Lightning McQueen: The Legendary Composite Bike

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Background

- A bike frame must be strong enough to withstand the forces put through it and yet be light enough to be rideable
- The exact geometry of a bike is tailored to the purpose of the bike- mountain bikes and road bikes will be slightly different, for example
- A comparison of materials used to manufacture bicycle frames is shown in Figure 1.

Material	Pros	Cons
Kevlar (K)	-Stronger relative to weight than **CF** -Lighter than **M** -Resists piercing forces	-Buckles under compression -Weakened by high temperatures
Carbon Fibre (CF)	-Stiffer relative to weight than **K** -Lighter than **M** -Can withstand high temperatures	-Less resistant to piercing forces than **K**
Metals-Steel and Aluminum (M)	-Strong -Stiff	-Heavy

Figure 1: Material properties

Figure 2: Kevlar braid sample

Objective

- To design and solid model a bike frame to be made from braided composites and come up with an experimental design for a mechanical test that would be performed on the bike frame.

Methods

- Solid modelling is used before manufacturing to ensure the object is designed as it should be- with the ability to make changes without wasting materials.
- A bicycle frame was solid modelled on Solidworks 2016 x64 (Figure 4)
- Bike frames are typically tested as a whole unit, with forces applied to the frame as if a rider was riding the bike.
- These forces are illustrated in Figures 5-9.

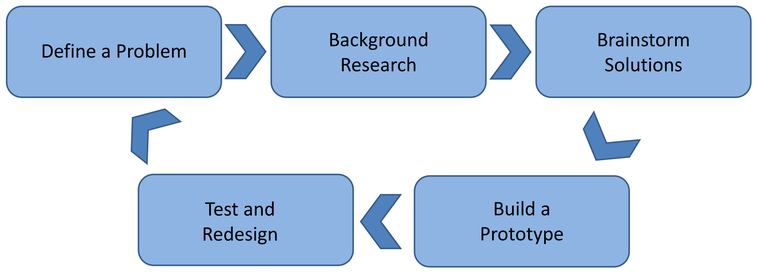

Figure 3: Steps of mechanical design

Figure 4: Solid modelled bike frame in Solidworks.

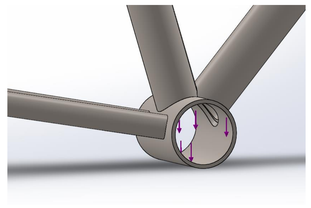

Figure 5: Bearing loads

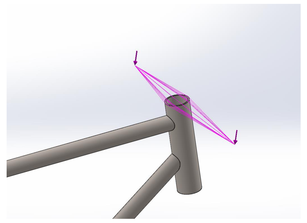

Figure 6: Remote loads

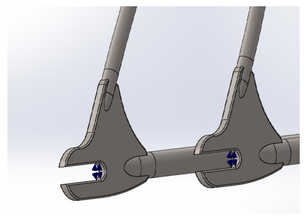

Figure 7: Bearing supports

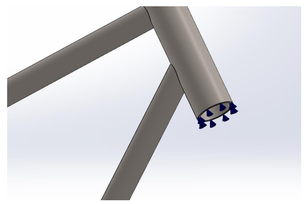

Figure 8: Elastic support

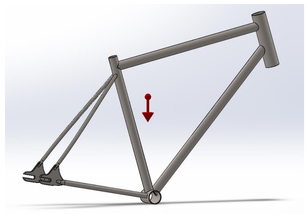

Figure 9: Gravity

Experimental Design

- An experiment was designed to provide parameters to test in the future.
- Experimental design is important because properly designing an experiment will allow for better execution of it.

Test #	Material	Frame Size	Type of Bike
1	AL	SM	MTN
2	CF	SM	MTN
3	K	SM	MTN
4	AL	MED	MTN
5	CF	MED	MTN
6	K	MED	MTN
7	AL	LRG	MTN
8	CF	LRG	MTN
9	K	LRG	MTN
10	AL	SM	RD
11	CF	SM	RD
12	K	SM	RD
13	AL	MED	RD
14	CF	MED	RD
15	K	MED	RD
16	AL	LRG	RD
17	CF	LRG	RD
18	K	LRG	RD

Figure 10: Parameters for future testing. See Figure 11 for key.

Abbreviation	Meaning
AL	Aluminum
CF	Carbon Fibre
K	Braided Kevlar
SM	Small
MED	Medium
LRG	Large
MTN	Mountain
RD	Road

Figure 11: Key for Figure 10

Future Work

- Testing would be performed using the parameters set above.
  - As carbon and aluminum are already in use for bike frames, they are controls to ensure the frame geometry is set properly
  - The application of Kevlar braids to a bike frame is untested. Future studies will show whether the application of Kevlar to a bike frame is feasible or not.

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