بسم الله الرحمن الرحيم

شبكة المعلومات الجامعية
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بالرسالة صفحات

لم ترد بالأصل

بعض الوثائق الأصلية تالفة

MEASURED AND PREDICTED FLOW INSIDE LOGARITHMIC SPIRAL CURVED DIFFUSERS

By

Eng. Salem Abdel Aziz Salem Ahmed

B.Sc., M.Sc. Mechanical Engineering

A Thesis Submitted to the
Faculty of Engineering at Cairo University
Mechanical Power Engineering Department
in Partial Fulfillment of the
Requirements for the Degree of
Doctor of Philosophy
in Mechanical Engineering.

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ABSTRACT

The diffuser represents an important fluid-mechanical element in many flow devices. The main purpose of the diffuser is to increase the pressure energy and reduce the kinetic energy of the flow. In centrifugal turbomachines, two common types of radial diffusers are employed: the vaneless and vaned diffusers. A vaned diffuser uses blades with different forms (straight, wedge, circular, airfoil, and logarithmic spiral) to better guide the flow and obtain a rate of diffusion higher than that can be obtained with a vaneless diffuser for the shortest possible length.

In the present work, the turbulent flow inside a single passage with logarithmic spiral profile for the vaned radial diffuser cascade is investigated experimentally and modeled numerically. The effects of three important parameters were investigated experimentally. These include the diffuser enlargement rate (which gives diffusers with various area and length ratios), the flow inlet incidence angle and the inlet Reynolds number.

A test rig is built to achieve the experimental plan. Three curved diffusers with enlargement rate of $k^* = 0, 0.5$, and 0.8 are designed and constructed from smooth thin-galvanized sheet metal. Several static pressure taps with (1 mm) inner diameter were fixed along mid-height of both curved side walls. An approaching channel, ended with inlet contraction nozzle, was connected to the inlet of the tested diffuser channel. It can be set parallel or oblique to the diffuser axis at the inlet in order to achieve a flow with positive and negative incidence angles at the diffuser inlet.

The mean flow velocity components and turbulent quantities (turbulent intensities and Reynolds shear stress) are measured at a series of stations within the diffuser passage from inlet to exit using hot-wire anemometer (CTA). In addition, the local static pressure along both curved side walls is also measured through the wall pressure taps using the electronic micromanometer.

Three-curved diffusers with $k^* = 0.0$, 0.5 and 0.8 were used to study the effect of the diffuser enlargement rate at zero inlet incidence. The curved diffuser

with $k^* = 0.5$ was used to study the effect of inlet incidence with positive values of (i = 4, 8, 12 deg) and negative values of (i = -4, -8, -12 deg). The effect of inlet Reynolds number on the flow characteristics for the same curved diffuser with $k^* = 0.5$, at two inlet incidence angles ($i = 8$ and -8 deg) was studied for the three values of Re ($= 7.0 \times 10^5, 8.7 \times 10^5$, and 1.0×10^6).

Two-dimensional code solver with the standard $k - \varepsilon$ turbulence model was employed to predict the published data of Kim and Patel (1994) and Majumdar et al. (1998) as well as our experimental results at zero inlet incidence.

The experimental study for the curved diffuser with different enlargement rate at zero inlet incidence shows that the non-uniformity in the streamwise mean velocity profiles decreases as the diffuser enlargement rate increases. When there is no separation, the mean pressure recovery coefficient at the diffuser exit increases as the diffuser enlargement rate increases. Within the diffuser, at the downstream sections, the peak level of turbulent quantities decreases slightly and the peak location moves away from the convex wall.

The experimental results at different positive and negative inlet incidence show that the non-uniformity of streamwise mean velocity profiles is higher at positive inlet incidence than it is at negative incidence. When there is no separation, the wall pressure recovery coefficient increases as the negative flow inlet incidence increases and decreases as the positive flow inlet incidence increases. Positive inlet incidence effect on turbulent quantities is more pronounced near the convex wall. Negative incidence effect enhances turbulent quantities near the concave wall and suppresses it near the convex wall.

The inlet Reynolds number, in the range of (7 to 10×10^5), has little effect on the mean and turbulent flow quantities.

Curved channel and diffuser published data are predicted using body-fitted curvilinear code solver with reasonable agreement. The mathematical model captures the main features of the present experimental results. However, the discrepancy increases near the diffuser curved side walls.

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