Improving the Performance of Vehicle Components by Structural and Material Optimization

Abubakre Alausa K00247380

Aim of the Project

The aim of the project is to improve the Performance of Vehicle Components through Structural and Material Optimization

Background

Making vehicle parts work better is essential in car engineering. This involves improving the design and composition of various parts to make them more effective, efficient, durable, and safe. Structural optimization means making the shape of parts stronger, stiffer, and better overall. To get this right, engineers use fancy computer-aided design (CAD) and finite element analysis (FEA) techniques to simulate and try different designs. They aim to make parts lighter without making them weaker. Material optimization means picking the best stuff for each part. Engineers think about things like how strong a material is compared to how heavy it is, how well it conducts heat, how well it stands up to rust, and how much it costs. They can choose from things like metals, composites, and polymers. They even use some cool materials like carbon fibre-reinforced polymers (CFRP) and high-strength alloys to improve how parts work while making them weigh less.

Finite Element Analysis (FEA) is a technology that is used to design and optimize swing arms in motorcycles. By simulating the behavior of the swing arm under different loads and conditions, FEA enables engineers to optimize its structural integrity, strength, and performance. This ultimately leads to better and safer motorcycles for riders.

Exemplary vehicle component

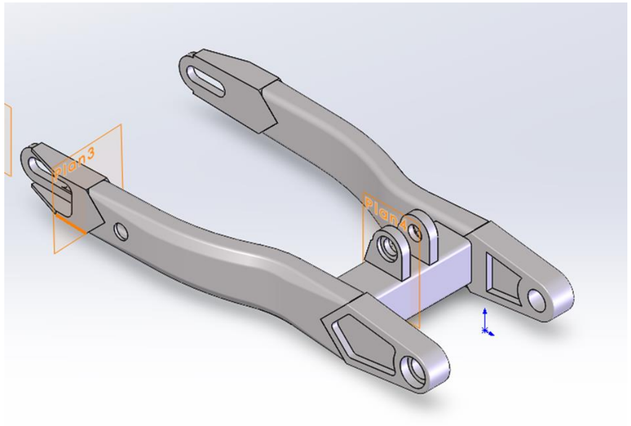
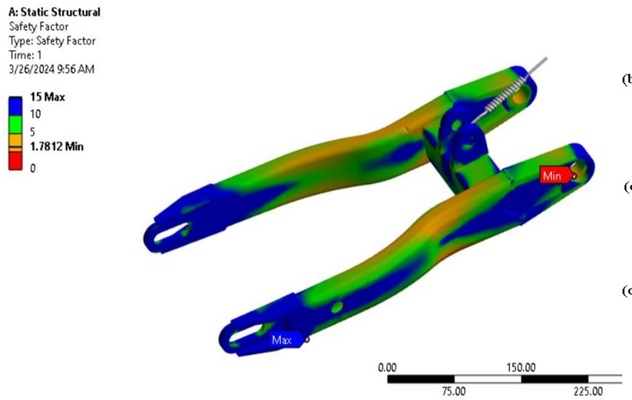


Figure 1: swing arm modle

.

A swing arm is a vital component commonly found in motorcycles and bicycles. It is a pivoting structure that connects the rear wheel to the frame. This connection allows the suspension system to absorb shocks and vibrations from uneven road surfaces, providing a smoother ride. Swing arms come in various designs, including single-sided and dual-sided configurations. They play a crucial role in determining the vehicle's handling, stability, and ride comfort. In performance-oriented applications, swing arms are often optimized through structural design and material selection to improve strength, weight, and responsiveness.



FEA on swing arm

Topology analysis

Result

A topology analysis was carried out on the swing arm to find ways to make it lighter without compromising its function. The results of the analysis showed the recommended areas where material could be removed to achieve a lighter swing arm without affecting its functionality.

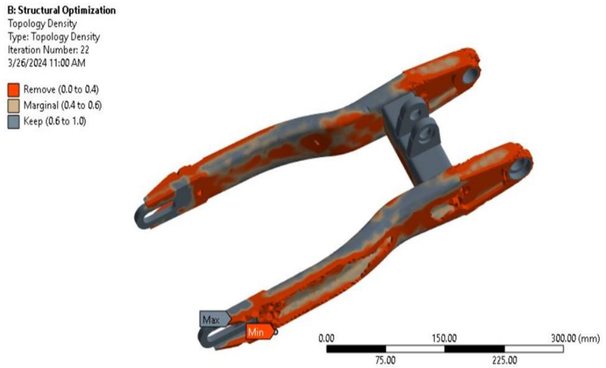


Photo of: Ansys Topology result

"In terms of material selection, the original model was made with aluminum. To achieve a lighter and stronger material, which would have a great impact on the performance, carbon fiber was selected. Using this material allowed for a stronger and lighter swing arm, which would certainly have increased the bike's performance."

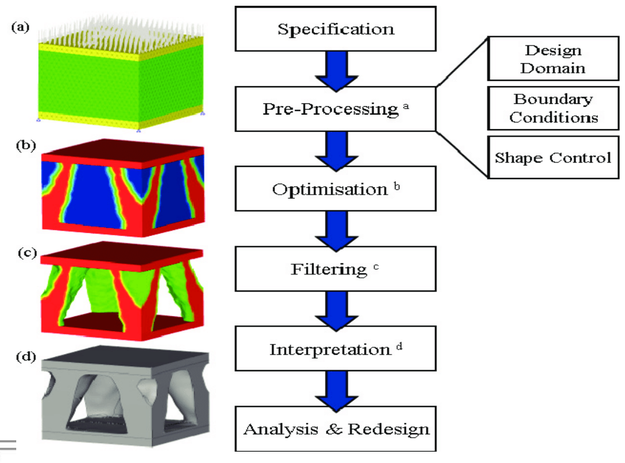


Photo of: topology setup steps

Conclusion

Figure 3: optimized swing arm

The Topology Optimization method begins with a full design space and eliminates inefficient material from the structure based on the stress level of elements. The resulting design offers a clear definition of topology without any grey area. Element removal is achieved by assigning rejected elements a material property number of zero and ignoring them when assembling the global stiffness matrix in subsequent finite element analysis. The weight of the design space is approximately 11.2 Kg, and it reduces with Topology. Optimization up to 5.8 Kg. which is notable. Reduction in weight achieved by 60%.

References

- Ahmad, H., Markina, A.A., Porotnikov, M.V. and Ahmad, F., 2020, November. A review of carbon fiber materials in automotive industry. In IOP Conference Series: Materials Science and Engineering
- Allioui, H. and Mourdi, Y., 2023. Exploring the full potentials of IoT for better financial growth and stability: A comprehensive survey.
- Ashby, M. F., Ash, M. F., Auckland, O., Johannesburg, B., and Newdelhi, M. (n.d.). MATERIALS SELECTION MECHANICAL DESIGN. Kamrankhodaparasti.Ir. Retrieved November 8, 2023, from http://kamrankhodaparasti.ir/wp-content/uploads/2023/04/Pages-from-material-selection-in-mechanical-design.pdf
- Ashkenazi, D., 2019. How aluminum changed the world: A metallurgical revolution through technological and cultural perspectives. Technological Forecasting and Social Change, 143, pp.101-113.