Fundamental Study on Flow Deflector to Improve Diffuser Performance

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1. Introduction

Diffusers of diverging pipes/ducts are extensively used in many industrial aspects. In consequence of various studies, diffuser works most efficiently at the expanding angle of 5 to 10 degree. However, in the automobile catalytic converter, an inefficient design of diffusers with large expanding angle under spatial and cost limitation has been designed. We have proposed a flow deflector inside the diffuser-part of an automobile catalytic converter, in order to reduce energy loss and to improve thermal uniformity. In this study, using conical and two-dimensional diffusers, we investigated experimentally the influence of the downstream substrate on the efficiency. In addition, we calculated the flow using OpenFOAM and compared it with the experimental results.

2. Methods

Figure 1 shows the conical diffuser with flow deflector model respectively. The present experimental apparatus is the same as our previous studies⁽¹⁻³⁾.

Computation was carried out using open-source software OpenFOAM version 2.3.0. The overview of numerical set-up is summarized in Table 1.

3. Results and Discussion

3.1. Pressure-loss coefficient from experiment

Figure 2 shows the pressure-loss coefficient ζ of the conical diffuser plotted against Re . For reference, the figure also shows previous data of ζ ⁽⁴⁾. The former concerns the ordinary-diffuser case with small θ_s .

We can confirm that the influence of the flow deflector is remarkable; at $Re \gtrsim 4 \times 10^4$, the reduction on ζ is more than 20% ref even in the ordinary-diffuser case, as well as the downstream-substrate case⁽³⁾.

3.2. Computation

Figure 3 shows a typical visualized flow field obtained by computation, namely, time-averaged velocity vectors inside the diffuser with the flow deflector in the ordinary-diffuser case, on the center plane, at $Re = 5.0 \times 10^4$. It is confirmed that the time-averaged flow field is mostly axi-symmetric throughout the diffuser. We can see a strong annular flow without separation near the walls of the diffuser, in addition to the main flow.

4. Concluding Remarks

It is revealed that the flow deflector is effective for diffusers as well as catalytic converters.

Reference

- (1) Hirata., et al., Proceedings IMechE, Part D: Journal of Automobile Engineering, 222-3, (2008) 455–467.

- (2) Inoue., et al., Proceedings of International Workshop on Environment & Engineering, 306, (2014) 1–6.

- (3) Hirata., et al., JSME Mechanical Engineering Journal, 4-6, (2017) 1–17.

- (4) Rend., et al., International Journal of Heat and Mass Transfer, Vol. 61, No. 1 (2013), pp. 56–61.

Fig. 1 Model: a conical diffuser with a flow deflector.

Table 1 Numerical set-up

Turbulence model	kOmegaSST
Pressure-velocity coupling	PISO
Discretization schemes	
Time	Euler
Gradients	Gauss linear
Laplacian Schemes	Linear, corrected
Interpolation	Linear
Boundary conditions	
Inlet	Fixed velocity. Values of k and ε correspond to 5% turbulence intensity
Outlet	Fixed pressure ($p=0$)

Fig. 2 Pressure-loss coefficient ζ of a conical diffuser versus Re

Fig. 3 Velocity vectors by computation