

Major Project Questions

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Question 1

Why do you think that the link arm out performed the original design, yet the swing-arm did not?

Question 1 Response (maximum 200 words)

As explained a key factor of mountain bike components is to be light. The GD designs were chosen based upon the lowest mass. The values of which a design can be chosen from is very limited and uses a lot of computing power to inspect each component thus increasing the time. The link arm chosen had the lowest mass and also outperformed the original which is predominantly down to luck and can be said to be the best possible design based upon the results.

The swingarm chosen based upon mass was not the best outcome when compared to the other measurables. If the other measurables were able to be considered then the swingarm could have possibly outperformed in other values except for mass. But it is important to note that the difference of each measurable was marginal and in the next revision as explained could offer a better outcome.

It can only be assumed that the reason why GD did not make a similar hollow structure to the original swingarm is based upon the AM constraints which are stated as no higher than 45-degree overhang and a minimum wall thickness of 3mm.

Question 2

You discuss "standard thickness" for the fixing bolts, what is this? Do you think that this is correct? How could this decision influence your results?

Question 2 Response (maximum 200 words)

The standard thickness is the diameter of the axle. It allowed for a standard loading condition across all simulated components and is the same diameter as the original bike. Autodesk does not allow for constraints and loading to be applied to the same face. In the simulation of each component, the constrained face is where the load is acting; to overcome this the axle was put in place. If the axle was not put in place then the FE simulation would not have been full constrained thus not giving reliable results.

Also, it was a far more real-world situation due to the wheel transferring the impact loading to the axle then to the swing and link arm. The axle was just for loading and inserted as a separate body and hidden when analysing results so it had no impact.

Question 3

Did you consider other manufacturing processes rather than just AM? Why/why not?

Question 3 Response (maximum 200 words)

No, I did not. The reason for this is that AM, when compared to other manufacturing processes, has far fewer constraints. Carbon fibre is commonly made using moulds which reduced the processes which could be used. Although moulding can make similar designs, it restricts the customizability of the product due to the cost of the processes and has many quality concerns. It is also a very wasteful process as explained and with the rightful growing pressure of the footprint of manufacturing, this needed to be addressed.

My opinion from my research is that AM was the best processes for the job, it addressed the wastefulness of the moulding process, it gives freedom of design and allows for the rapid design to product. Furthermore, This project challenged the status quo of current methods of bike design, and the restrictions of the traditional methods would not utilise GD to its fullest. The project's goals were to release the shackles of traditional methods and let GD see what it is physically possible, this could only be achieved by using AM. If other techniques were considered then the chances are you would have a similar design to what we already had.

Question 4

When comparing the same components made by additive manufacturing versus conventional manufacturing methods what are the impacts on material properties?

Question 4 Response (maximum 200 words)

Due to the additive nature of AM, there are some slight material property differences. This is mainly where the layers are fused, which becomes an area of weakness. For example, Atherton Bikes use titanium lugs for the construction of their bikes, if this was machined from a billet of titanium then the material will have isotropic properties. While the equivalent part which is 3D printed is almost as strong in the XY plane as the billet titanium is, however, the Z plane is not, making the material anisotropic.

The properties of Ti6Al4V (Grade 5) by Renishaw datasheet details ultimate tensile strength of 1089MPa in XY, and 1085MPa in Z. The equivalent material from AZO materials states an ultimate tensile strength of 1200MPa. Both are tested by ASTM E8 tension test. Additionally, the Youngs modulus of the 3D printed material is 129GPa and 126GPa XY and Z respectively compared to billet at 119GPa making the 3D printed material far tougher. While the difference is marginal the material is still not isotropic but 3D printed part can be designed and printed in such a way that this may not make a difference.

Question 5

Evaluate two alternative methods other than chemical treatment that can be used to recycle composite materials. Suggest how suitable they could be commercially?

Question 5 Response (maximum 200 words)

Mechanical recycling – Downsizing composite waste into powder and fibre rich fractions. This process can be scaled to industrial level, but only short fibres and fillers can be recovered. The market value of the recyclates is low and can only be used in low-grade afterlife products. With studies indicating an energy consumption of 0.14-0.31MJ/kg which is one of the lowest of all recycling processes.

Pyrolysis – Decomposition of composite through heating with microwave or oven heating with an inert atmosphere. Gives high strength retention of the fibres recovered, can be used at industrial scale. The microwave still being a laboratory scale, however, it allows for rapid heating which could be the future of the process. Byproduct energy can be used to sustain the process and is estimated to be 3-30MJ/kg. This process has become a more favourable option of the two due to the retention of the strength of the fibres.

Companies currently are reluctant to replace recycled fibres with virgin fibres due to the lack of standardisation and lack of known properties after processes. However, ELG Carbon Fibre has been verified by Bureau Veritas and now is used in the Team Ineos American Cup yacht as well as other industrial applications.