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COMPARISON OF SQUARE AND CIRCULAR SECTIONED WIND TUNNEL PERFORMANCE

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ABSTRACT

In this study, square and circular sectioned subsonic wind tunnel performance are examined numerically. The computational fluid dynamic (CFD) analysis of three-dimensional (3D) flow in square and circular sectioned wind tunnels are used for comparison. 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. Turbulence intensity is the main drawback of wind tunnels. Hence in this study, turbulence intensity of the square and circular sectioned desktop size wind tunnel is investigated.

Keywords: CFD, Wind tunnel, Turbulence

1. INTRODUCTION

In the design stage of a new product, numerical and experimental studies are commonly used. Numerical analyses should be performed for the new designs but these analyses do not give accurate results for some analyses types. Hence, numerical applications should be verified by experimental studies. Experimental studies are very important in designing a new product. In experimental studies, accuracy is the most critical point to verify the numerical 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.

In the literature, many different studies exist about the aerodynamic applications, wind tunnels, and flow effects on temperature and surfaces. The design and the aerodynamic and acoustic performance of wind tunnel applications can be found in the literature [1, 2, 3, 4, 5, and 6]. Many different aerodynamic experimental studies are performed with aerodynamics concepts and wind tunnels to verify the numerical results [7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and18]. Also, many different experimental applications exist in the

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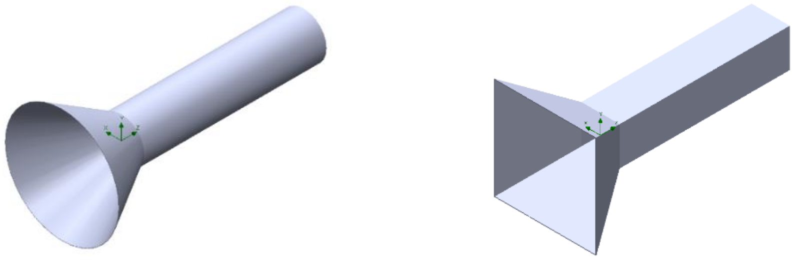
literature about the flow effect on surfaces such as abrasion and erosion [19, 20, and 21].

2. ANALYSIS

In this section, the turbulence intensity of the square and circular sectioned desktop size wind tunnel is investigated. In the analyses, the SolidWorks Flow Simulation tool is used. Square and circular sectioned wind tunnel models (in figure 1) with 0.03 m^2 section area and 0.8 m length are used. Inlet flow rate is applied as 1.2 m^3/s. The element number of the finite model is 375000. Flow simulation results are given in 6 sections (in figure 2).



(a) Circular (b) Square

Figure 1. Solid models of Tunnels

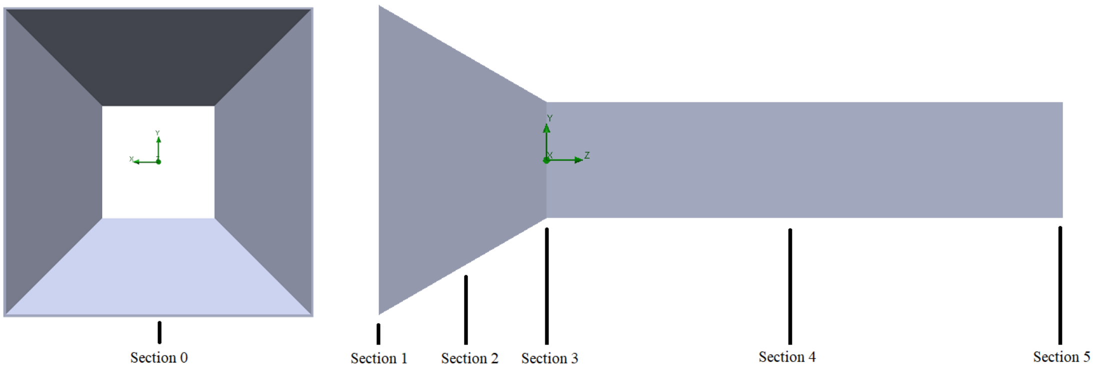
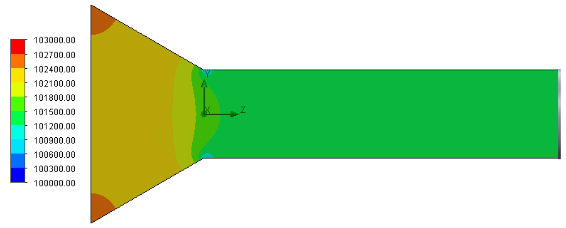


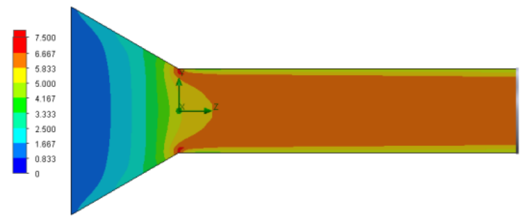
Figure 2. Sections for Results

3. ANALYSIS RESULTS

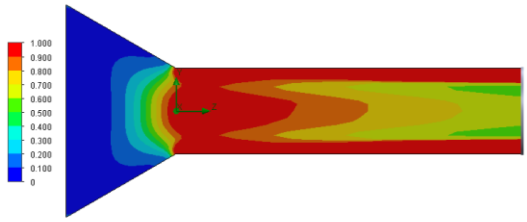
Two different desktop-size wind tunnel models are used in the analyses which are square and circular sectioned models. In the aerodynamic analyses, pressure distribution, velocity distribution, and turbulence intensity distribution are important parameters. Hence for the comparison, these parameters are used as performance parameters. Circular sectioned models results are given in figure 3 and square-sectioned models results are given in figure 4. In the literature, the test section is selected between the inlet and the fan. Hence, section 4 in figure 2 is defined as the test section.



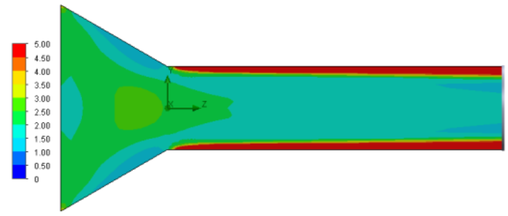
(a) Pressure distribution at section 0



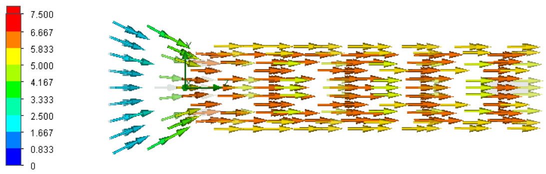
(b) Velocity distribution at section 0



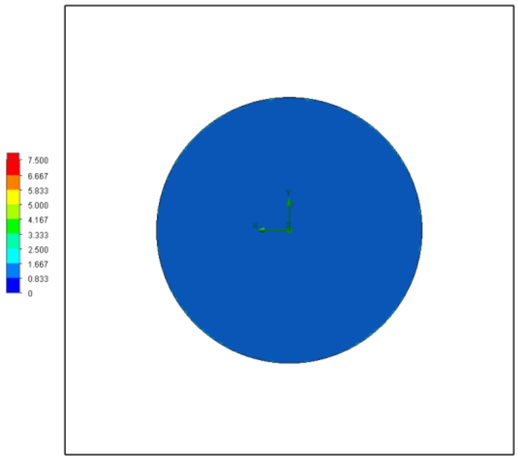
(c) Turbulence energy distribution at section 0



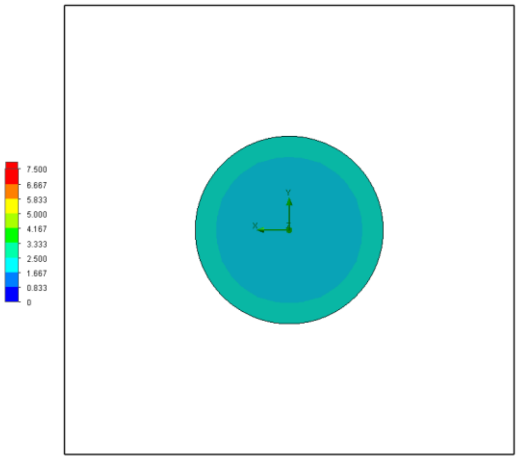
(d) Turbulence intensity distribution at section 0



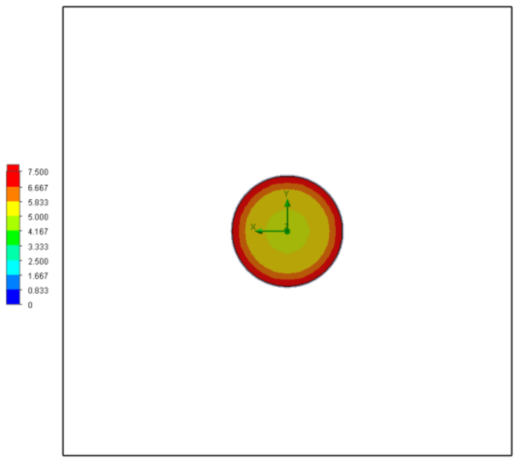
(e) Flow distribution at section 0



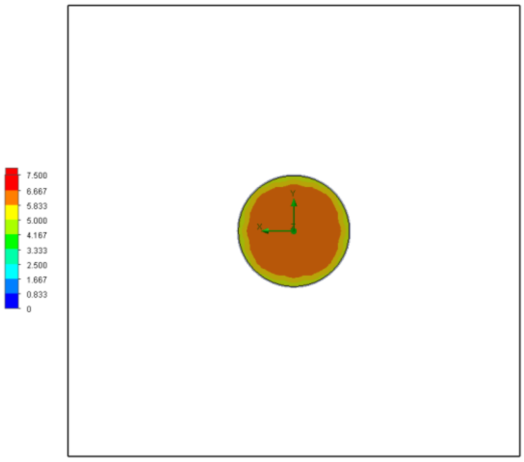
(f) Velocity distribution at section 1



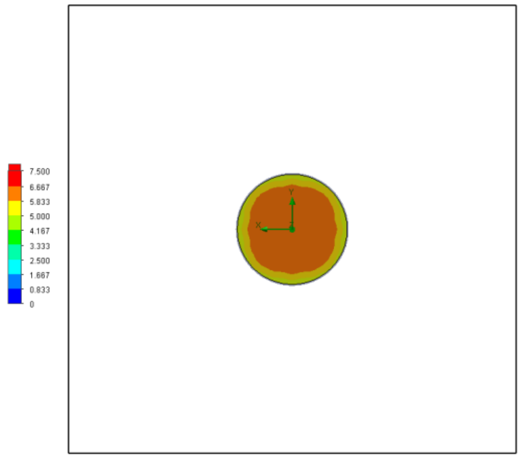
(g) Velocity distribution at section 2



(h) Velocity distribution at section 3

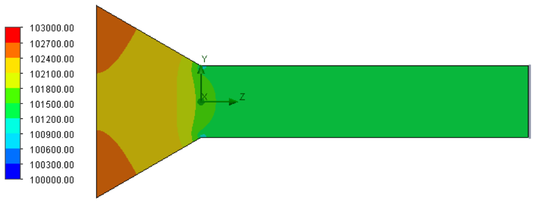


(i) Velocity distribution at section 4

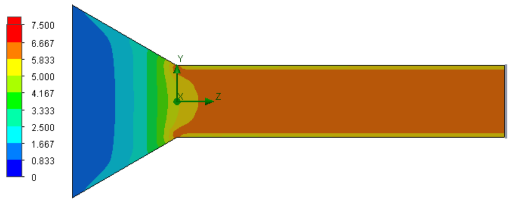


(j) Velocity distribution at section 5

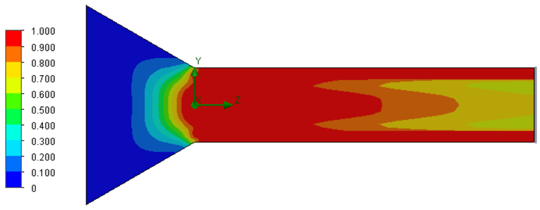
Figure 3. Circular sectioned wind tunnel model results



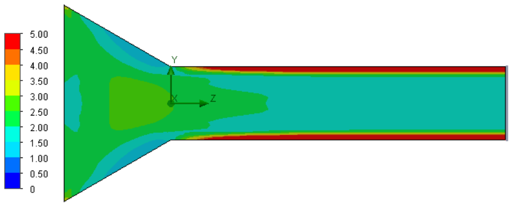
(a) Pressure distribution at section 0



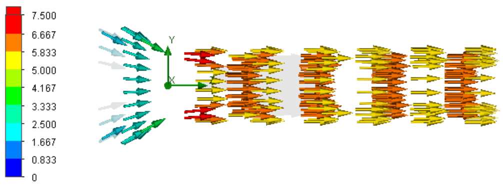
(b) Velocity distribution at section 0



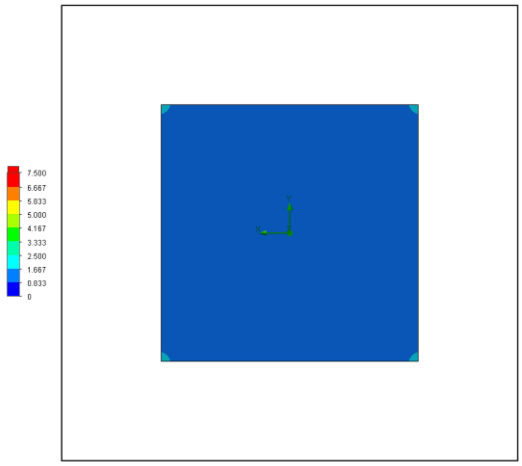
(c) Turbulence energy distribution at section 0



(d) Turbulence intensity distribution at section 0



(e) Flow distribution at section 0



(f) Velocity distribution at section 1

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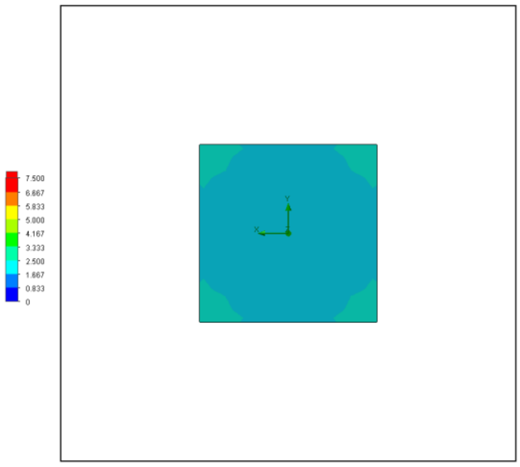
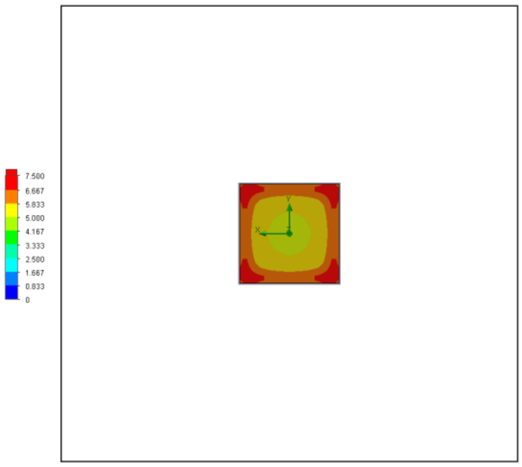
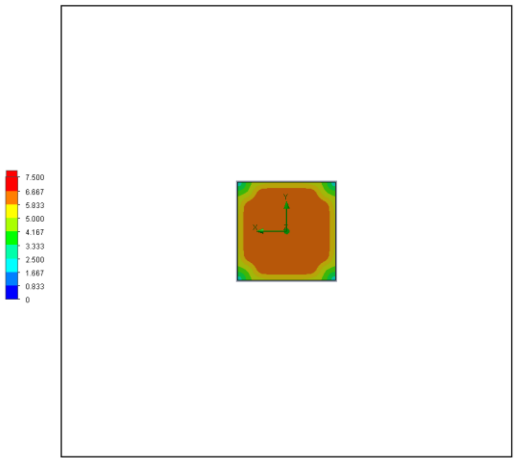


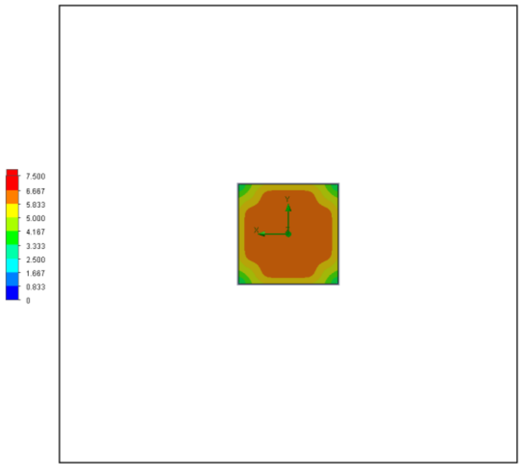
(g) Velocity distribution at section 2



(h) Velocity distribution at section 3

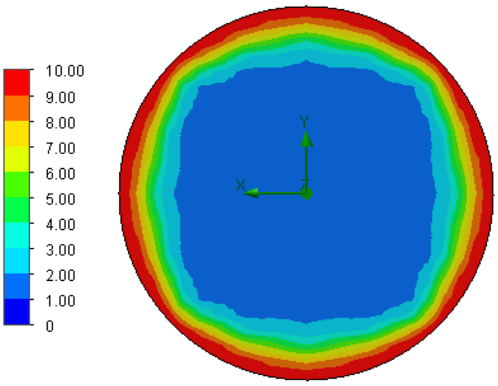


(i) Velocity distribution at section 4

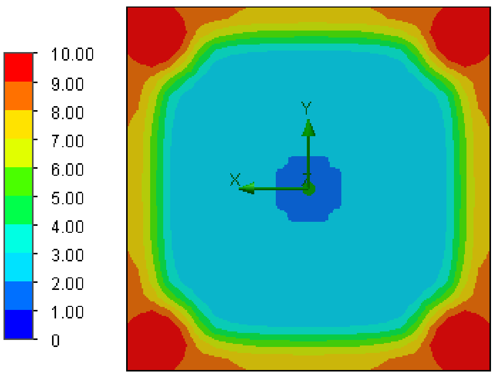


(j) Velocity distribution at section 5

Figure 4. Square sectioned wind tunnel model results



(a) Circular section



(b) Square section

Figure 5. Turbulence intensity distribution at section 4

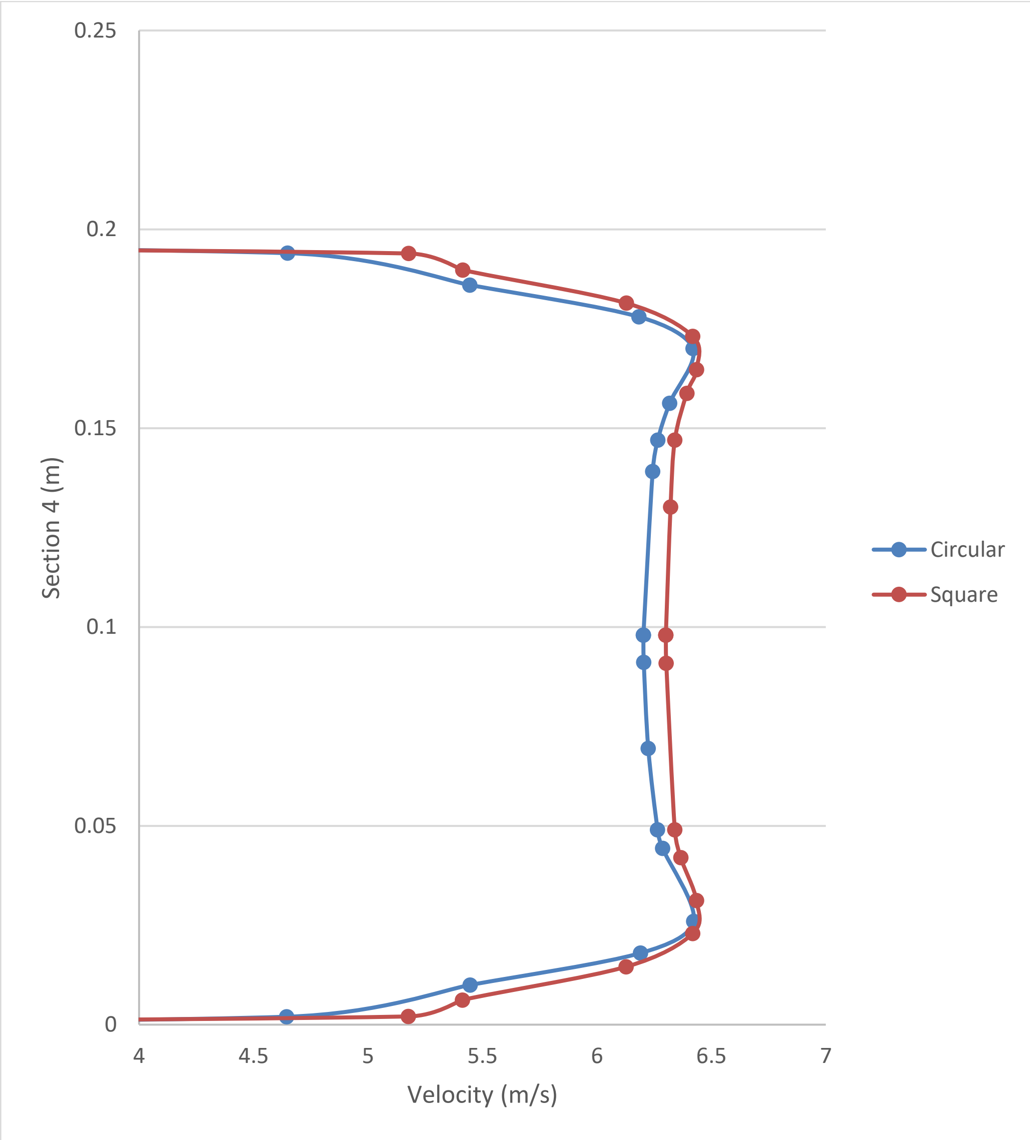


Figure 6. Velocity values at section 4

When the Figure 6 is examined, it is seen that when compared in terms of flow velocity, it has been determined that a velocity profile close to the tunnel entrance velocity is obtained in the circular cross-section wind tunnel compared to the square cross-section wind tunnel. The fact that the obtained speed value is close to the input speed increases the reliability of the experiments to be performed.

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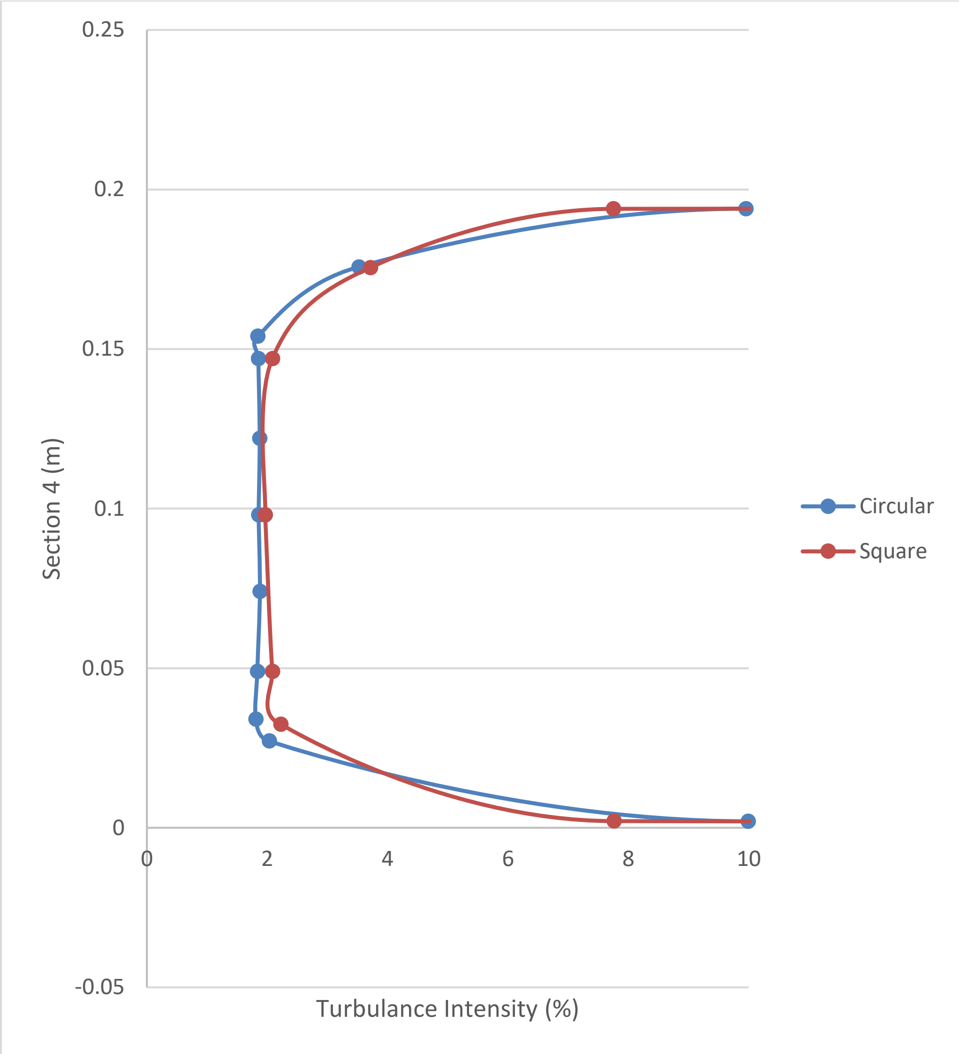

Figure 7. Turbulence intensity values at section 4

When the Figure 7 is examined, it is seen that when the turbulence intensity is compared, it has been determined that less turbulence occurs in the circular section wind tunnel compared to the square section wind tunnel.

4. CONCLUSION

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. Turbulence intensity is the main drawback of wind tunnels. Hence in this study, turbulence intensity of the square and circular sectioned desktop size wind tunnel was investigated. Turbulence intensity distribution at section 4 in figure 5 showed that the circular sectioned wind tunnel has a better flow regime so it can give more accrued experimental results.

5. FUTURE STUDY

To verify the numerical analyses experimental study must be performed. In this study, desktop size wind tunnel models are used because in the future study they will be produced and experimentally investigated.

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