International Journal of Engineering Research
Volume No.5, Issue No.6, pp : 479-481
ISSN:2319-6890)(online),2347-5013(print)
1 June 2016

Theoretics Study of The Effect of Suction and Blowing on Turbulence

ZHAO Jun
Institute of Physical and Chemical Engineering of Nuclear Industry,Tianjin, China
daisyyuxin@163.com

Abstract :Turbulence is very important in the equipment.It has direct relation to the performance and the power loss of the equipment. The turbulence in the equipment and the method for controlling wall-bounded flow should be studied.Turbulence is a very complicated flow state.Advances in the understanding of the coherent structure of wall-bounded turbulent flow have intensified interest in controlling near-wall turbulence.Many attempts have been made to devise a practical method for controlling wall-bound flows.These include the modification of the wall surface by installing riblets,as well as the use of a compliant wall or a spanwise oscillating wall.Among the approaches considered to date,the use of local suction and blowing deserves more detailed study because it provides an efficient and simple way for locally actuating the wall-bound flow.Moreover, the strength of the actuation can be controlled relative easy by local suction and blowing.Many engineering applications use local suction and blowing to modify a turbulent boundary layer.

In this paper,the effects of localized periodic blowing on a turbulent boundary layer were investigated by numerical calculation.Periodic blowing with different frequency was applied through a spanwise slot by varying the velocity.It is concluded that, with a periodic blow-suction disturbance,the diversification of the velocity will be changed,the effect and the intensity of the turbulence can be decreased.According to this,the performance and the power loss of the equipment can be optimized.

Keywords: Turbulence, Suction and blowing, Frequency

Introducation

- **Paragraph 1:** ***Background***

The cylinder is one of the important parts of the equipment, it has a direct impact on the performance of the equipment.Flow field near the cylinder is a important factor influencing the performances of the cylinder.Through the calculation of flow field near the cylinder ,the gas flow characteristics and the flow state can be analyzed.Flow state is mainly divided into two kinds ,including laminar flow and turbulence. Laminar flow is a kind of flow with more rules.Relatively, turbulent flow is more complex.Turbulence is a viscous fluid (liquid, gas, plasma) under the condition of high Reynolds number due to instability caused by the extreme chaotic flow state.It is a widespread fluid flow phenomenon in nature and engineering.At the same time it is an important problem need to be solved in the natural sciences and engineering technology. A lot of problems in engineering and technology has closely relation to turbulence[1]. Relative to the laminar boundary layer ,the turbulent boundary layer can make the wall friction resistance increases significantly.At the same time ,the energy consumption increases. It pose a serious threat for the safety and reliability of the system.Therefore, the analysis of the turbulent boundary layer flow structure and its forming reason and the study of the effective way to control the turbulent boundary layer turbulence become one of the research frontier.In the early days of the study, the turbulent boundary layer flow is considered to be a completely random phenomenon. In the middle of the twentieth century, with the rapid development of the fluid mechanics experimental technology, the pulsating characteristics of turbulence can be researched.Through a lot of experimental observation and measurement, it has been found that in the turbulent boundary layer, the large scale motion form has universality and repeatability.It is called coherent structure (also called quasi-ordered structure) [1].Further research shows that the turbulence is superimposed by multi-scale structural movement of the coherent structure[1], not only exists in large scale, also exists in small scale [1].Different scale of coherent structure has very strong intermittent phenomenon. Phase average results show that they share common features.Coherent structure's discovery is a major breakthrough in the study of turbulence, make the understanding of the nature of turbulence from completely random disordered phase into a new stage [1,2].Coherent structures are now widely recognised as the most important thing in turbulence structure.It plays an important role in the evolution and development of turbulence.Theoretical and experimental studies of turbulent coherent structures opens a new route for the understanding of the essence of turbulence [1]. Many attempts have been made to devise a practical method for controlling wall-bound flows.These include the modification of the wall surface by installing riblets,as well as the use of a compliant wall or a spanwise oscillating wall.Among the approaches considered to date,the use of local suction and blowing deserves more detailed study because it provides an efficient and simple way for locally actuating the wall-bound flow.Moreover, the strength of the actuation can be controlled relative easy by local suction and blowing.Many engineering applications use local suction and blowing to modify a turbulent boundary layer.

- **Paragraph2:** ***Methods***

The gas flow state near the cylinder may be changed with a local suntion and blowing, it can have certain influence to the power loss of the cylinder,it can also make the influence degree with the cylinder size changed. If the local suction and blowing was used, it is possible that the flow state is closer to laminar flow.Will the local suction and blowing change the flow state?In order to solve this problem, to judge whether the flow field near the cylinder is chanded, to study the velocity distribution near the cylinder, the change of the gas velocity distribution near the cylinder was calculated. McCormack method is a kind of calculation method of the fluid mechanics.A lot of fluid flow problems are able to give satisfactory results with this mehhod[3].In this paper, McCormack method is choosed to calculate the velocity distribution both with and without suction and blowing near the cylinder.

The control equations are two-dimensional navier-stokes equations.

Ignore the volume force and volume heat:

$$\frac{\partial U}{\partial t} = -\frac{\partial E}{\partial y} - \frac{\partial F}{\partial z}$$

$$U = \begin{Bmatrix} \rho \\ \rho v \\ \rho w \\ E_t \end{Bmatrix}$$

$$E = \begin{Bmatrix} \rho v \\ \rho v^2 + p - \tau_{yy} \\ \rho v w - \tau_{yz} \\ (E_t + p)v - v\tau_{yy} - w\tau_{yz} + q_y \end{Bmatrix}$$

$$F = \begin{Bmatrix} \rho w \\ \rho v w - \tau_{yz} \\ \rho w^2 + p - \tau_{zz} \\ (E_t + p)w - v\tau_{zy} - w\tau_{zz} + q_z \end{Bmatrix} \quad (1)$$

Among them： $E_t = \rho(e + \frac{v^2 + w^2}{2})$

$$\tau_{yz} = \tau_{zy} = \mu\left(\frac{\partial w}{\partial y} + \frac{\partial v}{\partial z}\right)$$

$$\tau_{yy} = -\frac{2}{3}\mu(\frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}) + 2\mu\frac{\partial v}{\partial y}$$

$$\tau_{zz} = -\frac{2}{3}\mu(\frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}) + 2\mu\frac{\partial w}{\partial z}$$

$$q_y = -k\frac{\partial T}{\partial y}$$

$$q_z = -k\frac{\partial T}{\partial z}$$

$$e = c_v T$$

$$p = \rho RT$$

Among them ρ is the gas density， p is the pressure，v and w is the speed in y and z direction，e is the internal energy，T is the temperature of the gas，μ is the viscosity coefficient of the gas,，c_v is the constant pressure specific heat.

Firstly , the equation is changed by using the spatial difference method and the forward right end items. McCormack methods[3] is used to calculate the y direction velocity distribution along the axial direction.

Compute grid is divide to 80 x 80, z direction step length is 0.1 mm, y direction calculation step length 0.05 mm.

Time step is:

$$\Delta t = K(\Delta t_{CFL}) \quad (2)$$

Among them：

$$\Delta t_{CFL} = [\frac{v_0}{\Delta y} + \frac{w_0}{\Delta z} + a\sqrt{\frac{1}{\Delta y^2} + \frac{1}{\Delta z^2}} + 2\nu_{i,j}(\frac{1}{\Delta y^2} + \frac{1}{\Delta z^2})]^{-1}$$

$$\nu_{i,j} = \max[\ 4/3(\gamma\mu_{i,j} / p_r / \rho_{i,j})]$$

K is the number of klang, 0.7;

Δy is the y direction step length;

v_0 is the z direction step length;

γ is the specific heat ratio;

a is the local velocity of sound;

p_r is the prandtl number;

v_0 is the minimum y direction speed;

w_0 is the minimum z direction speed;

$\mu_{i,j}$ is the viscous coefficient at each grid point;

$\rho_{i,j}$ is the current density at each grid point.

International Journal of Engineering Research
Volume No.5, Issue No.6, pp : 479-481

ISSN:2319-6890)(online),2347-5013(print)
1 June 2016

- **Paragraph 3: *Results***

The velocity profile without suction and blowing is calculated at first.The velocity profile is showed in figure 1.

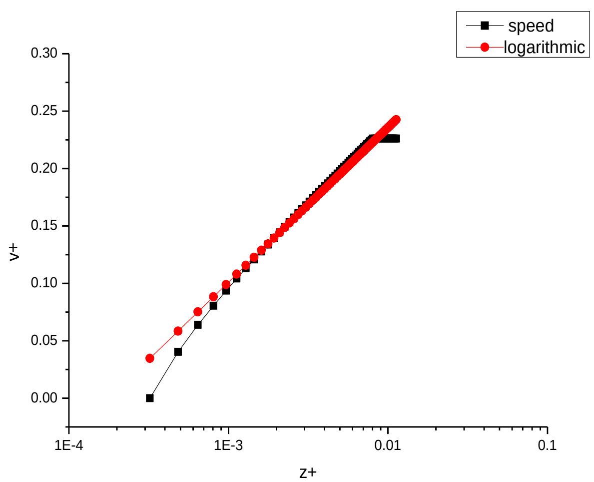
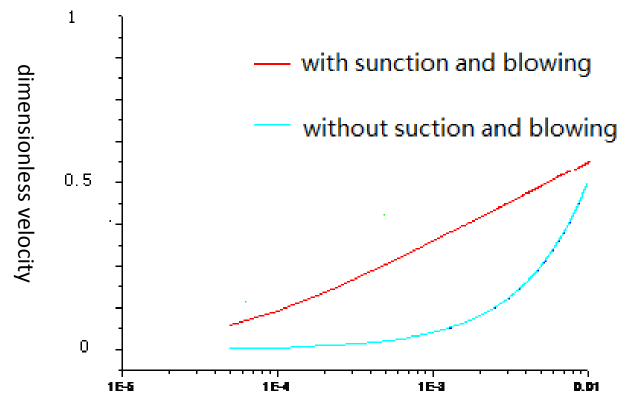


Fig.1 velocity profile

It can be seen from the figure 1 that the velocity profile in the logarithmic law area is coincide with the fitting curve.From the boundary layer characteristics shown in figure 1 (buffer layer, the logarithmic law area), turbulence is exist near the cylinder.And as it is shown in figure 1,the boundary layer is very thin, the velocity gradient is large. There should be a very strong turbulent fluctuation.This all should be considered when calculating the power loss of the cylinder.The local suction and blowing may change the velocity profile.So the velocity profile with a suction and blowing have been calculated.The change is showed in figure 2.



The relative position ,z direction

Fig.2 y direction velocity distribution along the z direction

It can be seen in figure 2 that the y direction velocity distribution has obvious been changed with a local suction and blowing(the suction and blowing velocity is v').The flow state is close to laminar. The change caused the decrease of the velocity pulse, which will decrease the power loss of the cylinder.

References

Zhao Jun，the eddy viscosity constitutive relations and control of Reynolds stress for coherent structures in wall turbulence.Tianjin university master degree thesis.2008:100-101.

H. alltel, Fluid mechanics. Prandtl.science press. 2008:227-306.

John D.Anderso,Computational fluid mechanics.Mechanical industry publishing house.2009:100-300.