



MCR front upright development

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Introduction

The goal of the project was to increase performance of the university’s MCR S2 race car, which is used in the Sports 2000 Duratec Championship. As various regulations restrict upgrades, weight reduction was chosen as the car is 6.5kg heavier than the minimum kerb weight of 521kg [1].

The original upright had not been optimized, suggesting it was heavier than needed. The front upright was developed using CAE methods to create a higher performance design.

Project Aims

- Design an upright, manufacturable in-house.
- Reduce the upright’s weight by 0.60kg.
- Maintain each attachment points stiffness.

Methodology

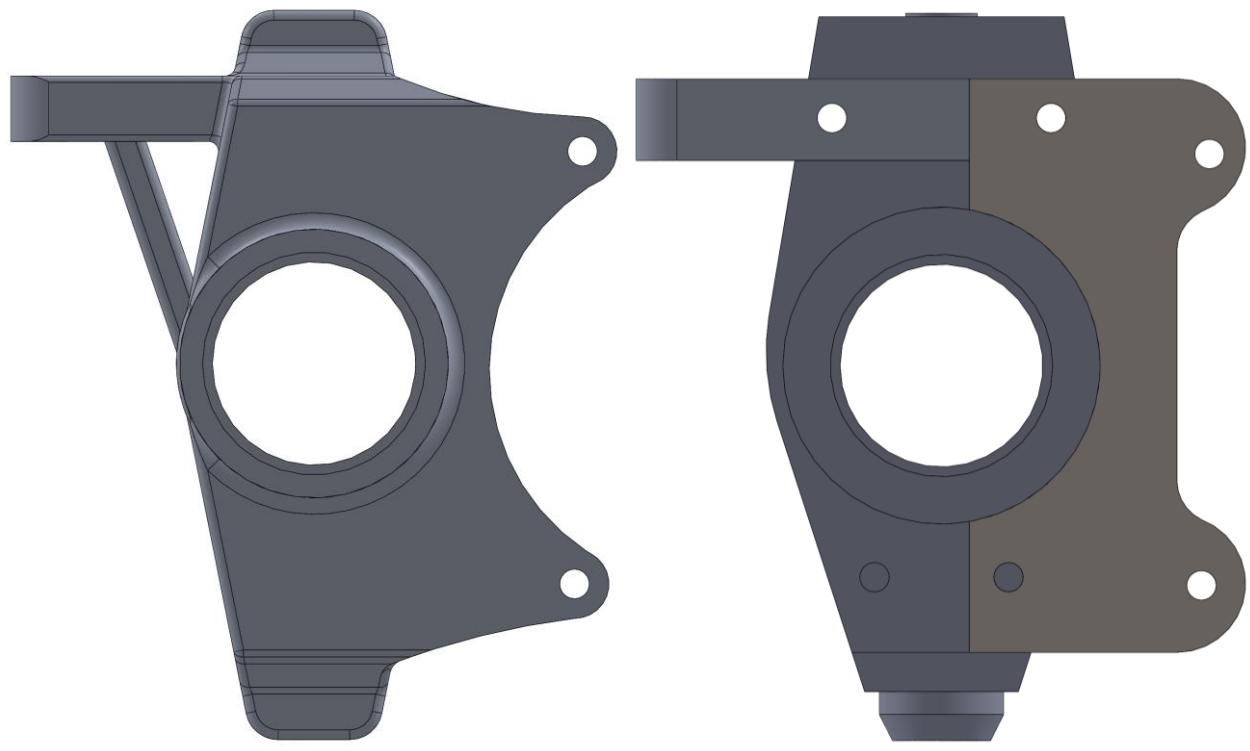
The original upright is a three-piece construction with both the upright and steering arm made from 6061-T6 aluminium and the brake bracket from mild steel. It was removed from the car and measured, from which a CAD model was created.

FEA testing was conducted on the original upright using SolidWorks and Design Studio to identify areas of weakness. A mesh independence study was conducted to determine the optimum mesh element size. Stress concentrations were found at edges with component contact.

Four topology optimization studies were conducted using SolidWorks. The results from the original upright’s FEA testing and topology optimization were used to inform the new upright designs.

The new upright would be produced from a single piece of 7075-T6 aluminium. 7075-T6 has a 84.5% higher UTS compared to 6061-T6, meaning it can withstand higher stresses before failure. Eight designs were produced, each new design aiming to improve on the previous design.

Maximum lateral loads for each attachment point were calculated to use during FEA. FEA was conducted on each new design and von Mises stress, displacement, strain and stiffness compared to the original.



Final optimized upright (left) with weight of 1935g and original upright (right) with weight of 2527g

Results

The second and final topology results were used to inform the final, best design. On average, for each attachment point, the final design had 52% lower stress, 2% larger displacement and 29% lower strain compared to the original.

Most stiffnesses were improved over the original upright.

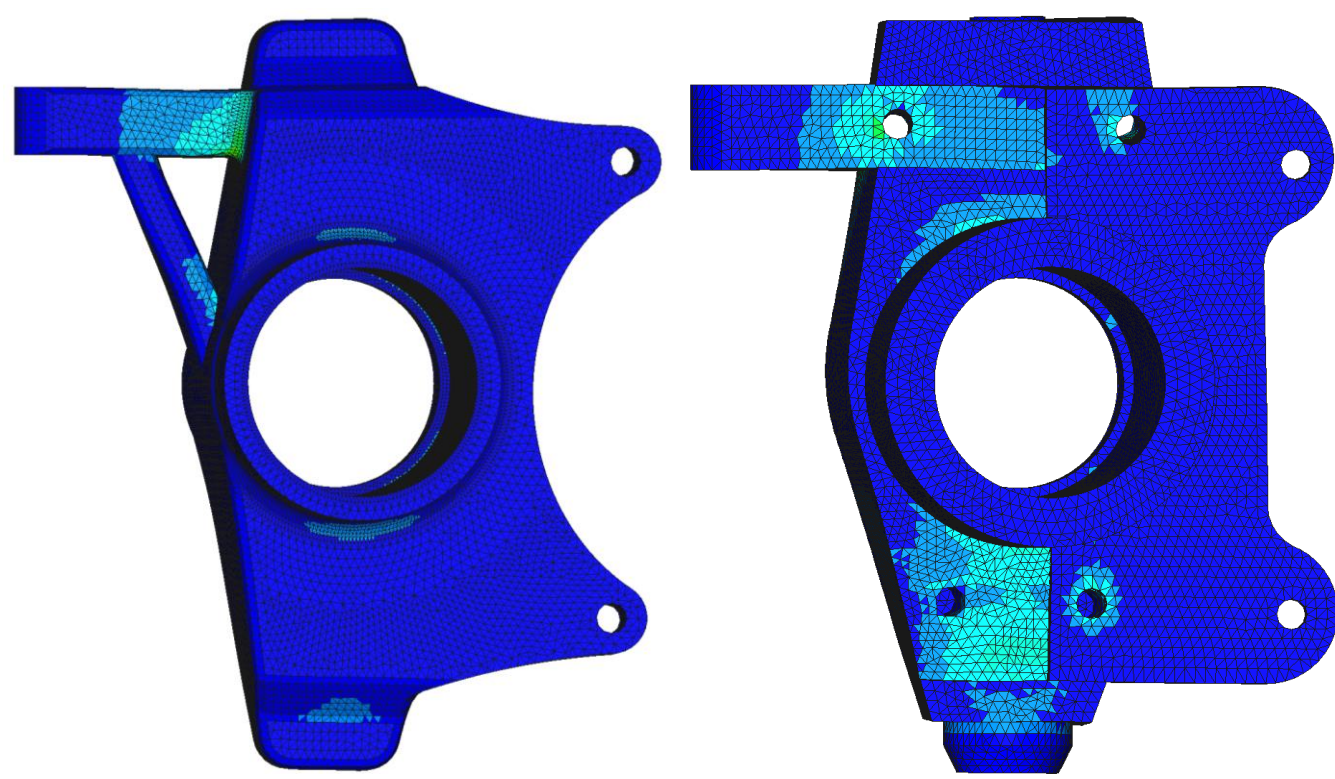


Final optimized upright overlaid with second topology study (left) and final topology study (right)

Stiffness of each attachment point for the original and final optimized upright (green cells indicate higher stiffness)

Original upright			
Attachment Point	Stiffness (N/m)		
	X	Y	Z
Upper caliper-tierod-upright	1.558E+09	7.986E+08	2.696E+08
Lower caliper-upright	1.944E+09	2.697E+09	1.369E+09
Tierod-upright	2.555E+09	1.059E+09	7.810E+08
Lower upright	2.166E+09	2.943E+09	1.385E+09
Upper caliper	1.899E+08	1.109E+08	6.323E+06
Lower caliper	2.305E+08	8.913E+07	3.133E+06
Upper wishbone	6.826E+08	1.037E+09	1.873E+08
Lower wishbone	4.206E+08	1.968E+09	1.764E+08
Tierod	2.254E+08	2.690E+07	3.316E+07
Hub	4.125E+08	2.184E+09	7.944E+08

Final optimized upright			
Attachment Point	Stiffness (N/m)		
	X	Y	Z
Upper caliper-tierod-upright	N/A	N/A	N/A
Lower caliper-upright	N/A	N/A	N/A
Tierod-upright	N/A	N/A	N/A
Lower upright	N/A	N/A	N/A
Upper caliper	3.072E+08	1.558E+08	2.178E+07
Lower caliper	3.619E+08	1.898E+08	2.416E+07
Upper wishbone	8.094E+08	3.285E+08	5.924E+08
Lower wishbone	4.201E+08	1.575E+09	2.675E+08
Tierod	4.351E+08	7.294E+07	2.964E+07
Hub	6.664E+08	3.808E+09	1.187E+09



Unaveraged von Mises stress distribution under acceleration load of 6145.8N for optimized and original upright

Conclusions

Each upright developed was lighter than the original design. The final design chosen achieved a weight saving of approximately 0.59kg (23.4%) compared to the original, achieving the target saving.

Most of the suspension attachment points had greater stiffness than the original upright, however, the upper wishbone, lower wishbone and steering arm were slightly less rigid in certain directions. The final optimized upright improved the stress distribution for each loadcase.

The new upright design was manufacturable in-house using the 3-axis CNC milling machine.

References

[1] Sports 2000, "SRCC SPORTS 2000 DURATEC CHAMPIONSHIP," 2020. [Online]. Available: https://sports2000.co.uk/wp-content/uploads/2020/02/2020-Duratec-Published-Copy_compressed.pdf.