11.2.2.2 of the Textbook may be consulted;
(3) A domain a bit larger than one cycle is recommended for the simulation (Fig. 3), so that the periodic boundary condition can be implemented easily. That is, the results at AA and BB sections are exchanged each other, and the same for CC-DD .
(4) Your results are compared with reference [1].
(5) The reference length is defined as $D_{eq}=A_{cyc}/\pi L_{cyc}$,where A_{cyc} is the heat transfer area per cycle.

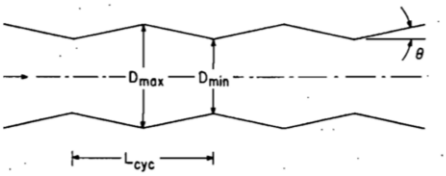

Fig.1

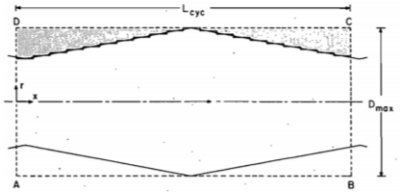

Fig.2

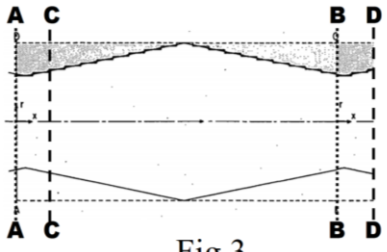

Fig.3

5. References

[1] E M Sparrow, A R Prata. Numerical solutions for laminar flow and heat transfer in a periodically converging-diverging tube, with experimental confirmation. Numerical Heat Transfer, Numerical Heat Transfer, vol. 6, pp. 441-461,1983
[2] 陶文铨编著. 数值传热学（第二版）.西安：西安交通大学出版社，2001. pp.488-492