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CFD ANALYSIS OF HEAT TRANSFER AND FLUID FLOW FROM WING TYPE TURBULATOR

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Abstract
A numerical analysis was carried out to investigate heat transfer and flow characteristics in a rectangular channel with turbulent flow by using rectangular wing .A computational fluid dynamics software package was used to compute the 3-D steady viscous flows with heat transfer. A rectangular wing with finite thickness of vortex generator is studied. Fin was studied at different angle of attacks of 30˚ and 45˚ and different velocity of inlet .For this wing Nusselt number and Reynolds Number is calculated .The effects of turbulent are stimulated by (k-ε) turbulent model. The results show that vortex generator effectively increases the heat transfer in the rectangular channel. Also the pressure drop was more while using this vortex generators
Keyword: CFD, Vortex Generator, Rectangular Wing

Introduction

An attempt has been made to carry out CFD analysis to fluid flow and heat transfer characteristics of a rectangular channel with a certain thickness. The heat transfer due to the use of rectangular wing has increased as observed in CFD analysis. The Nusselt number has increased with the increase in Reynolds number also the friction factor has increased with the increase in Reynolds number. Also the performance evaluation factor was found out and compared with Reynolds number, it was increasing with the increase in the Reynolds number.

Nomenclature

A surface area
b span of the vortex generator
c chord length of the vortex generator
Cp specific heat of the fluid
*Dh*hydraulic diameter
*h*convective heat transfer coefficient
H length dimension (distance between the plates)
*k*thermal conductivity of the fluid
L length of the channel
Nu local Nusselt
*Pr*Prandtl number
Re Reynolds number
T temperature
*x,y,z*axes

Details of the rectangular duct considered:

The duct is made of aluminum material with size of 50x25mm as shown in fig.1 with a length of 275mm.At the middle of the rectangular channel a rectangular fin is attached with different angle of attacks of 30˚ & 45˚ and the analysis is carried out. The rectangular wing has a dimension of length-10mm, breadth-1mm and height-20mm.The bottom wall temperature was kept at 300˚C and at inlet ambient condition is used. The inlet velocity of the channel was taken as 2m/s, 3m/s and 4m/s.The hydraulic diameter Hd of the duct is 33.33mm. The number of elements for without fin were 465226 and for rectangular wing at 30˚ and 45˚ were 484660 and 487561 respectively (Figure 2).

Results and discussions:

Analysis of vortices generated at 2m/s in rectangular wing. From the Fig 3 we can see that there are only z velocity vectors, which are along the length of rectangular channel. At the initial plane no vortices are created.

From the Fig 4 the velocity vectors are striking on the rectangular wing, due to which their direction changes. There is negligible change in the x component of velocity, the vortices are created by the y component of velocity. The z component becomes less in magnitude due to striking.

From the Fig 5, vortices are created after striking the rectangular wing, there is increase in the y component of velocity also the z component of velocity increases. The vortices strength depends upon the y component of velocity.

From the Fig 6, after striking the wing, the vortices losses their strength as they move along the rectangular channel. We can also see that there is much drop in the y component of velocity (Table 1).

From the above tables we can conclude that with the increase in the Reynolds number the Nusselt number goes on increasing this means with the increase in turbulence the heat transfer increases.

We can see that as the Reynolds number increases the Performance Evaluation Parameter goes on decreasing (Figure 7). Performance of the system goes on decreasing with the increase in velocity. From the above graph it is found that performance evaluation parameter for 30˚ is better than 45˚.

Table 1

Velocity (m/s)	Reynolds Number		Nusselt Number	
AOA	30˚	45˚	30˚	45˚
2	3430.69	3422.22	21.944	22.1065
3	5255.28	5205.35	31.1916	31.308
4	7079.58	6957.73	39.806	39.765

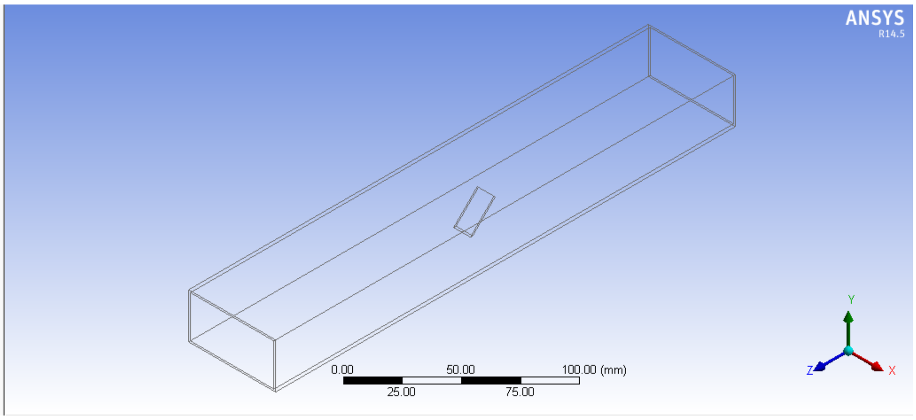

Figure 1. Rectangular wing at a distance of 137.5mm from inlet.

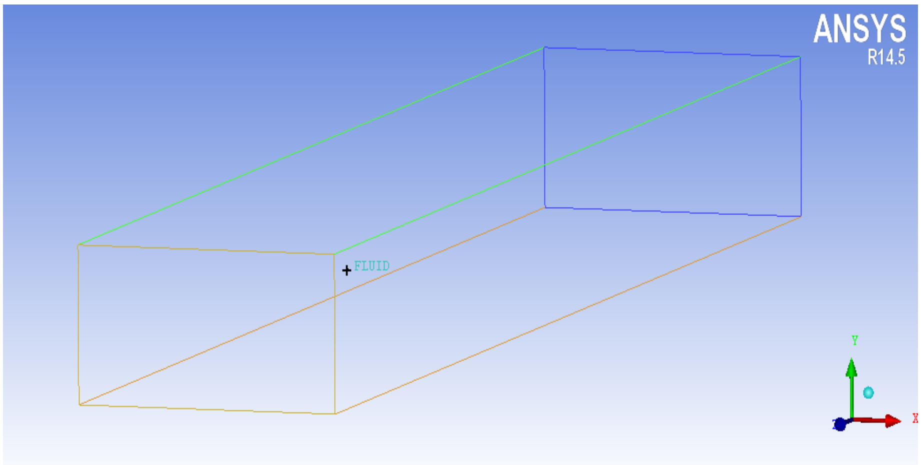

Figure 2: Without fin rectangular duct.

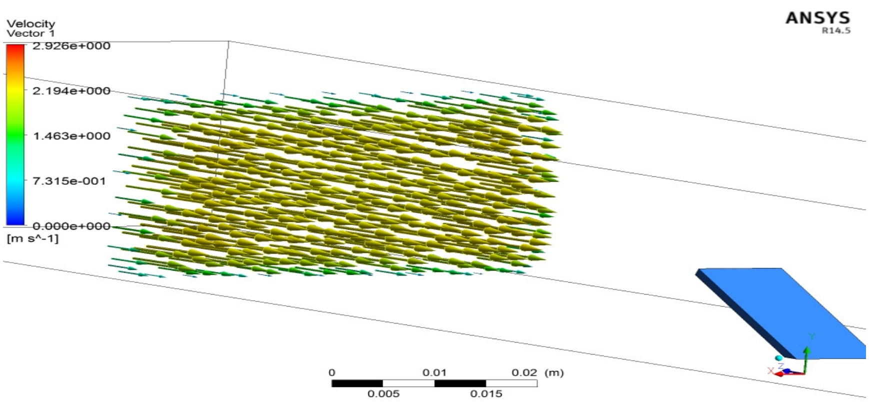

Figure 3: Velocity vectors at a distance of 50mm from the inlet.

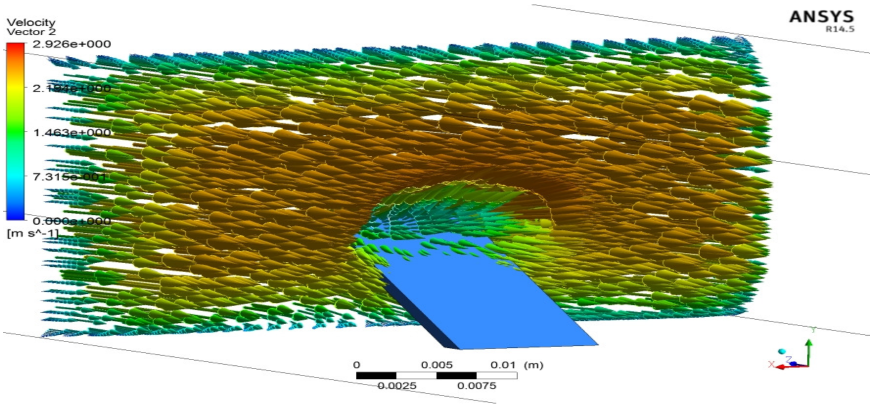

Figure 4: Fig Velocity vectors at a distance of 119.5mm from the inlet.

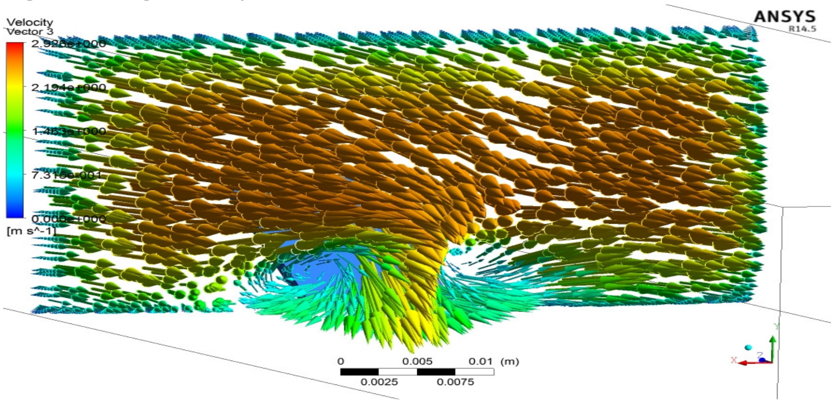

Figure 5: Velocity vectors at a distance of 137.5mm from the inlet.

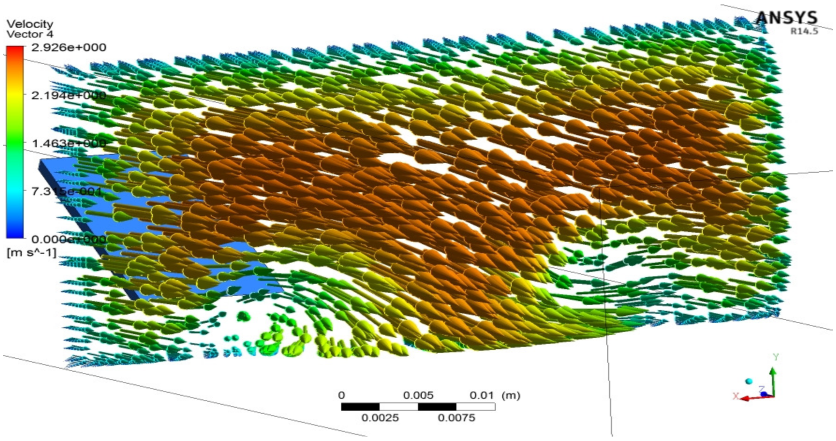

Figure 6: Velocity vectors at a distance of 175mm from the inlet.

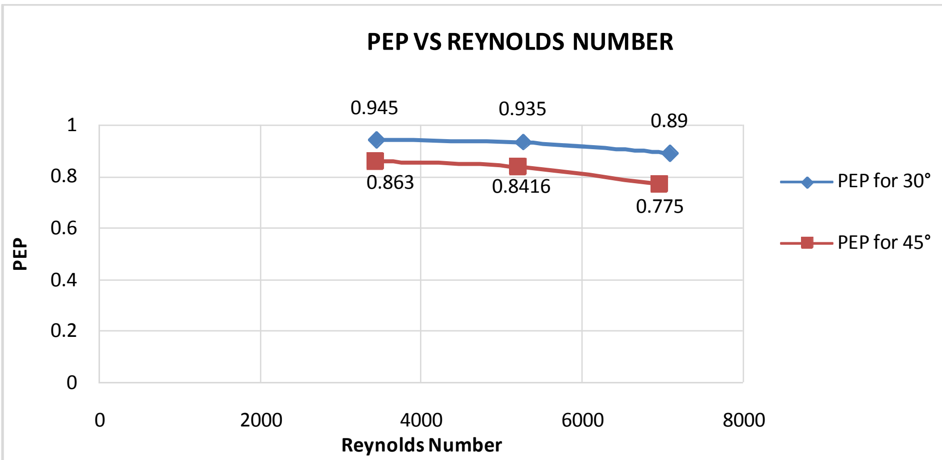

Figure 7 Performance Evaluation Parameter for Rectangular wing at AOA 30° & 45°.

Conclusion:

- The Nusselt number ratio for a rectangular wing at attack angles of 30° and 45° shows that the heat transfer enhancement takes place to some extent and a higher attack angle produces higher heat augmentation but at the cost of pressure loss. It is also seen that the pressure loss is greater at higher attack angles. Thus the overall performance evaluation parameter goes below one. The performance evaluation parameter goes on decreasing with the increase in angle of attack.
- The plots as well as figures conclude that vortices formed in rectangular wing lasts till the end of the rectangular channel, hence there is heat augmentation in case of rectangular wing but at the loss of pressure.
- In rectangular wing at an AOA 45° magnitude of y component of velocity vector is having more magnitude than that of rectangular wing at AOA 30°. Hence heat transfer rate is more at 45°.

References:

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2. Heat transfer enhancement in a rectangular channel using vortex generator in a laminar flow by Ninad C. Maniar