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Three-dimensional Evolution of the Flow Through a Curved Square Duct

T. Watanabe[1*], S. Yanase[1]

[1]*Graduate School of Natural Science and Technology, Okayama University, 3-1-1 Tsushima-naka, Okayama-city, Okayama 700-8530, Japan*

Email: watanabe@et2001.mech.okayama-u.ac.jp

Abstract

There exist a large number of investigations of fluid flow through a curved duct. Moost of the former works were, however, limited within 2-D framework i.e. of uniformity in the main-flow direction. The role of three-dimensional (3-D) perturbations has not been well understood in such flows. In the present paper, 3-D properties of the flow through a curved square duct are investigated numerically by use of the spectral method and it is found that traveling-wave solutions do exist in the region where time-periodic solutions is obtained by 2-D calculations.

Figure bellow shows the streak lines of the traveling-wave solution obtained. The main-flow direction is from right to left and the right-hand side wall is the outer wall of the duct. It is clearly seen that an asymmetric perturbation travels in the form of packet in the symmetric velocity field.

Spectral analyses are also conducted to understand the properties of the traveling-wave solutions. It is worthy noting that dominant modes have the same phase velocity, which proves that the traveling-wave is unique under the calculations conducted here.

Although the uniformity in the main-flow direction assumed in 2-D calculations does not hold in the traveling-wave solutions, visualizations of them in a cross section is closely similar to those 2-D time-periodic solutions, which suggests that the 2-D assumption is effective to understand the curved duct flows not only in the steady solutions but also in the time-dependent solutions.

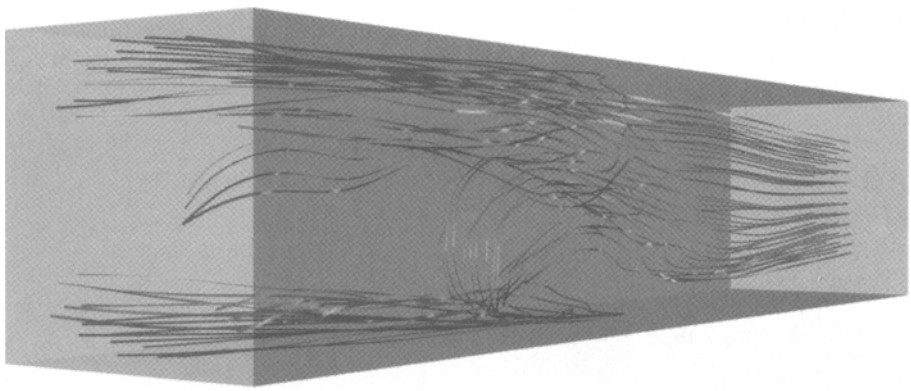

Figure: Visualization of the streak lines of traveling-wave solution

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