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COMPARISON OF HEXAGONAL, SQUARE, AND CIRCULAR SECTIONED HONEYCOMB PERFORMANCE IN A WIND TUNNEL

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ABSTRACT

Experimental studies are very important in designing a new product. In aerodynamic designs, wind tunnel tests are commonly used in experimental studies. In experimental studies, accuracy is the most critical point to verify the results. Laminar flow is preferred in the test section to obtain accurate results. Turbulence intensity is the main drawback of wind tunnel tests. Hence in this study, turbulence intensity of the hexagonal, square, and circular sectioned honeycomb is investigated. In numerical studies, a circular sectioned subsonic wind tunnel is used. The computational fluid dynamic (CFD) analysis of three-dimensional (3D) flow in a circular sectioned desktop size wind tunnel is used for comparison.

Keywords: CFD, Wind tunnel, Honeycomb, Turbulence

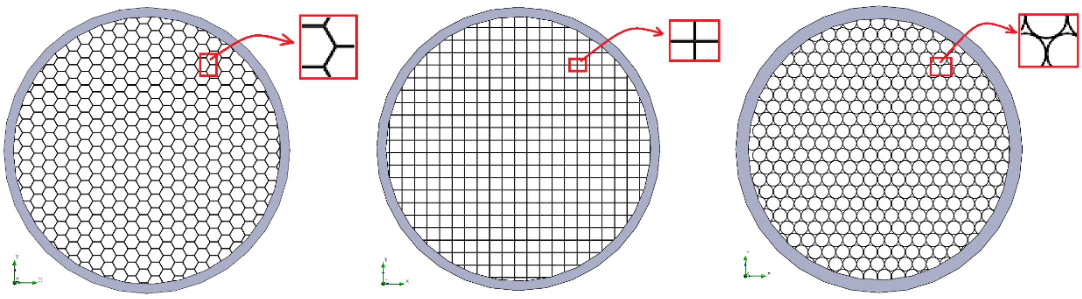
1. INTRODUCTION

In aerodynamic designs, wind tunnel tests are commonly used in experimental studies. In experimental studies, accuracy is the most critical point to verify the results. Experimental setup directly affects the accuracy, to obtain more accurate results setup must be optimized. In aerodynamic designs, wind tunnel tests are commonly used in experimental studies. Turbulence intensity is the main drawback of wind tunnels. It must be minimized to improve the accuracy of the experiments. Honeycombs are used to decrease the turbulence intensity of the wind tunnels. Different shaped honeycombs can be used such as hexagonal, square, and circular.

In the literature, many different studies exist about the honeycombs, wind tunnels, and flow effect on temperature and surfaces. Some different applications exist for the effect of the honeycomb tip and orientation on the cooling of turbines [1, 2, 3, 4, and 5]. Many different aerodynamic experimental studies are performed with aerodynamics concepts and wind tunnels to verify the numerical results [6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17]. Also, many different experimental applications exist in the literature about the flow effect on surface abrasion and erosion [18, 19, and 20].

2. ANALYSIS

In this section, the turbulence intensity of the hexagonal, square, and circular sectioned honeycombs (in figure 1) are investigated. In the analyses, the SolidWorks Flow Simulation tool is used. A Circular sectioned desktop size wind tunnel model (in figure 2) with 0.03 m^2 section area and 0.8 m length is used. Each cell area of the honeycomb is 78.5 mm^2 and the length of the honeycomb is 0.2 m. Inlet velocity is applied as 6 m/s. element number of mesh model is 375000. Flow simulation results are given in 7 sections (in figure 3).



(a) (b)

(c)

Figure 1. (a) hexagonal, (b) square, and (c) circular sectioned honeycomb models

Figure 2. Wind tunnel model

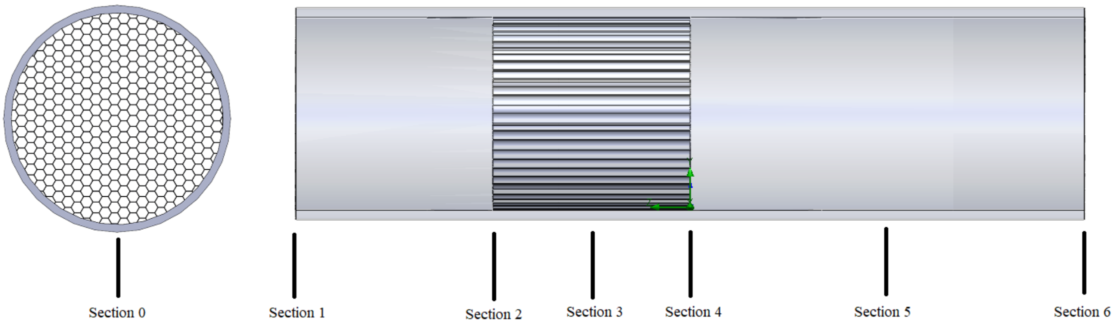
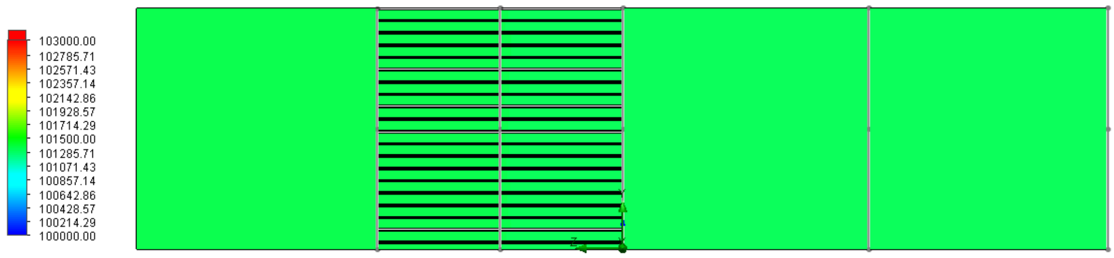


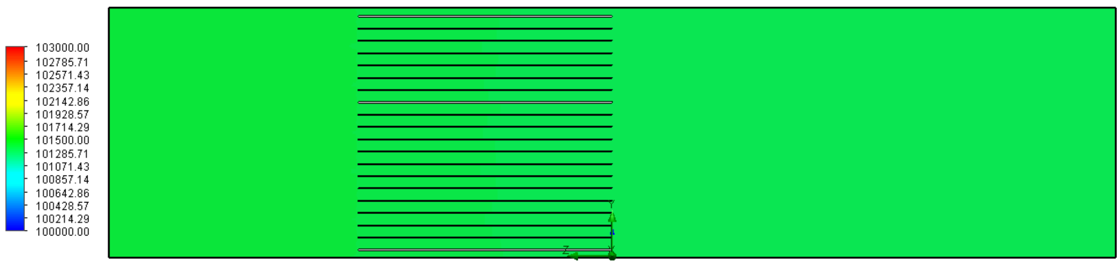
Figure 3. Section lines

3. ANALYSIS RESULTS

Analysis results of the hexagonal, square, and circular sectioned honeycombs are given in this section. In the aerodynamic analyses, pressure distribution (figure 4), velocity distribution (figure 5), and turbulence intensity distribution (figure 6) are important parameters. Hence for the comparison, these parameters are used as performance parameters. Also, velocity distribution at different sections is given for hexagonal, square, and circular honeycomb in Figures 7, 8, and 9 respectively. In the literature, the test section is selected between the honeycomb and the fan. Hence, section 5 in figure 3 is defined as the test section.



(a) Hexagonal



(b) Square

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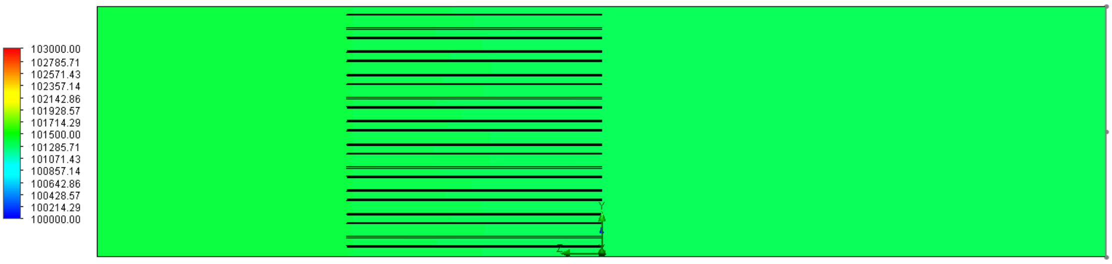
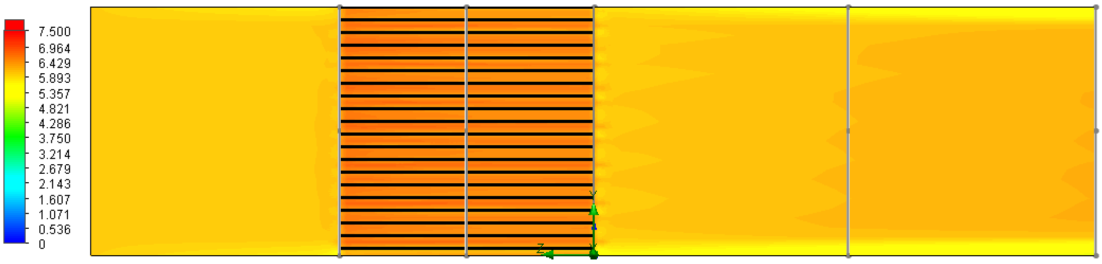
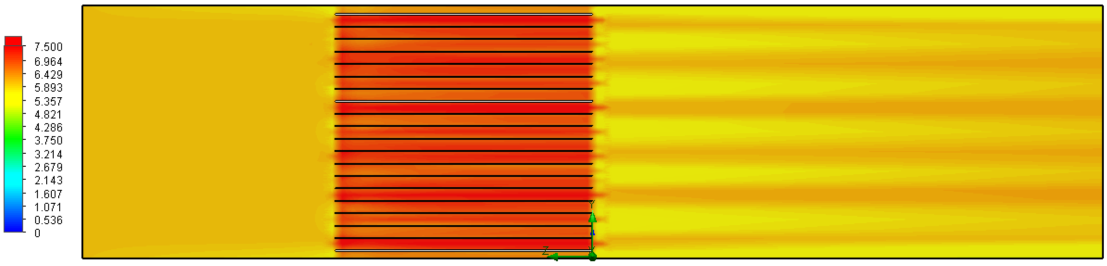


(c) Circular

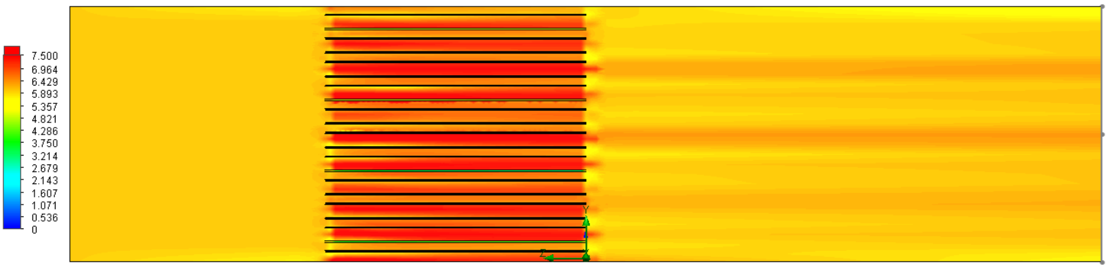
Figure 4. Pressure distribution at section 0



(a) Hexagonal

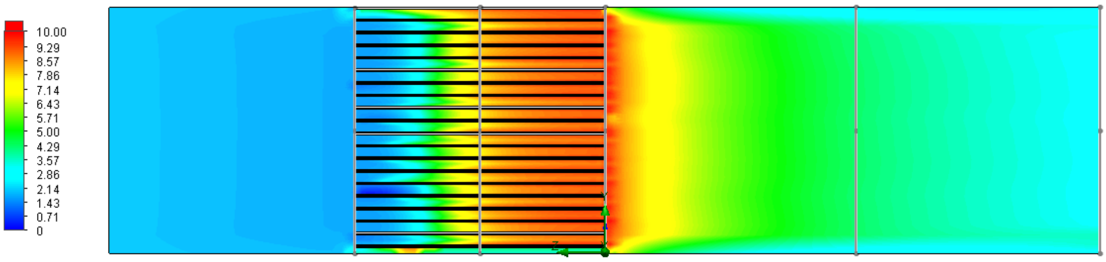


(b) Square

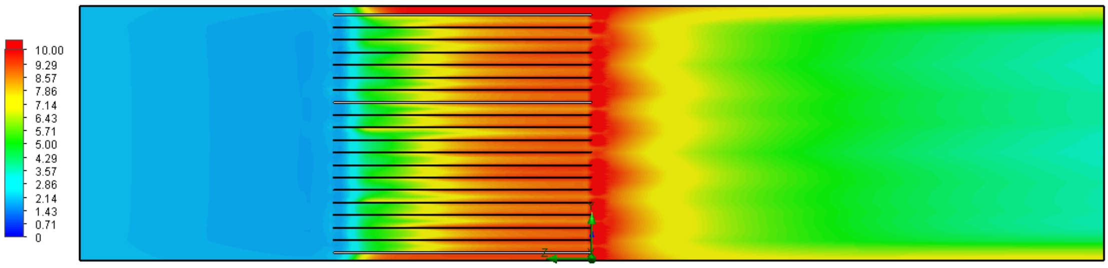


(c) Circular

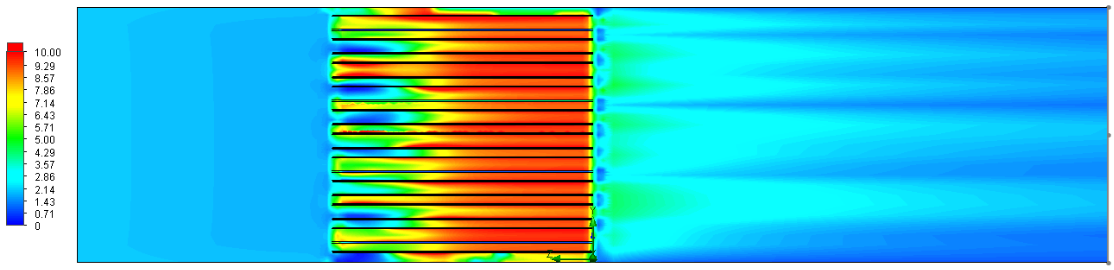
Figure 5. Velocity distribution at section 0



(a) Hexagonal

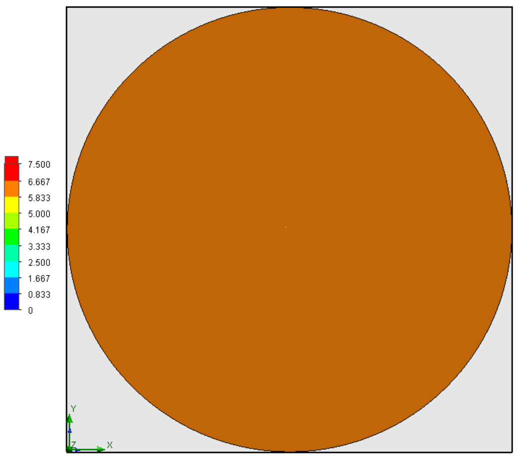


(b) Square

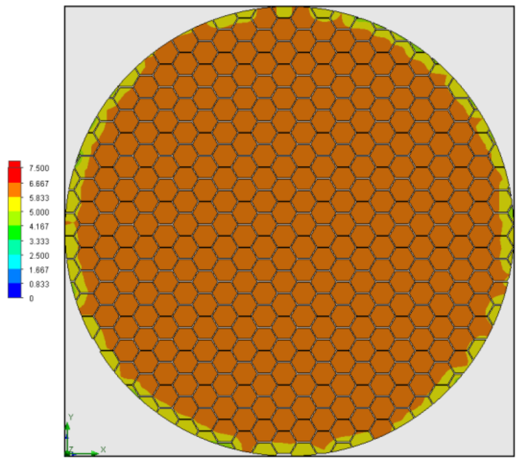


(c) Circular

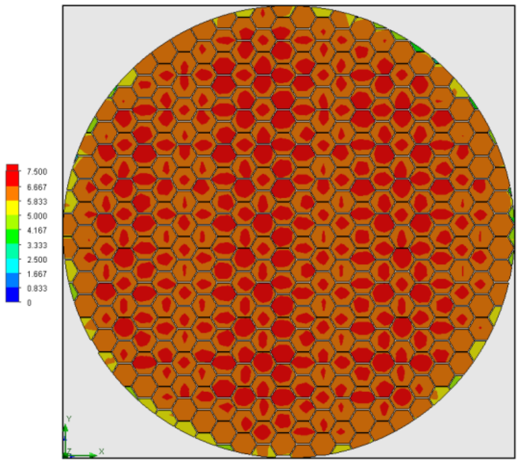
Figure 6. Turbulence intensity distribution at section 0



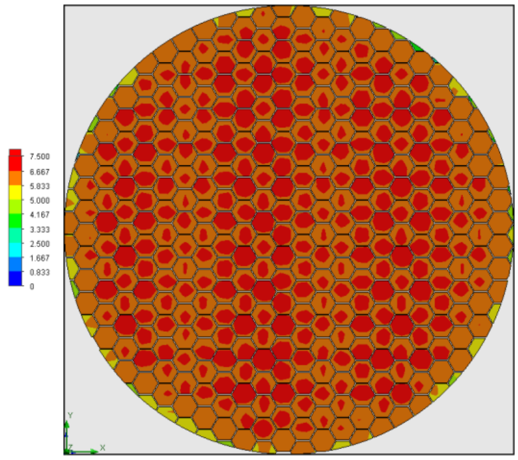
(a) Velocity distribution at section 1



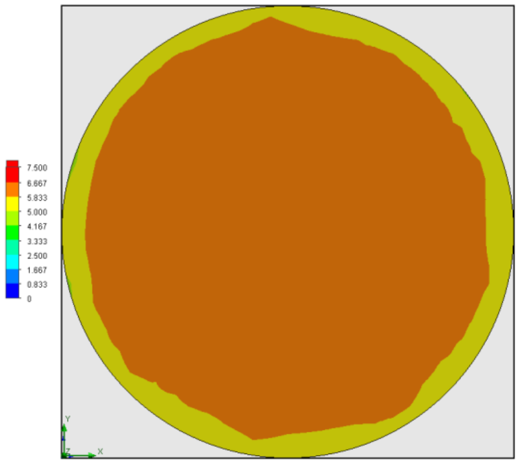
(b) Velocity distribution at section 2



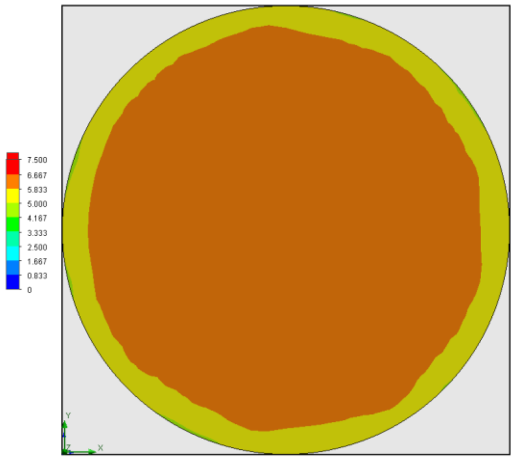
(c) Velocity distribution at section 3



(d) Velocity distribution at section 4

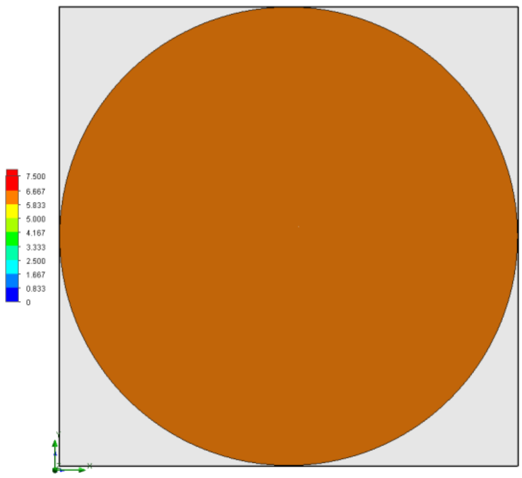


(e) Velocity distribution at section 5

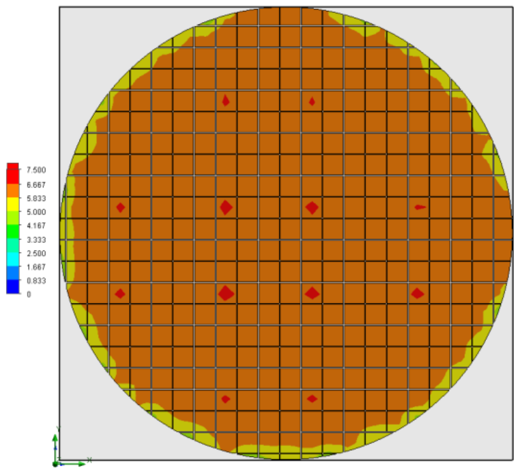


(f) Velocity distribution at section 6

Figure 7. Velocity distribution of hexagonal honeycomb



(a) Velocity distribution at section 1



(b) Velocity distribution at section 2

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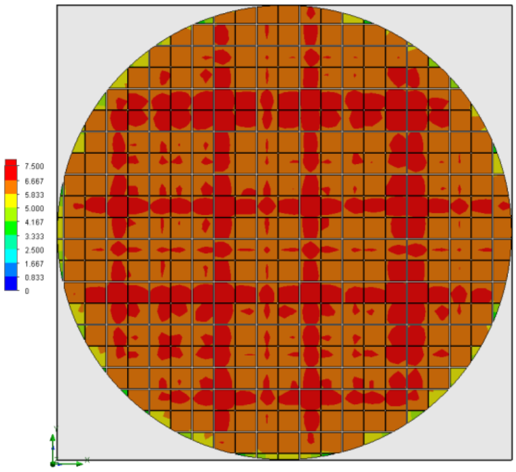
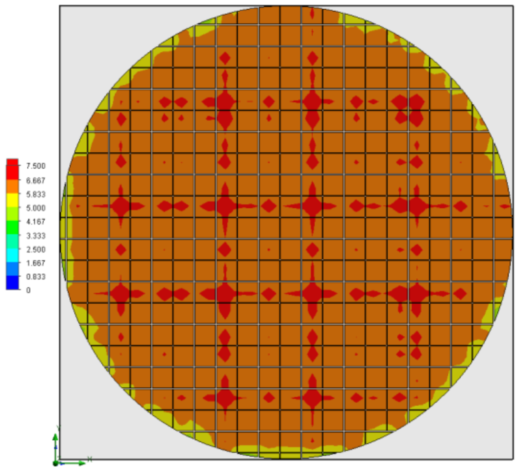
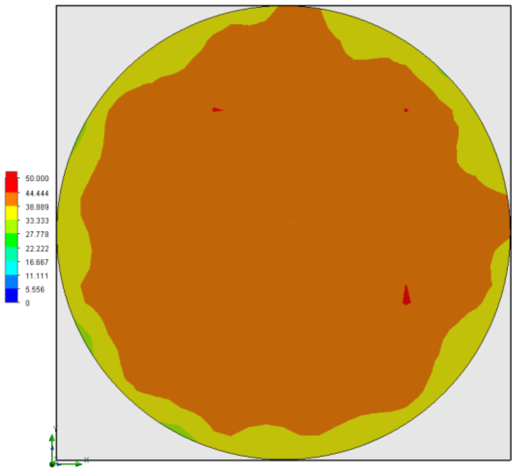


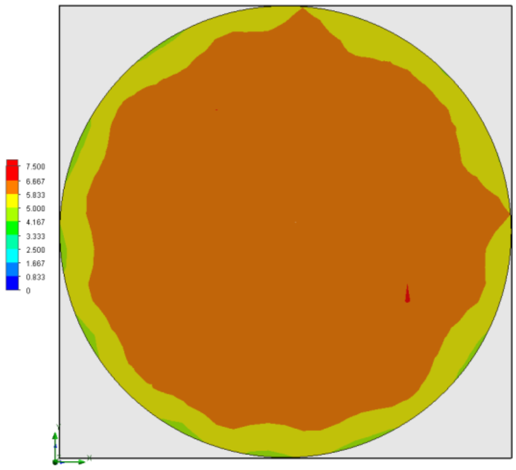
(c) Velocity distribution at section 3



(d) Velocity distribution at section 4

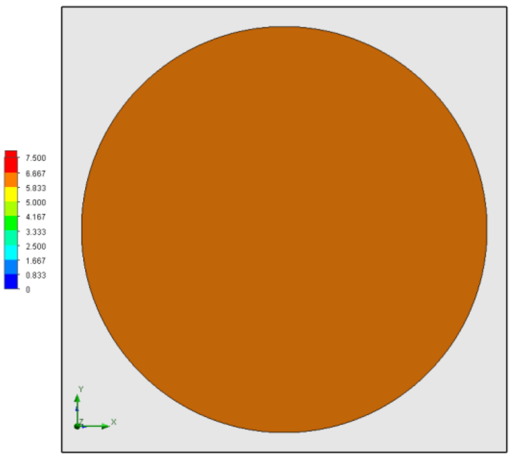


(e) Velocity distribution at section 5

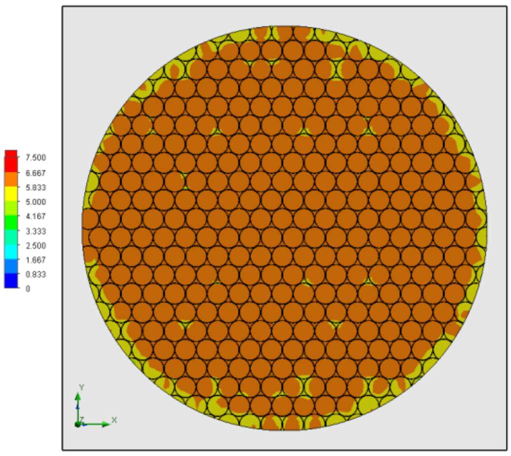


(f) Velocity distribution at section 6

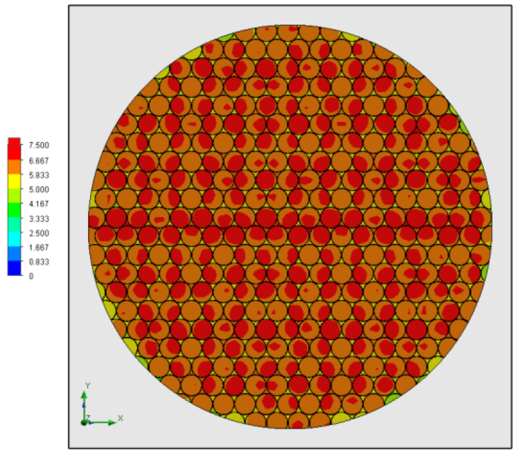
Figure 8. Velocity distribution of square honeycomb



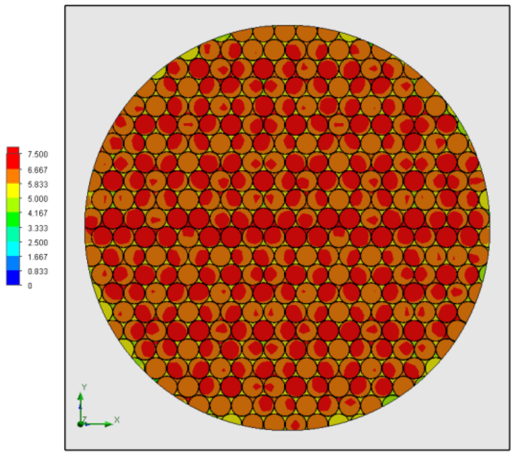
(a) Velocity distribution at section 1



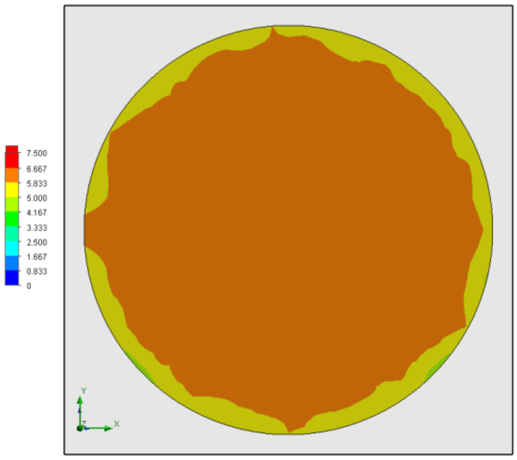
(b) Velocity distribution at section 2



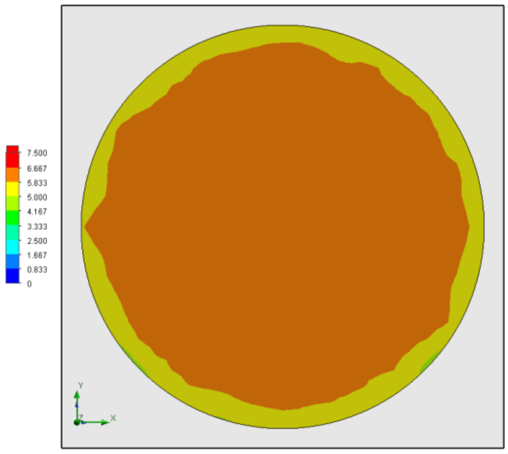
(c) Velocity distribution at section 3



(d) Velocity distribution at section 4



(e) Velocity distribution at section 5



(f) Velocity distribution at section 6

Figure 9. Velocity distribution of circular honeycomb

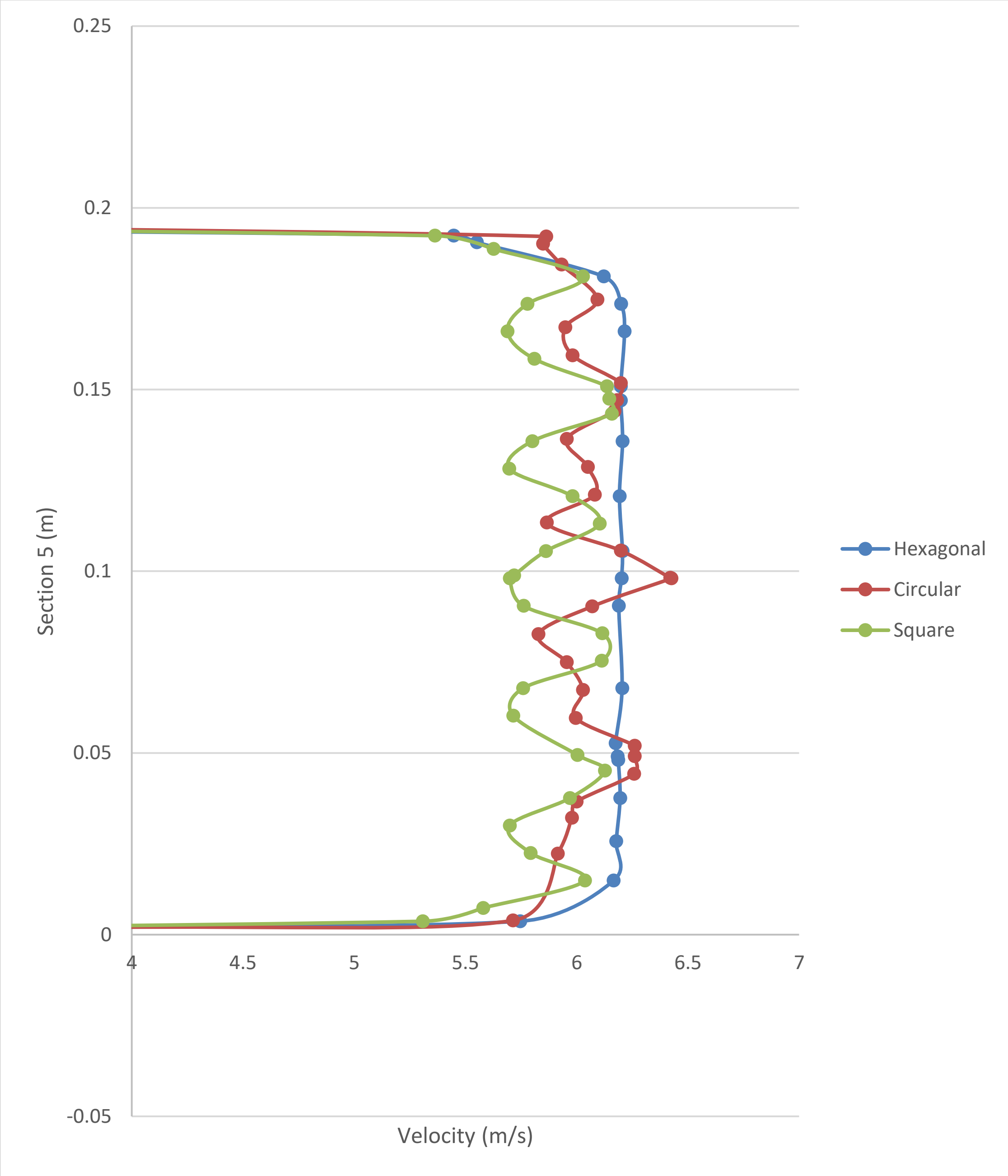


Figure 10. Velocity values at section 5

When the Figure 10 is examined, it is seen that when compared in terms of velocity, it has been determined that a more uniform velocity profile is obtained from the hexagonal honeycomb structure compared to other structures.

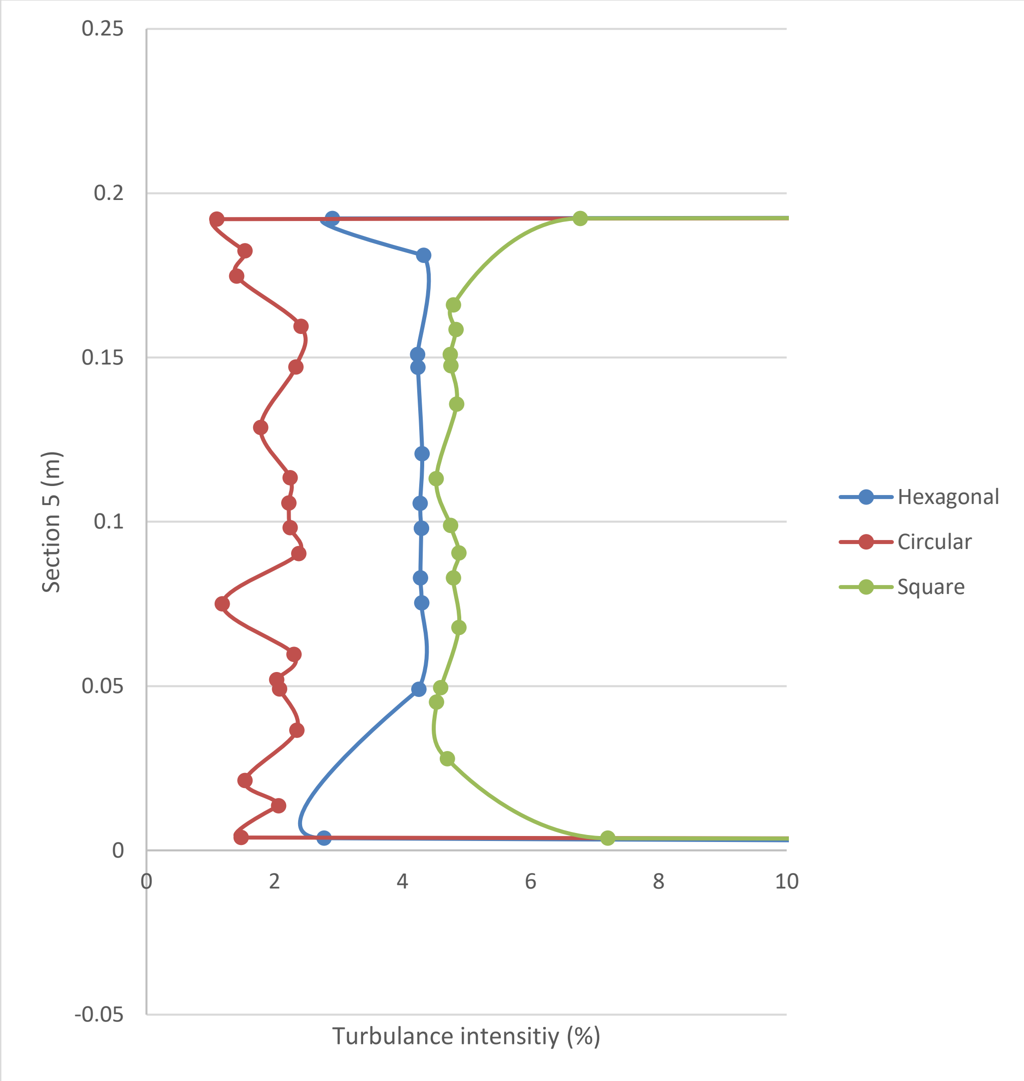


Figure 11. Turbulance intensity values at section 5

When the Figure 11 is examined, it is seen that when compared in terms of turbulence intensity, it has been determined that a more smooth flow profile is obtained from the hexagonal honeycomb structure, especially in the measurement region, compared to other structures.

4. CONCLUSION

Honeycombs are used to decrease the turbulence intensity of the wind tunnels. Different shaped honeycombs can be used such as hexagonal, square, and circular. In this study, the turbulence intensity of the hexagonal, square, and circular sectioned honeycomb was investigated. In the numerical studies, a circular sectioned subsonic wind tunnel was used. The computational fluid dynamic (CFD) analysis of three-dimensional (3D) flow in a circular sectioned desktop size wind tunnel was used for the comparisons. The flow characteristic of these there shaped honeycombs were given in figure

6. This figure showed that a square-sectioned honeycomb gives a better flow regime than the circular one. And the hexagonal sectioned honeycomb gives a better flow regime than the others.
This result is directly related to the cell corners and solid-fluid interaction surfaces. Optimum corner shape and surface area are at the hexagonal-shaped honeycomb so it can give more accrued experimental results.

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