Design and manufacture a Wind Tunnel

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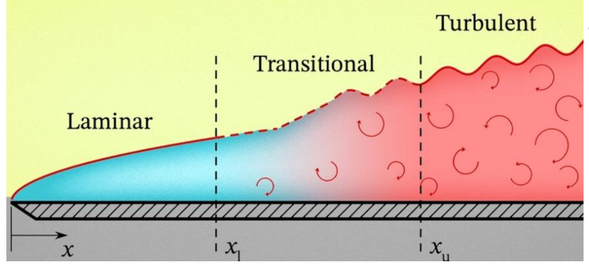
Aim of the Project

The Aim of the project is to design, manufacture, assemble and test a Wind Tunnel test rig.

Background

Aerodynamics is the science of air and the impact that the moving air has on a solid object placed in the direction of the moving air. Most of the equations used in aerodynamics stem from fluid dynamics and these equations are used to find properties and constants like boundary layer, Reynolds number and quality of airflow, for example laminar, transitional, or turbulent



As fluid flows over an object or an object goes through the fluid, the fluid in contact with the object will create a thin layer of fluid moving in a different pattern to that not in contact with the object, depending on the relative velocity the boundary layer will have an increased or decreased Reynolds number which means that the fluid could go from laminar to turbulent flow at a certain distance away from the start of the object

Airflow Characteristics

When designing a forced air-flow system that uses a fan, the fan operating points need to be found in order to verify if the selected fans will be sufficient enough to overcome the pressure drop in the system, this will also show the true volumetric flow rate of the system at the given fan speeds, from this the true calculated velocity can be found.

$$\Delta P_{Contraction} = \frac{(0.02)(1.204)(1.98)^2}{2} \quad \Delta P_{Contraction} = 0.047\ Pa$$

$$\Delta P_{Diffuser} = \frac{(0.6 * 0.56)(1.204)(1.98)^2}{2} \quad \Delta P_{Diffuser} = 0.75\ Pa$$

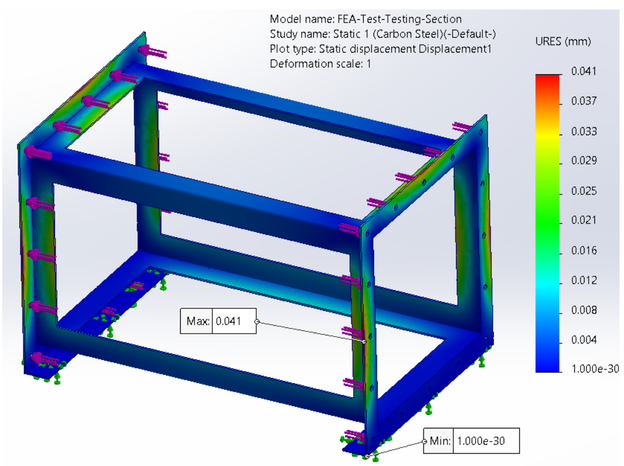
$$\Delta P_{Mesh} = \frac{(0.4)(1.204)(9.86)^2}{2} \quad \Delta P_{Mesh} = 23.36\ Pa$$

$$\Delta P_{Total} = \Delta P_{Duct} + \Delta P_{Contraction} + \Delta P_{Diffuser} + \Delta P_{Mesh}$$

$$\Delta P_{Total} = (22.87) + (0.047) + (0.75) + (23.36) \quad \Delta P_{Total} = 47.03\ Pa$$

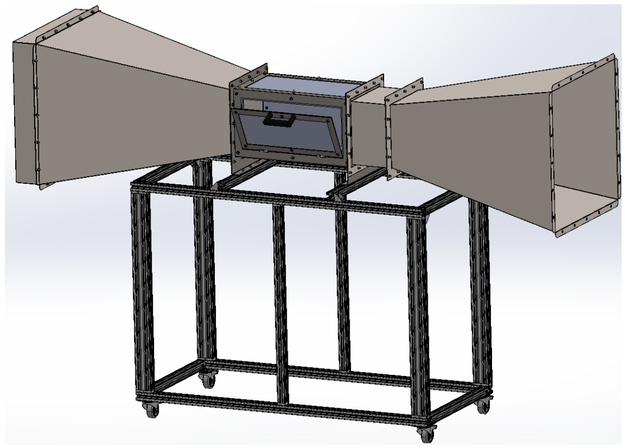
Finite Element Analysis

Once the meeting with Bolgers was complete it was then onto creating a FEA analysis of the Testing section to ensure that it can support the weight of the ends of the wind tunnel.

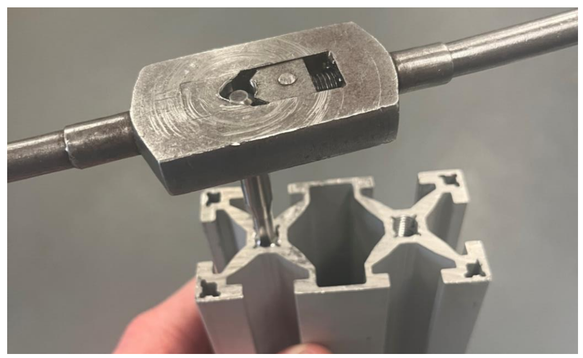


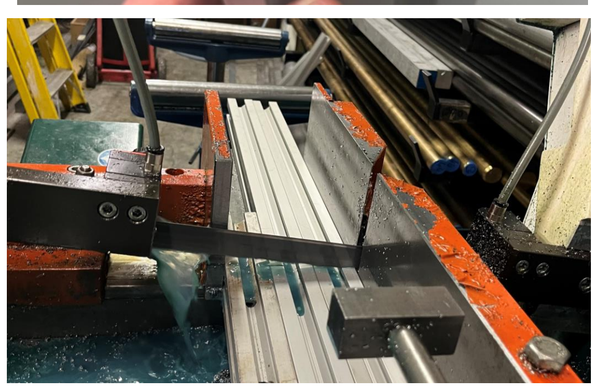
Final Design

The final design incorporates the redesign of components for manufacture and also the new components that were designed, these include the Fan Mount Section and Finger guard along with a few others.



Manufacture





Conclusion

- The Design and Redesign of components was achieved while keeping DFMA intent.
- The Calculations showed the velocity that was possible inside the Testing Section.
- The manufacture and assembly was a success with the help of Bolgers.
- The FEA analysis proved the geometry and materials had the correct mechanical properties for the design.

References

- Chandler, D. L., 2020. *Understanding how fluids heat or cool surfaces,* Massachusetts: MIT News Office.
- Simscale,-2023.-*What-is-Aerodynamics?.*- [Online-Available-at: https://www.simscale.com/docs/simwiki/cfd-computational-fluid-dynamics/what-is-aerodynamics/ [Accessed 6 February 2024].

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