1. INTRODUCTION

Motorcycle helmets play a critical role in ensuring rider safety, yet their design can often result in increased aerodynamic drag and instability, particularly in lateral wind conditions. The AGV K5S™ helmet, while providing excellent protection, has the potential for aerodynamic performance enhancements. This study focuses on modifying the existing helmet's spoiler by integrating a flexible aerodynamic element that deforms in response to airflow. The primary objective is to mitigate the lateral forces acting on the rider's head, thus reducing the physical effort required to maintain head position and improve overall riding comfort.

The impact of semi-active spoiler systems in motorcycle helmets is multifaceted. On the positive side, these systems significantly improve aerodynamic efficiency, thereby reducing wind resistance and rider fatigue. This is particularly beneficial for professional racers and long-distance riders, who can experience enhanced stability and comfort.

2. MAIN SECTION

This study consists of a few steps. The project commenced with high-resolution 3D scanning of the AGV K5S helmet and its existing spoiler. This step was critical for generating a precise digital model that captured every necessary detail of the helmet and spoiler. The raw 3D scan data was then imported into specialized mesh editing software for repair. During this stage, imperfections and scanning artifacts were systematically corrected to refine the mesh and prepare it for further modifications. Following the mesh repair, the next step involved modeling the spoiler. Using the refined 3D mesh as a reference, a new spoiler was meticulously designed and extended to incorporate the planned aerodynamic element. This model served as the basis for subsequent aerodynamic analysis.

The aerodynamic performance of the helmet was first evaluated using Computational Fluid Dynamics (CFD) analysis on the original model without any modifications. This provided a baseline for comparison. Next, CFD analysis was conducted on the helmet with the newly modeled spoiler to assess the impact of the modification under standard conditions. To further understand the aerodynamic behavior under different scenarios, a CFD analysis was performed on the helmet with the spoiler in lateral wind conditions. This step was crucial for evaluating the helmet's performance in real-world riding situations where lateral forces are significant. The focus then shifted to the active aerodynamic element of the spoiler. Static pressure data from the CFD simulations was utilized to analyze the deformation of the flexible aerodynamic element. This data provided insights into the stresses and strains experienced by the element under varying airflow conditions. Based on the deformation analysis, the spoiler model was remodeled to reflect the deformed state of the aerodynamic element. This step ensured that the flexible part's behavior under aerodynamic forces was accurately represented in the final design.

Finally, a comprehensive CFD analysis was conducted on the helmet with the remodeled, deformed spoiler. This final analysis aimed to validate the aerodynamic improvements and confirm the efficacy of the semi-active spoiler.

2.1. 3D SCANNING

The 3D scanning process was done by an external app that runs on a phone. 3D scanning data acquired from the front camera's proximity sensor. The raw scanning file had so many flaws that needed to be fixed. Raw file can be seen in Fig.1.

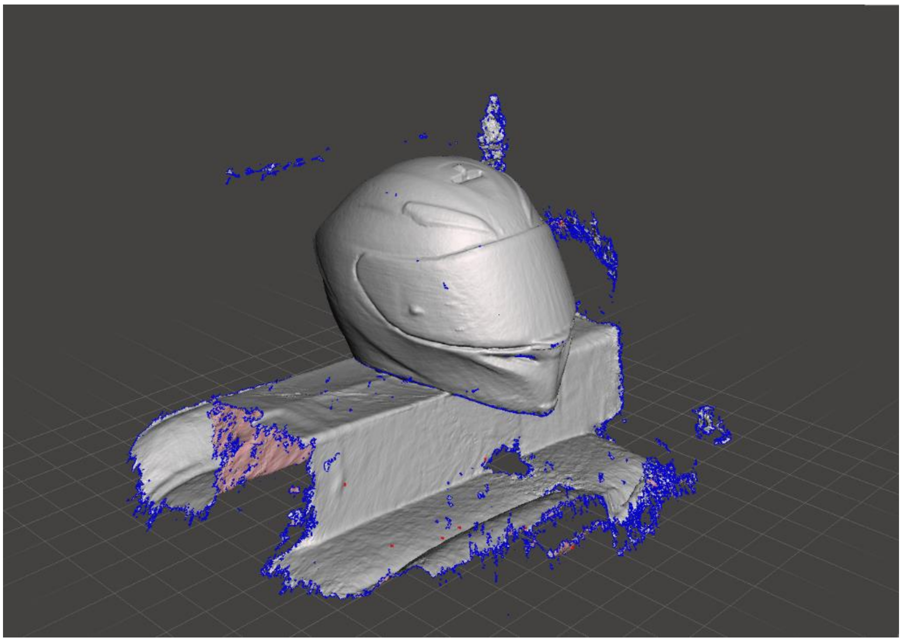

Figure 1

2.2. MESH REPAIRING

Mesh repairing was a crucial part of the project. Mesh needed to have enough detail and needed to have just enough resolution to optimize working time and output data. Mesh repairing has done in Autodesk Meshmixer™. Meshmixer is powerful enough to manipulate large sized mesh files and easy to use. Mesh needed to be hole free and solid to run CFD on it. This repaired mesh is used in both CFD simulations and reference for further modeling.

2.3. MODELING AND ANALYSIS

The full roadmap leading to result consists of some iterations. For achieving final product, a still spoiler needed to be designed. Then analyzing the data from CFD to make the semi-active aero elements. Using this data to calculate amount of displacement and remodeling according to this displacement data. After remodeling, remodeled spoiler (with semi-active elements obviously) needed to be runned in CFD for a final time.

2.3.1. First CFD Run

This run will show the properties of AGV K5S™ such as drag and airflow outside of the helmet. These results will be critical for further development and will affect designing of the spoiler.

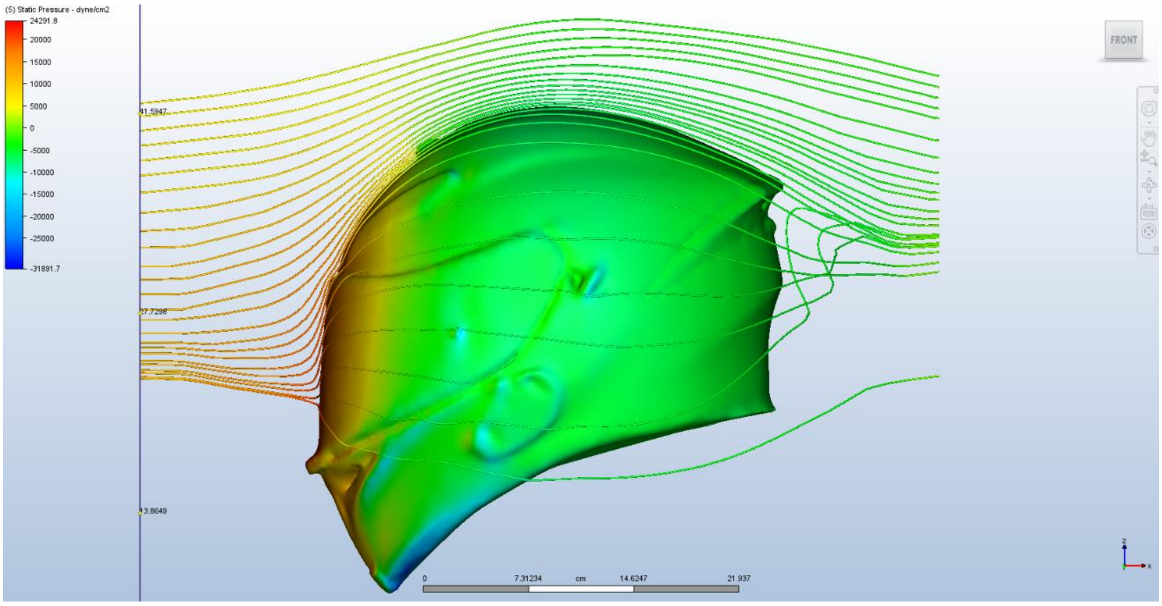

Figure 2

All calculations simulates 130km/h wind speed and 20°C air tempreture. The Results can be seen in Fig. 2. As it can be seen at the back area of the helmet the air is turbulent. Which can cause instability and rider fatigue.

2.3.2. Initial Modeling Of Spoiler

Spoiler modeled according to first CFD run results. Keeping in mind both ecstatic and functionality (Can be seen at Fig. 3).

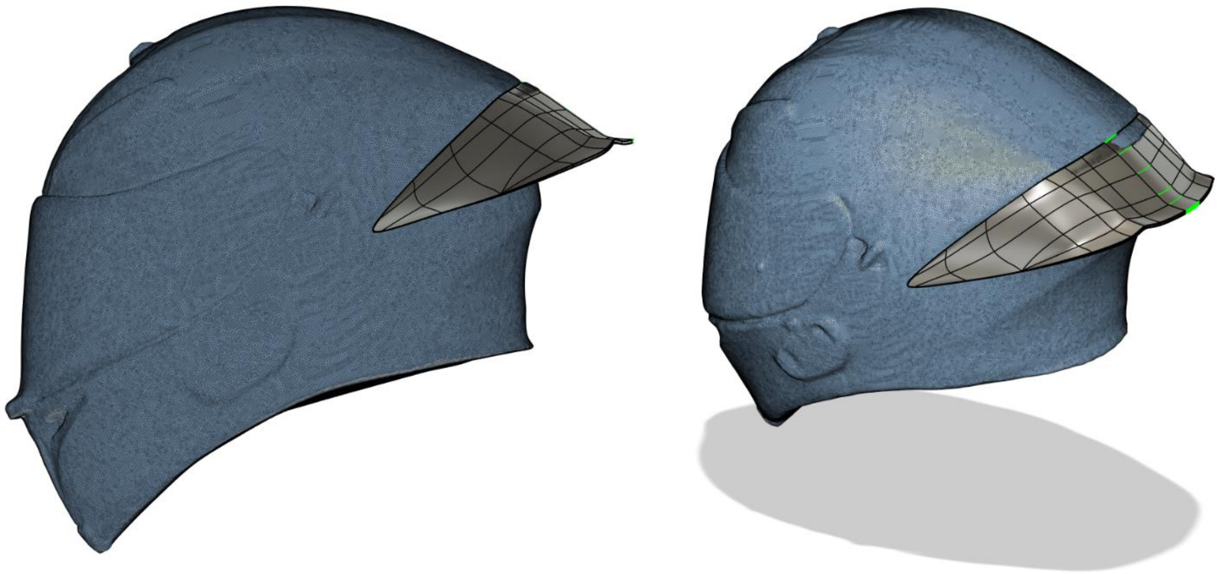

Figure 3

2.3.3. Second CFD Run

This CFD simulation contains results of helmets airflow only with spoiler without a semi-active aero element. As it can be seen on Fig. 4, a slight modification like a stretched

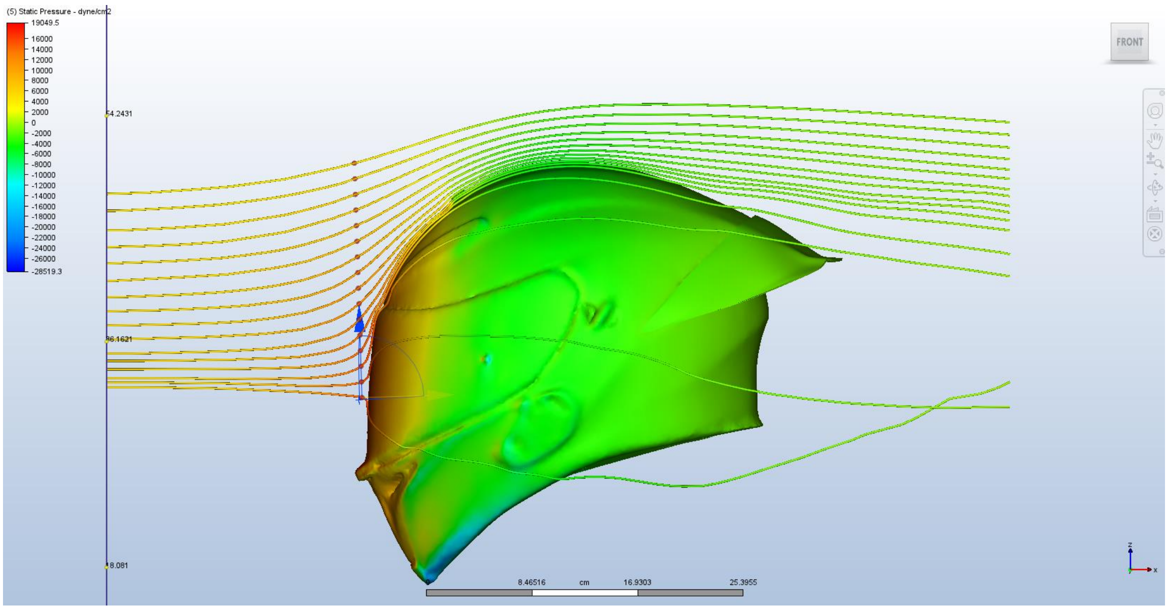

Figure 4

spoiler can make a huge difference. If we compare our results to Fig. 2, the airflow is much more uniform and smoother. This CFD simulation proves spoilers actually make an impact on helmets' aerodynamical properties.

For the next step of the process, hydrostatic pressure needs to be calculated when the rider's head turned 90 degrees sideways. For this we run the simulation for the second time, but airflow needs to be perpendicular to helmets normal.

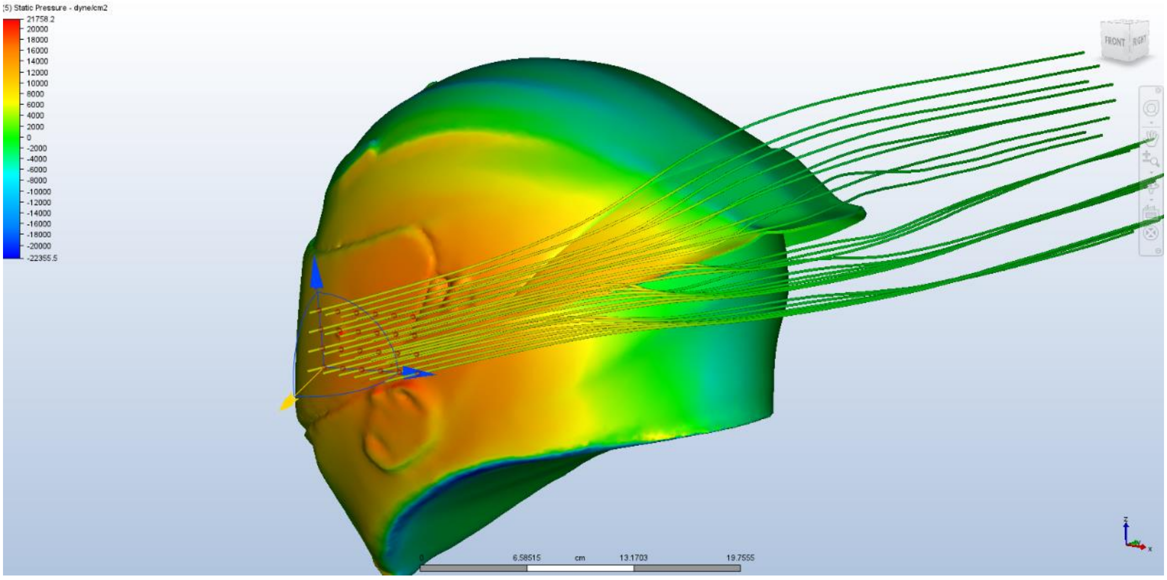

Figure 5

When we run the CFD with these variables the results will be shown as in Fig. 5. We can clearly see, the side of the spoiler (which is the part needed to flex) hydrostatic pressure is around 10000dyne/cm^2 which is 1000 N/m^2.

2.3.3. Calculation Of Displacement And Modeling Active Aero Elements

A critical aspect of this project involved calculating the displacement of the semi-active aerodynamic elements under airflow conditions. Utilizing static pressure data obtained from the initial CFD simulations (Fig. 5), the deformation behavior of the flexible aerodynamic element was modeled.

For the calculation of displacement, we use the data from CFD run (Fig. 5). As it can be seen in Fig. 6 the lighter outline is non-displaced model and the darker outline is displaced model. The material used for calculating the flex is ABS (Polycarbonate).

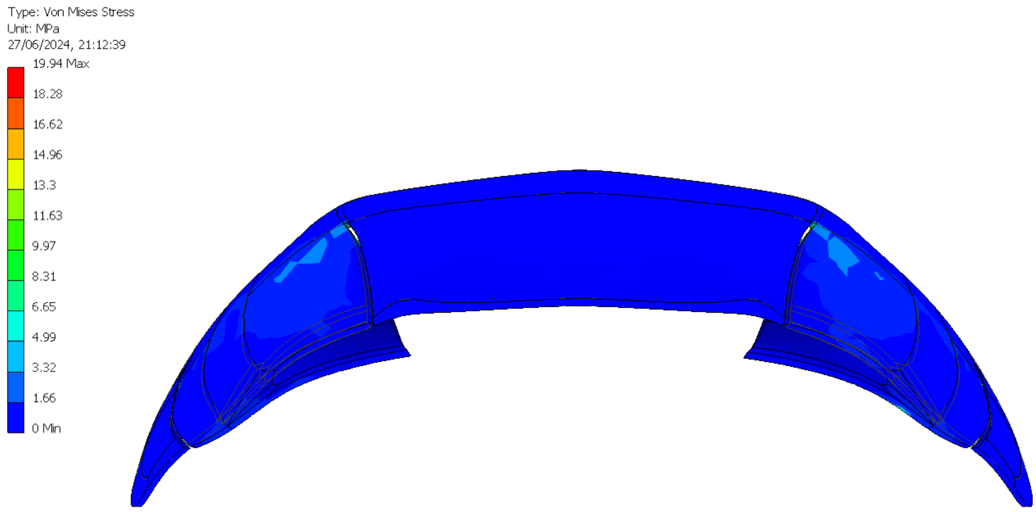

Figure 6

2.3.4. Final CFD Run

The final phase of the project involved conducting a comprehensive CFD simulation on the helmet equipped with the remodeled (Fig.7), deformed semi-active aerodynamic element. This simulation aimed to validate the performance improvements predicted by the initial displacement calculations and modeling. This final analysis was crucial in demonstrating the practical benefits of the semi-active spoiler modification under realistic riding conditions.

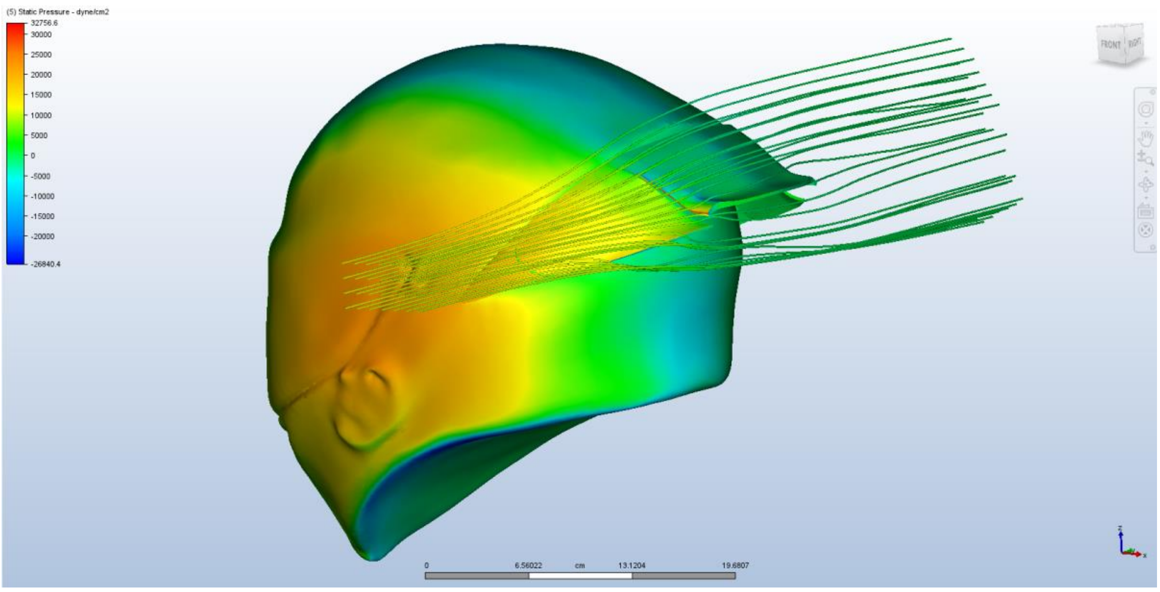

Figure 7

3. CONCLUSION

This project investigates the potential of a semi-active spoiler system for motorcycle helmets. Through 3D scanning, modeling, and CFD analysis, the project aims to demonstrate the effectiveness of this design in reducing head buffeting and improving rider stability during lateral winds. The results will guide further development and refinement, paving the way for a more comfortable and safer riding experience.

Beyond the scope of this project, the semi-active spoiler concept holds great promise for future advancements. The design can be optimized for a wider range of helmet models and wind conditions. Additionally, the concept can be integrated with active control systems, allowing for real-time adjustments based on sensor data. This could potentially lead to a truly dynamic system that adapts to varying wind speeds and directions.

The successful implementation of this semi-active spoiler system could have a significant impact on the motorcycle industry. Improved helmet stability translates to a more comfortable and secure riding experience, potentially leading to increased rider satisfaction and potentially even attracting new riders to the sport. Additionally, by reducing rider fatigue, the system could contribute to improved safety by enhancing focus and reaction times.

In conclusion, this project lays the groundwork for a revolutionary advancement in motorcycle helmet design. The semi-active spoiler concept offers a promising solution to the challenge of lateral wind buffeting, paving the way for a safer and more enjoyable riding experience for all.

RESUME

Genco Gencer ÖZÇAKIRLAR;

Born on 19th September 2002 at Çerkezköy, Tekirdağ. Lived for 18 years in Istanbul until university. He has a keen interest in innovative design and engineering solutions. He is studying in Trakya University at Mechanical Engineering Department currently. Genco has been fascinated by the mechanics of how things work from a young age. Her dedication to meticulous problem-solving and her continuous pursuit of learning make her a standout in the field.

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Awards:

METU Görev Yer Altı: 2nd Place 2022