Swinburne University of Technology

Faculty of Science, Engineering and Technology

ENG20007- Design and Product Visualisation Project

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Name of Assignment: **Project Report Submission**

Project Title: **Postie Bike**

Group ID: **Group 35**

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Date of Submission: 27/05/2024

Chat GPT has been used in developing and writing this assignment

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1. Introduction - 104006361

This chapter will provide a background on hydrogen powered vehicles and the necessity to transition away from fossil fuel powered transportation means. Additionally, communications into this report's structure and aims will be made, defining the student's objectives, roles within the project, and this reports organisation. To acknowledge student contribution within the report, accompanying each section title will be a student number to indicate the author.

1.1 Background

Hydrogen-powered vehicles present a promising solution to the challenges posed by traditional fossil fuel-based transportation systems, offering zero-emission propulsion and potential sustainability benefits. In recent years, research efforts have intensified to explore the feasibility and viability of hydrogen fuel cells in various vehicle platforms, including motorcycles. This literature review aims to synthesize current research on hydrogen-powered vehicle components, focusing on their applicability to the design and development of a hydrogen-powered postie bike, while identifying gaps in existing literature.

Internal Combustion Engines (ICEs) have been pivotal in the development of modern transportation and industry, offering a reliable and efficient means of converting fuel into mechanical work. However, ICEs face significant drawbacks, primarily due to their environmental impact. They emit substantial amounts of greenhouse gases and pollutants, contributing to air quality degradation and climate change [1]. Additionally, the finite nature of fossil fuels underscores the need for sustainable alternatives. Hydrogen power emerges as a promising solution, offering clean energy potential with water as its only emission byproduct. The transition to hydrogen and other renewable energy sources is crucial to mitigate the adverse effects of ICEs and ensure a sustainable energy future.

"Fuel cell application in the automotive industry and future perspective" by Olabi et al. [2] provides a comprehensive overview of hydrogen fuel cell technology within the automotive sector. However, while the study emphasizes advancements in larger vehicles, such as cars and buses, there is a lack of specific discussion on the adaptation of fuel cell technology for smaller vehicles like motorcycles.

"Progress on design and development of polymer electrolyte membrane fuel cell systems for vehicle applications: A review" by Wang et al. [3] explores the developments of polymer electrolyte membrane fuel cell (PEMFC) components and systems. The paper reviews major vehicle companies research into PEMFC systems, and their configurations, gas supplies, degradation mechanisms & mitigation strategies, and the optimisation of power density and layout of the cell systems. Despite the relevance of PEM fuel cells for automotive applications, the literature gap lies in the limited focus on the scalability and integration of these advancements into compact vehicle designs, such as motorcycles.

While existing literature provides valuable insights into the advancements of hydrogen fuel cell technology and PEMFC components, there remains a significant gap in research addressing the specific requirements and challenges of integrating these technologies into small-scale vehicles like postie bikes. The research problem can be succinctly summarized as follows:

"The current literature lacks comprehensive studies on the adaptation of hydrogen fuel cell technology and PEM fuel cell components to meet the unique design and performance requirements of hydrogen-powered postie bikes, hindering the development of efficient and practical solutions for sustainable last-mile delivery." Designing our own hydrogen-powered postie bike represents a crucial step towards bridging the existing gap in literature regarding the adaptation of hydrogen fuel cell technology to small-scale urban transportation.

1.2 Aims and objectives of research.

The primary aim of this research is to explore the feasibility and design requirements for integrating hydrogen fuel cell technology into small-scale vehicles, specifically focusing on the development of a hydrogen-powered postie bike. This involves addressing the existing gaps in literature regarding the adaptation of fuel cell systems for compact vehicle platforms. The specific objectives of the research are:

- Literature Synthesis: Conduct a comprehensive review of current research on hydrogen-powered vehicle components, with an emphasis on the applicability of these components to small-scale vehicles like motorcycles.
- Design Exploration: Investigate the design and engineering challenges associated with integrating polymer electrolyte membrane fuel cell (PEMFC) systems into a postie bike.
- Feasibility Analysis: Assess the practicality, efficiency, and sustainability of using hydrogen fuel cells for last-mile delivery solutions.
- Prototype Development: Develop a conceptual design for a hydrogen-powered postie bike, including component selection, system integration, and performance optimization.
- Gap Identification: Identify and document gaps in existing research and provide recommendations for future studies to facilitate the broader adoption of hydrogen fuel cell technology in small-scale urban transportation.

1.3 Contributions of the research by each student

The following table, Table. 1, outlines the contributions of each student to the overall project.

Table. 1.1 – Table outlining student contribution.

Assembly	Sub Assembly	Parts Contributor	FEA	Sustainability
Main Assembly	Assembled by 104006361			
Chassis	Frame	104006361	104006361	104006361
	Lugs			
	Rear wheel arms			
	Tail and rear Light		104006361	
Front Steering	Handlebars	103105940	103105940	103105940
	Front Shocks			
Wheels	Rear Wheel	103597864 [Hub Motor and Shock Absorbers from GrabCAD]	103597864 (Rim)	103597864 (Rim)
	Front Wheel			
	Rear Suspension			
Storage and Seat	Storage Cage	104186153		
	Front Storage			
	Battery Storage			
	Seat			

1.4 Summary

Hydrogen-powered vehicles offer a promising alternative to traditional fossil fuel-based transportation by providing zero-emission propulsion and sustainability benefits. Despite significant advancements in hydrogen fuel cell technology, current research predominantly focuses on larger vehicles such as cars and buses, leaving a gap in the adaptation of this technology for smaller vehicles like motorcycles. This chapter reviews existing literature on hydrogen-powered vehicle components, particularly polymer electrolyte membrane fuel cells (PEMFC), to assess their applicability to the design and development of a hydrogen-powered postie bike. The research identifies a lack of comprehensive studies addressing the specific requirements and challenges of integrating hydrogen fuel cells into small-scale vehicles, which is crucial for developing efficient and practical solutions for sustainable last-mile delivery. By designing a hydrogen-powered postie bike, this research aims to bridge this gap and contribute to the advancement of hydrogen fuel cell technology in small-scale urban transportation.

2. Chassis literature review – 104006361

2.1 Introduction

The chassis serves as the structural backbone of any vehicle, providing support, stability, and integrity to accommodate various components and systems. In the context of hydrogen-powered postie bikes, the chassis plays a pivotal role not only in supporting the traditional mechanical components but also in integrating advanced hydrogen fuel cell systems and storage solutions. This section delves into the critical aspects of chassis design tailored specifically for hydrogen-powered postie bikes, considering the unique requirements and challenges associated with incorporating alternative propulsion technologies into compact urban vehicles.

In this section, we will explore key considerations in chassis design for hydrogen-powered postie bikes, including structural integrity, weight optimization, space utilization, and compatibility with hydrogen storage solutions. By examining existing literature, recent advancements, and innovative design approaches, we aim to provide insights into the challenges and opportunities associated with developing a robust and efficient chassis for hydrogen-powered postie bikes. Through a holistic approach that integrates mechanical engineering principles with sustainable technology solutions, we seek to pave the way for the realization of greener, more sustainable urban transportation systems.

2.2 Literature review

To comprehensively investigate the intricacies of chassis design for hydrogen-powered postie bikes, this literature review will follow a structured approach that examines various mechanisms crucial for supporting and optimizing the chassis. We will delve into key aspects such as material selection, rake angle & trail, centre of gravity, and wheelbase, analysing their relevance to motorcycle design and their accommodation of hydrogen integration. Each subsection will provide insights into how these mechanisms influence chassis performance, structural integrity, and overall vehicle dynamics, thereby laying the groundwork for the successful integration of hydrogen fuel cell technology into postie bike designs.

2.2.1 Frame Material Selection:

In the context of chassis design for hydrogen-powered postie bikes, material selection plays a crucial role in determining the structural integrity, weight, and overall performance of the frame. Various factors, including load-bearing capacity, functional requirements, environmental conditions, durability, and cost-effectiveness, must be carefully considered when choosing materials for the frame construction. Common materials in automotive industries are steel alloys, titanium, and carbon fibre, offering a spectrum of properties suitable for chassis applications [4].

Specifically, AISI 1015, 1018, 1020 and 4340 steels are popular steels for motorbike and small electric vehicle applications [5][6][7]. For the current investigation, AISI 4340 Alloy Steel was selected for the frame material. This was driven by a combination of accessibility, affordability, and desirable mechanical properties. AISI 4340 is classified as a low carbon steel and contains trace amounts of alloying elements like manganese and sulphur. Its popularity stems from its ease of machinability and weldability in combination with its high yield strength and deformation resistance making it well-suited for various manufacturing applications [8]. While the alternative materials of AISI 1015, 1018 and 1020 also embody these qualities, since AISI 4340 offers the superior strength-to-weight ratio [4][5][6], it will be our preliminary choice to prototype development for our hydrogen post bike, with further exploration into these materials and their sustainability factors being undertaken in chapter 8.

2.2.2 Rake and Trail:

Rake angle and trail are critical parameters in motorcycle chassis design as they directly impact the frame's geometry and overall handling characteristics [4]. The decision regarding these angles is crucial in achieving the desired balance between agility and stability for the intended purpose of the bike.

The rake angle determines the inclination of the front forks relative to the vertical plane, influencing the bike's steering response and agility. A steeper rake angle results in quicker steering, making the bike more responsive to rider input and suitable for dynamic riding styles. Conversely, a shallower rake angle provides greater stability at high speeds but may compromise agility in tight corners [9]

Trail, on the other hand, is the horizontal distance between the front tire's contact patch and the intersection of the steering axis with the ground. It affects the bike's self-centring tendency and straight-line stability. A longer trail enhances stability by promoting self-correction of the steering, especially at high speeds, but may result in heavier steering inputs and reduced manoeuvrability at low speeds [9].

When determining the appropriate rake angle and trail for a motorcycle chassis, engineers must consider factors such as the intended riding style, terrain, and rider preferences. The decision regarding rake angle and trail involves a trade-off between competing priorities, and it often requires iterative testing and refinement to achieve the desired balance. Ultimately, for the application of our postie bike a steep rake angle and short trail will be necessary to prioritize agility and quick cornering ability required to make swift deliveries in an urban environment.

2.2.3 Centre of Gravity and Wheelbase:

The centre of gravity (CoG) refers to the point within the motorcycle where its mass is concentrated. It plays a crucial role in determining the bike's balance and stability during acceleration, braking, and cornering manoeuvres. A lower centre of gravity enhances stability by reducing the bike's tendency to tip over or lean excessively during turns [9].

Resultantly, engineers strive to position the motorcycle's major components, such as the engine, fuel tank, and rider, in a manner that lowers the CoG and centralizes mass distribution. This often involves mounting heavier components as close to the bike's longitudinal axis as possible and optimizing packaging to minimize the CoG's height. By lowering the CoG, designers can improve the bike's agility, responsiveness, and resistance to lateral forces, ultimately enhancing its dynamic performance and handling characteristics.

The wheelbase refers to the distance between the centres of the front and rear wheels. It serves as a critical parameter in motorcycle chassis design, influencing the bike's stability, manoeuvrability, and longitudinal weight distribution.

A longer wheelbase typically results in greater straight-line stability, making the bike feel more planted at high speeds and reducing the tendency for unwanted oscillations or wobbles [9]. However, a longer wheelbase may also compromise the bike's agility and responsiveness in tight corners or urban environments.

Conversely, a shorter wheelbase enhances agility and manoeuvrability by reducing the turning radius and allowing for quicker transitions between corners [9]. Sport bikes and motorcycles designed for dynamic riding often feature shorter wheelbases to optimize agility and responsiveness, facilitating rapid changes in direction and precise control through tight turns.

Achieving the optimal balance between CoG and wheelbase is essential in motorcycle chassis design to ensure a harmonious blend of stability and manoeuvrability. By strategically positioning the CoG and tuning the wheelbase to suit the bike's intended purpose and rider preferences, engineers can create motorcycles that deliver exceptional performance, confidence-inspiring handling, and an exhilarating riding experience across a wide range of conditions and riding styles.

2.3 Summary and key findings

In conclusion, this literature review has provided a structured examination of key mechanisms crucial for supporting and optimizing chassis design for hydrogen-powered postie bikes. Each subsection has offered different insights into chassis performance and overall vehicle dynamics.

Material selection emerges as a critical consideration, with AISI 4340 Alloy Steel identified as a preliminary choice for frame construction due to its favourable combination of accessibility, affordability, and desirable mechanical properties. The discussion around rake angle and trail emphasizes the importance of balancing agility and stability, particularly in urban environments where swift deliveries are paramount. For our postie bike application, a steep rake angle and short trail are deemed necessary to prioritize agility and quick cornering ability.

Regarding the centre of gravity and wheelbase, the focus lies on achieving a harmonious balance between stability and manoeuvrability. Lowering the centre of gravity enhances stability, while strategic positioning of major components optimizes agility and responsiveness. The wheelbase, meanwhile, influences the bike's stability and manoeuvrability, with a shorter wheelbase enhancing agility, making it ideal for the dynamic riding style of a postman.

In essence, by understanding and optimizing these key chassis design parameters, we can pave the way for the successful integration of hydrogen fuel cell technology into our postie bike design. Through iterative testing and refinement, we can achieve the optimal balance between agility, stability, and performance within our postiebike that meet the demands of urban delivery while embracing sustainable energy solutions.

3. Literature review – 103105940

3.1 Introduction

The front suspension and handlebars serve as a significant role in the comfort, stability, and agility of the bike. Research has been carried out to investigate the key characteristics of how the three criteria above can be achieved. The design of the handlebars must be able to withstand about half the rider's weight and therefore must be strong but still cost effective. While the front suspension needs to handle any potholes or bumps the bike may encounter while traveling on the road.

The handlebars must be at a comfortable height as the rider will be working for long hours and cannot be cramped up when riding. The suspension must be able to handle and withstand large loads to make the ride comfortable as well as protect fragile packages they may be delivering.

3.2 Literature review

This literature review delves into the components needed in the design of the handlebars and front suspension of a hydrogen powered postie bike. The key aspects investigated will be, vibration through the handlebars, caster angle.

Handlebars

The handlebars of a bike play a vital role in the comfort of the rider as they must support around 50% of the rider's load when mounted on the bike. Vibrations are introduced to the rider through poor road conditions, engine, and improper structural design [10]. Research has indicated that improper handlebar design can lead to Hand-Arm Vibration Syndrome (HAVS) caused by prolonged exposure to vibrating machinery. A study conducted in the Philippines highlighted the prevalence of HAVS among workers using vibrating tools, emphasising the need for effective vibration dampening solutions [11]. To reduce vibration in the handlebars they can be filled with rubber material and/or grips can be added to combat the vibration. Ergonomically designed handlebars can significantly reduce rider fatigue and enhance manoeuvrability [12]. Therefor the design for the handlebars must improve the riders comfort allowing them to ride for longer and be more efficient in their work.

Front Suspension

The front fork of a motorbike plays an integral role in the quality of the ride as it takes the brunt of the force when encountering rough road surfaces. To allow the bike to steer, the front wheel must be grounded, which means the front suspension must not bounce but take the force and keep the front wheel on the ground [13]. There are many factors to consider when designing the angle for the front suspension as it affects how the bike will perform i.e. racing, sport, or touring. This is the caster angle, with 20-25% being more agile and leaning more toward racing and 25-30% being more stable. The caster angle must be considered for the rider's comfort as the post man will be riding the bike for extended periods of time requiring a more stable ride [14]. Achieving the correct caster angle will help improve rider comfort and performance of the bike.

3.3 Summary and key findings

This literature review delves into the components needed in the design of the handlebars and front suspension of a hydrogen powered-postie bike, focussing on vibration through the handlebars and caster angle for the front suspension.

The handlebars of a motorcycle play a vital role in the comfort of the rider, as they support around 50% of the rider's mass. Poor road conditions, engine vibrations, and improper structural design can introduce vibrations to the rider, which can lead to Hand-Arm Vibration Syndrome (HAVS) from prolonged exposure. A study conducted in the Philippines highlighted the prevalence of HAVS amongst workers using vibrating machines, emphasising the importance of vibration dampening solutions. To help reduce vibration grips can be added to the handlebars along with rubber on the inside of the handlebars. Ergonomically designed handlebars can significantly reduce rider fatigue and enhance manoeuvrability. Therefore, the design for the handlebars must improve rider comfort, allowing them to ride for longer and be more efficient when working.

The front fork of a motorbike plays an integral role in the quality of the ride, as it absorbs the force from rough road surfaces to keep the front wheel grounded and ensure stable steering. The angle of the front suspension, known as the caster angle, affects how the bike performs in different contexts, such as racing, sport, or touring. A caster angle of 20-25% is more agile and suitable for racing, while an angle of 25-30% provides more stability, which is better for touring. For a postie bike, a more stable caster angle is preferred to accommodate extended periods of riding, improving comfort and performance. Achieving the correct caster angle is crucial to enhance rider comfort and overall bike performance, particularly for postman who require a stable and comfortable ride for extended durations.

4. Literature review – 103597864

4.1 Introduction

Through the research of various existing pieces of literature, we will now aim to determine the vital characteristics of the ideal wheels and rear suspension system for our hydrogen powered postie bike design. As with any bicycle, the design of our wheels is of utmost importance as they are the component through which the vehicle achieves motion and are also the place in which the rest of the bicycle and its occupant’s weight falls. For this reason, it must be designed in such a way that it is both sturdy and able to withstand and utilise the torque provided to it by the motor. The design of our postie bike’s rear suspension system is also important, as it is responsible for reducing the vibration of the frame due to rough terrain. This is especially crucial for a postie bike as vibrations may result in damage to particularly delicate payloads, leading to potential costs from the postal service and inconvenience to the customer.

4.2 Literature review

4.2.1 Wheels:

We will begin by researching the optimal design for our wheels (both front and rear). Though our chosen concept design consists of a two-wheel postie bike with a motor integrated into the rear wheel hub, it would still be useful to analyse and consider possible alternate designs. One important component of an electric bicycle is the placement of the motor, and while some bikes have the motor placed somewhere inside of the frame, many have it placed directly in the wheel. This method of motor integration is useful as it reduces the total weight of the bicycle (combining the wheel hub and motor into a single part) and reduces manufacturing costs [15].

As our design solution utilises spoked wheels, it is also important to find the ideal properties for spokes. As was found by Penumarthi and Dosapati [16], a greater number of spokes integrated into a wheel design generally leads to more stability and less deformation, although this also comes with the drawback of greater material usage [16].

In terms of materials, it was found that some common ones for spokes are stainless steel and aluminium [17], and for wheel rims were titanium alloys, carbon fibres, steel or different kinds of aluminium [16][18]. As the wheels support the cumulative weight of the bicycle and its load, it is also important that the chosen material be strong but relatively lightweight [18].

4.2.2 Rear Suspension:

Through further analysis of research material pertaining to the design of bicycle suspension systems, a greater understanding could be gained to aid in the design and justification of this group's rear suspension system. Though not present in all bicycle designs, rear suspension systems reduce vibrations felt in the chassis of the vehicle with a minimal impact on energy efficiency [19]. This reduction in vibrations would be particularly valuable in the context of a postie bike which may be carrying a fragile payload.

4.3 Summary and key findings

Through research into available and relevant material, a greater understanding of wheel and rear suspension design requirements could be gained and utilised in the development of this team's postie bike. Through this research, the decision to move forward with a two-wheeled dual-suspension bicycle design was justified. Common material choices for these parts were also discovered, which will assist in determining the ideal materials for this group's wheels and rear suspension system.

5. Design and development – 104006361

5.1 Introduction

The following section will evaluate and compare design concept 1; drawn by student 104006361, with the others from the group, concluding a final design to move forward with in this project. With the best design determined, this section will move to investigate the assemblies and parts create for their assigned section of the model, providing reasoning and analysis to the construction of these components.

5.2 Design Concept

This section will outline the concept presented by this student, comparing it with the others from the group.

5.2.1 Design analysis & research arguments

Concept 1 as seen in Figure 1; detailed drawings available in Appendix 2.1, features a very typical design for a motorbike combined with the frame of a bicycle. Using this design, concept 1 minimises the weight, manufacturing difficulty, and the costs, using a simple steel pipe structure for the frame and minimal custom parts. Included are multiple storage solutions, with a rear cage that can integrate with traditional postiebike storage as seen in Figure 5.1. Together, these attributes make concept 1 a valuable project in the realm of postie bikes.

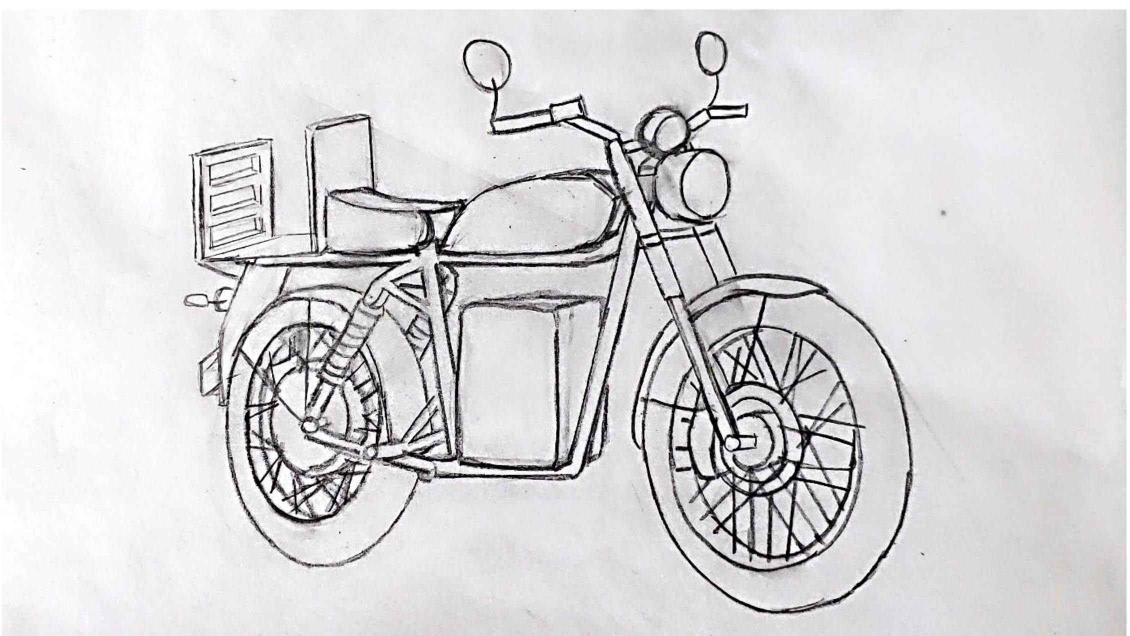

Fig. 5.1 – Extract of conceptual drawings for concept 1

Fig. 5.2 – Postiebike Storage [20]

5.2.2 Concept scoring

The evaluations of our initial design were done using a weighted criteria table. As seen in Appendix 2.4, the criteria considered were the bikes cost, manufacturability, weight, maintenance ability, functionality, and aesthetics. With lowest cost, manufacturability and functionality being considered the most important attributes, they had a weighting of 2 points, while the other criterions had 1. This choice reflected the requirements of the project, which held a focus on the application as a postiebike. Accordingly, ensuring the design was roadworthy and had package storage (functionality), while also being easily deployable and maintainable on a large scale in the postal service (cost and manufacturability) was paramount. In conjunction with this, our personal aspirations for the weight, maintenance capacity and aesthetics where also measured, but weighted lower in correlation to weight divergence from the project guidelines. Concept 1; drawn by student 104006361, was the most highly regarded, scoring 38/45 points. The reasons for the scoring for each criterion are as follows:

- Lowest cost (3.5/5) – Least parts and wheel of all designs. Cost could be further reduced by minimising rear shocks from 2 to 1and adjusting storage compartments.
- Manufacturability (4.5/5) – Very simple design using easily welded pipe structure and no decal panelling.
- Weight (4/5) – Least body panelling of the designs and only 2 wheels (all other design had 3)
- Maintenance (5/5) – Open body design with minimal shell/casing obstructing parts. Allows for very easy maintenance on the system.
- Functionality – Unlike other designs all roadworthy systems in place. Storage solution could be greater – streamlined storage allows.
- Aesthetics – Most appealing of design to group members.

Concepts 1's outstanding performance in all categories meant it received the highest score and was ultimately selected to be the design moving forward in this project.

5.3 Final design parts – Chassis

For the final design chosen, Concept 1, this student oversaw the design the main chassis, as well as the construction of the main assembly, with the following section outlining the design progression and final parts & assemblies built.

5.3.1 Sub-assembly 1: Frame

The frame subassembly of our design is seen in Figure 5.3, for additional details the CAD models and drawings for this assembly can be found in Appendix 1.1.

The models are provided are the following:

- Frame drawing (Appendix 1.1.1)
- Frame part model (Appendix 1.1.2)
- Lug sub-assembly model's (Appendix 1.1.3)

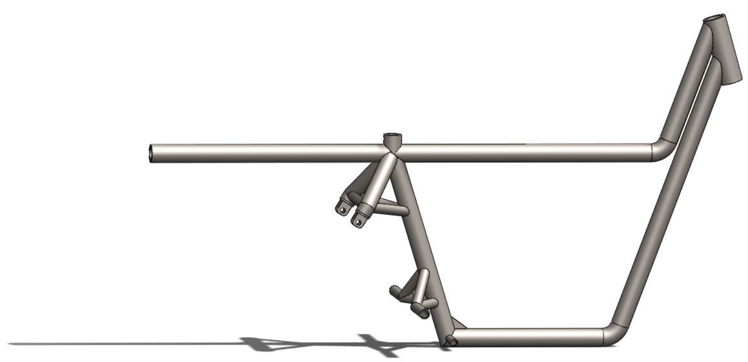

Fig. 5.3 – Frame Sub-Assembly

Design analysis & research arguments:

The frame is very similar to that of a safety bicycle and consists of two triangles: a main triangle and a paired rear triangle as seen in **Figure 5.3.** This design is appropriate considering the desired manoeuvrability and therefore lightweight design for a postiebike, meaning we wanted to minimise excess structural parts and go with a very simple design. Our frame however differentiates in that the main triangle is a trapezium, as room needed to be made to accommodate the Hydrogen fuel cell and battery. In modelling this frame, weldments were used as it reflected the most likely manufacturing for a metal pipe structure.

Fig. 5.4 – Safety bicycle frame design [21]

5.3.2 Sub-assembly 2: Rear Wheel Arm

The Rear Wheel Arm subassembly of our design is seen in Figure 5.5, for additional details the CAD models and drawings for this assembly can be found in Appendix 1.1.

The models provided are the following:

- Weldments arm model (Appendix 1.1.4)
    - Toolbox bearing

Fig. 5.5 – Rear Arm Sub-Assembly

Design analysis & research arguments:

The rear wheel arm is quite standard and completes the bottom arm of the rear triangle as seen in figure 3. Considering its metal pipe structure, weldments was used in modelling to reflect part manufacturing. Additionally, standard AISI AFBMA 18.2.3.2 bearings were used from the SolidWorks toolbox as employing standardised parts is favourable to making all custom products.

5.3.3 Sub-assembly 3: Tail and Lights

The Tail and Lights of our design is seen in Figure 5.6, for additional details the CAD models and drawings for this assembly can be found in Appendix 1.1.

The models provided are the following:

- Tail and Light Sub-Assembly model (Appendix 1.1.5)
    - Tail part model
    - Bracket part model.
    - Taillight part model
    - Tail FEA

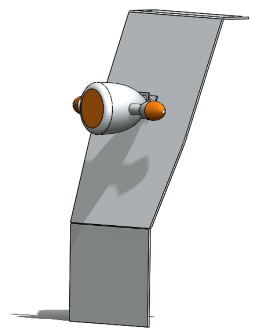

Fig. 5.6 – Tail Sub-Assembly

Design analysis & research arguments:

The tail is a simple sheet metal structure that is easily cut and bent to the desired shape. Attached to this is a rear light secured by a sheet metal bracket. This bracket features gaps, allowing for various fasteners and lights to be used if necessary. Although the rear light is customized, it's advisable to replace it with an existing part. The customized design serves to showcase the student's skill & provide a more complete visual model and does not accurately represent a working taillight.

5.4 Final Design - Main assembly

The CAD models and drawings for main assembly can be found in Appendix 1.1.

The models provided are the following:

- Main Assembly Drawing (Appendix 1.1.6)
- Main Assembly Model (Appendix 1.1.7)

The design analysis and research arguments of the main assembly do not need to be acknowledged, as they are justified throughout the overall report and the sub-assembly explanations.

5.5 Conclusions

Chapter 5 evaluated and compared Design Concept 1, proposed by student 104006361, with other concepts within the group, ultimately selecting it as the final design to proceed with in the project. Design Concept 1, featuring a combination of motorbike and bicycle frame elements, was scrutinized through design analysis and research arguments. This concept prioritized minimizing weight, manufacturing complexity, and costs by employing a simple steel pipe structure for the frame and incorporating multiple storage solutions, making it a promising candidate for the postie bike project, scoring 38 out of 45 points in the criteria table. Its simplicity in design, reduced part count, ease of maintenance, and overall appeal contributed to its outstanding performance across all criteria.

Moving forward, this student’s model contributions to the selected design were examined. The frame, rear wheel arm, tail, lights, and main assembly were meticulously designed and analysed, taking into account factors such as structural integrity, manufacturability, and functionality.

Overall, Chapter 6 highlighted the rigorous evaluation process undertaken to select the most suitable design concept and outlined the subsequent development of key components for the chosen design, laying the groundwork for the project's advancement.

6. Design and development – 103105940

6.1 Introduction

When beginning our design phase for the postie bike our team all developed a sketch and idea of what we would like the postie bike to look like and function. Each group member developed a design for the postie bike with each differing from each other allowing us to view a wide range of what our hydrogen powered postie bike could look like. Designs were hand sketched with basic measurements and design features labelled to give all members an idea of what each design had to offer. These designs were then graded with the following weighted criteria:

- Ease of maintenance (Weighting of 1)
- Functionality (Weighting of 2)
- Aesthetics (Weighting of 1)
- Cost (Weighting of 2)
- Manufacturability (Weighting of 2)
- Weight (Weighting of 1)

Each member then graded all the designs according to this criterion allowing a final design to be chosen. This selected design would be the one the group will go on to develop further.

6.2 Final Design- Handlebars and Front Suspension

Design analysis & research arguments.

The handlebars and front suspension are made up of many components that had to be designed to fit and interact not only with each other but the entire bike. This led to many redesigns trying to fit it together while still working with the correct angles to allow for a comfortable ride. The front suspension had to be able to hold the load of the rider 50-100kg, payload of 40kg and withstand the forces objected onto it from the road surface. Therefore, a larger spring was needed inside the suspension to combat these forces applied to it. The front suspension assembly can be found in appendix 1.2.1 or seen in Figure 6.1 below.

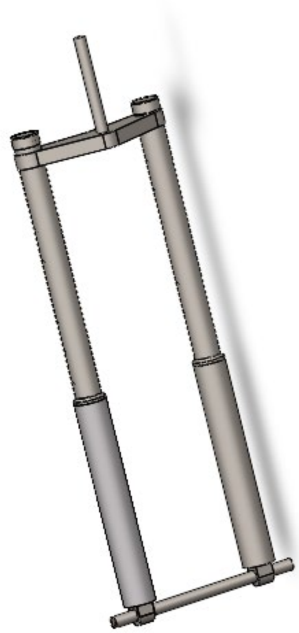

Fig 6.1 – Fork Sub-Assembly

Which is made of the following components:

- Bottom fork 1.2.2
- Top fork 1.2.3
- Spring 1.2.4
- Axil 1.2.5
- Ring seal 1.2.6
- End cap top 1.2.7
- Suspension clamp 1.2.8
- Clamp Pipe 1.2.9
- Axil Housing 1.2.10

The handlebars were positioned to enable the most comfortable ride possible while continuing the streamlined design the group was trying to achieve. The handlebars assembly can be found in appendix 1.2.9 or as seen in Figure 6.2 below.

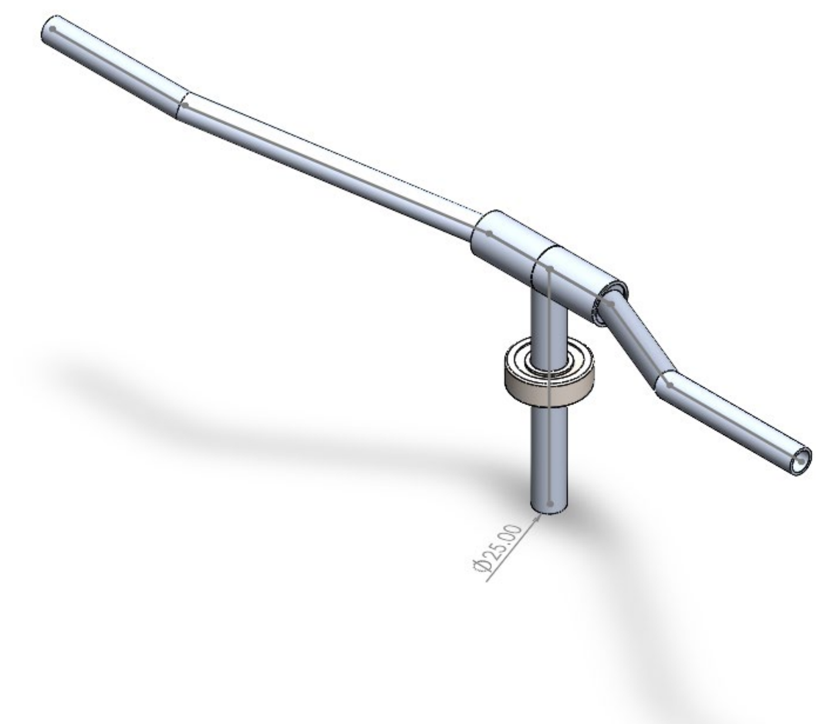

Fig 6.2 – Handlebar Sub-Assembly

Which is made up of the following components:

- Handlebar clamp 1.2.11
- Handlebars 1.2.12
- Bearing (Toolbox)

6.3 Concept scoring

Concept 2 as seen below in Figure 6.3 scored 31.5 as seen in appendix 2.4, which was ranked third in comparison to the other designs. The design consisted of three wheels with an internal drive train running to the rear wheels. The trike design allows provides several advantages to its two-wheeled counterpart. Primarily, they offer enhanced stability especially during stopping which will be happening a lot when delivering mail. Additionally, the trike, allows for a larger more comfortable seat to help the rider endure longer riding times. Its larger frame provides a lot of space for storage of mail and packages without cramping the rider. The bike also offers a safer ride as the rider is unlikely to tip over allowing less experienced or less abled riders to partake in delivering mail. The trike also offers a lot off customisation which would help Australia Post to adjust it specifically to their needs.

This is the scoring the bike received against the key criteria:

- Ease of Maintenance (3.5/5)- This score was due to the internal drive train as it isn't as easy to access in comparison to concept 1 and 3.
- Functionality (4/5)- Due to its storage capabilities and comfort it offers a 4 was on the top end for the rating.
- Aesthetics (4.5/5)- This score was the second highest as the bike has a high visual appeal and is a bit different having three wheels instead of two.
- Cost (2.5/5)- This scored the lowest as it has a lot more materials compared to the other bikes.
- Manufacturability (4/5)- The bike was more complex in comparison to other designs which is why it did not score as high as the others.
- Weight (2.5/5)- This design is the largest out of the concepts and that is why it did not score as high in this category.

Once all the scoring was done from all the team members it was concluded that design concept 1 was the design that would go on to be produced.

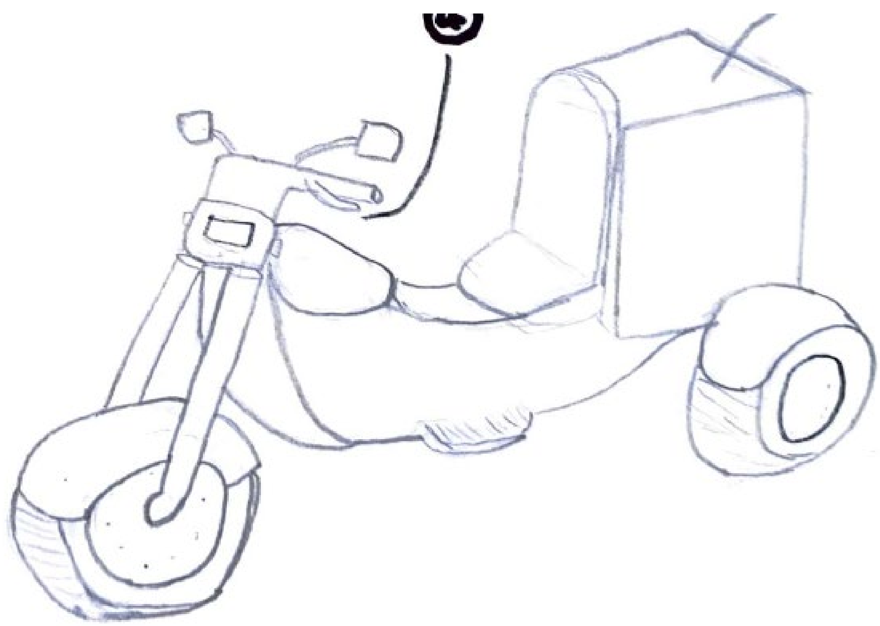

Fig. 6.3 - Extract of conceptual drawings for concept 2

6.4 Conclusions

Chapter 6 investigated design concept 2 against the other designs put forward by the other group members. With voting conducted to see which design would best optimise the criteria of ease of maintenance, functionality, aesthetics, cost, manufacturability, and weight.

The final design featured a well-thought-out handlebar and front suspension system. The handlebars were designed for a streamlined aesthetic while still providing the rider with maximum comfort. The front suspension was engineered to withstand significant loads and road forces, ensuring durability and rider comfort.

During the concept scoring phase, concept 2, which consisted of a trike design, demonstrated superior stability, storage capacity, and rider comfort/safety. However, it scored lower on aspects like cost, ease of maintenance and weight due to its more complex design and size. Despite its innovative advantages the overall assessment from team members led to the selection of design concept 1 as the final design for further development. This design balanced functionality, manufacturability, and cost effectiveness, making it the most optimal choice for further development.

The iterative design process, detailed analysis, and thorough evaluation of each concept ensured that the final product met the necessary criteria.

7. Design and development – 103597864

7.1 Introduction

Before beginning work on the final design, it was important to gather a variety of design ideas in order to find the best approach to follow. This process consisted of each member of the design group coming up with their own approximate design for a hydrogen powered postie bike, before submitting it to a group document to be graded by the other members. Each member would construct their design through surface level research and inspiration from existing designs, before drawing multiple views of their design solution along with basic measurements so that fellow group members could adequately grade their design. Once each design was completed and submitted to the collective document, they would be graded by each group member based on 6 weighted criteria:

- Cost (Weighting of 2)
- Manufacturability (Weighting of 2)
- Weight (Weighting of 1)
- Ease of maintenance (Weighting of 1)
- Functionality (Weighting of 2)
- Aesthetics (Weighting of 1)

Once each design was rated, their collective criteria ratings were tallied and the design with the highest total rating was chosen to be designed.

7.2 Design analysis & research arguments

The design of this team's wheels consists of many individual parts, each of which went through redesigns to reach an ideal state. One of the first details to be considered for their designs were their size. For this, this group member looked towards finding a standard size which would fit the already designed frame (to save on manufacturing costs as a custom size would not be required). To this end, it was concluded that wheels with a 300mm radius (from the centre to the inside of the rim) would best fit.

It was also concluded that a design with 36 spokes would be apt, as a postie bike carrying a battery, a 40kg payload and a 50-100kg rider (as outlined in the provided project brief) would require far greater stability, and thus more spokes, than the average bicycle. These spokes were also designed to be thicker than that of an average bicycle, being 2.4mm thick, to further increase the stability of the wheels. While these details will inevitably result in greater costs and weight, they were deemed worthwhile as the extra stability would decrease the likeliness of wheel failure, reducing the chance of late or even damaged payloads which could result in customer dissatisfaction and costs to the postal service. This would also reduce the chance of the rim deforming, leading to lower maintenance costs.

7.3 Concept scoring

As seen in **Appendix 2.3**, as well as Figure 7.1 below, this team member's design (Concept 3) consists of a three-wheel postie bike with a storage space integrated into the seat of the vehicle. The inclusion of a third wheel in this design assists in supporting the distribution of weight, which is especially important in a postie bike which is intended to carry greater loads than that of a standard bicycle. This however also significantly increases the material usage and total weight of the bike, and would also increase production costs of the bicycle. The integration of the storage space into the seat of the bicycle would reduce the total amount of space needed on the bicycle as a separated storage space would be unnecessary. This design choice does come with drawbacks however, as the amount and size of items able to be carried would be limited by the size of the seat interior, and the driver would need to disembark from the vehicle in order to insert and remove parcels from the storage space.

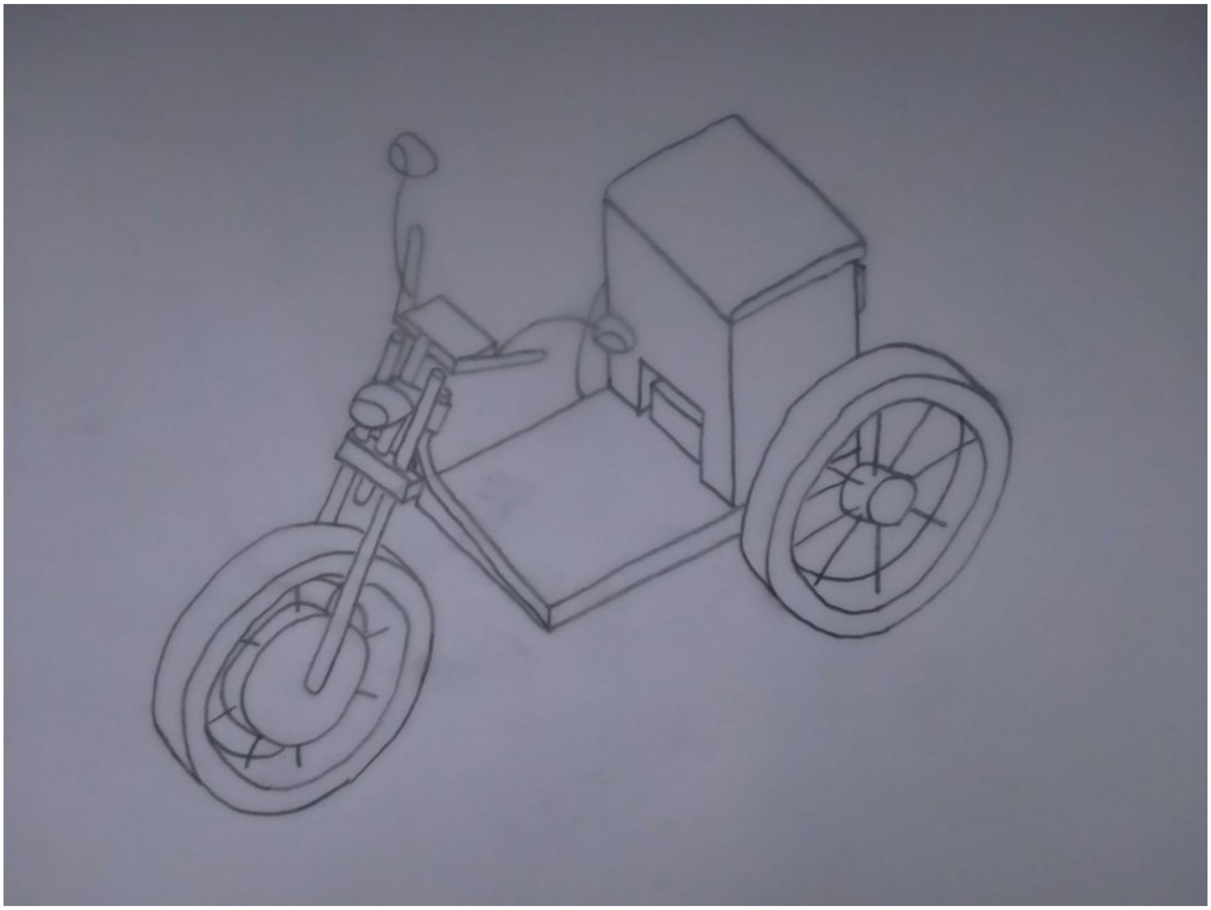

Fig. 7.1 – Extract of Concept 3 drawing

As seen in Appendix 2.4, design concept 3 ended up having the second highest total score when considering the 6 key qualities deemed important in our design.

- Lowest Cost: This design had a “Lowest cost” score of 3 as, while the design was simple and did not require a separated storage system, the extra wheel and increased space needed for it would significantly increase productions costs.
- Manufacturability: Due to the simple design however, this concept earned a “Manufacturability” score of 5, as it has an easy to produce chassis and seat.
- Weight: This design had one of the lowest “Weight” scores of 3 due to the extra wheel and larger seat.
- Maintenance: Due to the lack of complex parts in this design, maintenance of it would end up being rather simple, earning it a score of 5 in this criterion.
- Functionality: This design concept earned a score of 4 in these criteria, equal to both concepts 1 and 2.
- Aesthetics: Design concept 3 had the lowest “Aesthetics” score of 3, tied with design concept 4, due to its rather simple design not lending itself to a very pleasing look.

Following the scoring of these designs, it was concluded that concept design 1 would be the best to move forward with.

7.4 Final design

7.4.1 Sub-Assembly 1: Front Wheel

Shown below in Figure 7.2, is the front wheel sub-assembly. It consists of a hub model, rim model, tyre model and spoke models designed by this team member.

Fig 7.2 – Front Wheel Sub-Assembly

7.4.2 Sub-Assembly 2: Rear Wheel

Shown below in Figure 7.3, is the rear wheel sub-assembly. It consists of the same rim and tyre models used in the front wheel sub-assembly but utilises a different hub motor model taken from GrabCAD, as well as different spoke models designed by this group member to account for the different hub size.

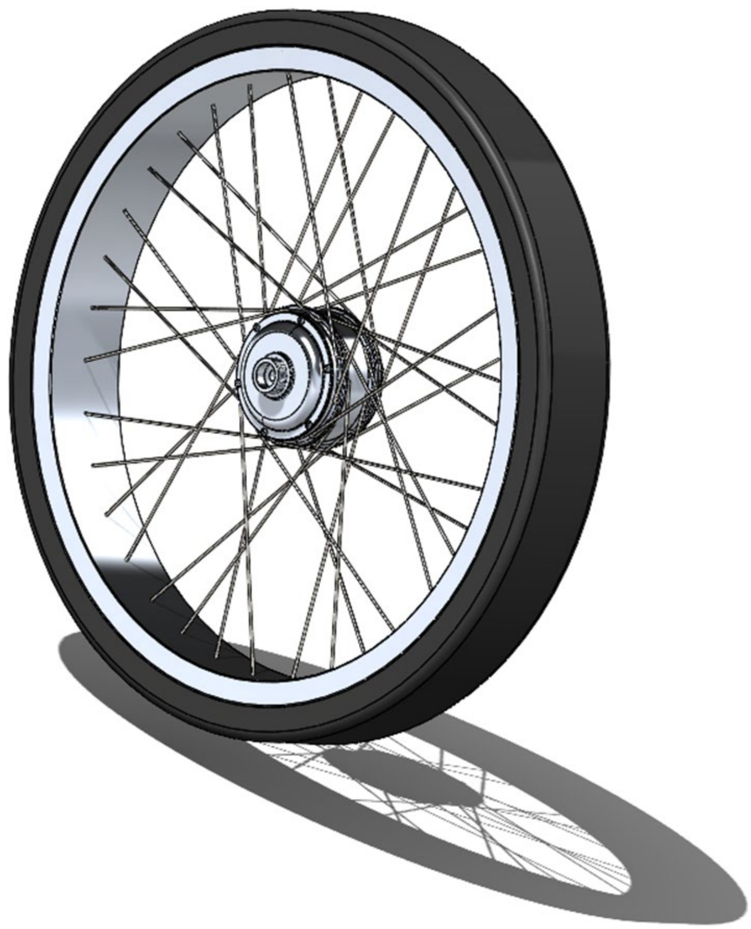

Fig 7.3 - Rear Wheel Sub-Assembly

7.4.3 Sub-Assembly 3: Rear Suspension

Shown below in Figure 7.4, is the rear suspension sub-assembly. It consists of two copies of a shock absorber sub-assembly taken from GrabCAD, as well as modified versions of the lug sub-assemblies from the bicycle frame sub-assembly. The axle and lug connectors in this sub-assembly were designed by this group member.

Fig 7.4 – Rear Suspension Sub-Assembly

7.5 Conclusions

While design concept 3 held the second highest overall score out of the four proposed, consisting of a three-wheeled design with a storage space integrated into the seat of the vehicle, it was ultimately decided that this group would move forward with design concept 1, which is a two-wheeled design with multiple storage spaces spread across its frame. Based on the concept drawings and research into relevant literary pieces, wheels and a rear suspension system were designed using the SolidWorks software. The wheels were designed with a 300mm radius from centre to rim so that they could fit into the already designed frame and given 36 spokes so that they can withstand the combined weight of the chassis, rider and payload. The rear suspension system was designed with dual shock absorbers taken from the Grab CAD library, and an axle allowing it to connect to the rear wheel.

8 Sustainability & Finite element analysis - 104006361

8.1 Introduction

This section will undertake a tangible analysis on the chassis assembly of the postiebike design. Investigations into material selection will be made and validated through Finite Element Analysis' (FEA) and substantiality testing. Additionally, recommendations into material or design changes will be made through the application of a design study.

8.2 Material selection

The preliminary material selection based on the literature review in section 2.2 was AISI 4340 alloy steel, with AISI 1015, 1018, and 1020 also being considered. The following table, Table 8.1 compares the material properties of these steels.

Table. 8.1 – Table of proposed frame material properties, retrieved from SolidWorks material library where available.

Material	Yield Strength (MPa)	Mass Density (kg/m^3)	Shear Modulus (MPa)	Elastic Modulus (MPa)
AISI 1015	325	7870	8000	205000
AISI 1018 [7]	370	7870	8000	205000
AISI 1020	350	7870	8000	205000
AISI 4340	470	7850	8000	205000

In the following sections, AISI 1018 will not be considered, as its unavailability within the SolidWorks material library means it cannot be analysed through the conducted design study and SolidWorks sustainability.

8.3 Validation through FEA and Sustainability testing

This section will perform finite element analyses of the parts, evaluating the results to help determine suitable material.

8.3.1 Frame finite element analysis

The primary component completed by the student is the weldments frame, which requires a FEA to determine the most appropriate material. The comprehensive FEA report with force magnitude and position explanations is available in Appendix 5.1.1, with the following summary highlighting the key results. The stress plot in Fig. A shows a maximum stress of 38 MPa at the seat location. This stress result produces a safety factor of ~12.4 and would be cause for design changes. The displacement plot in Fig. A indicates an erroneous maximum displacement of 32,833.938 mm in the gusset, clearly an outlier. To ensure meaningful analysis, the graph's maximum displacement is capped at 2 mm. Excluding the gusset outlier, the actual maximum displacement is approximately 1.4 mm at the left end of the top pipe. This measure is reasonable and not cause for design adjustments.

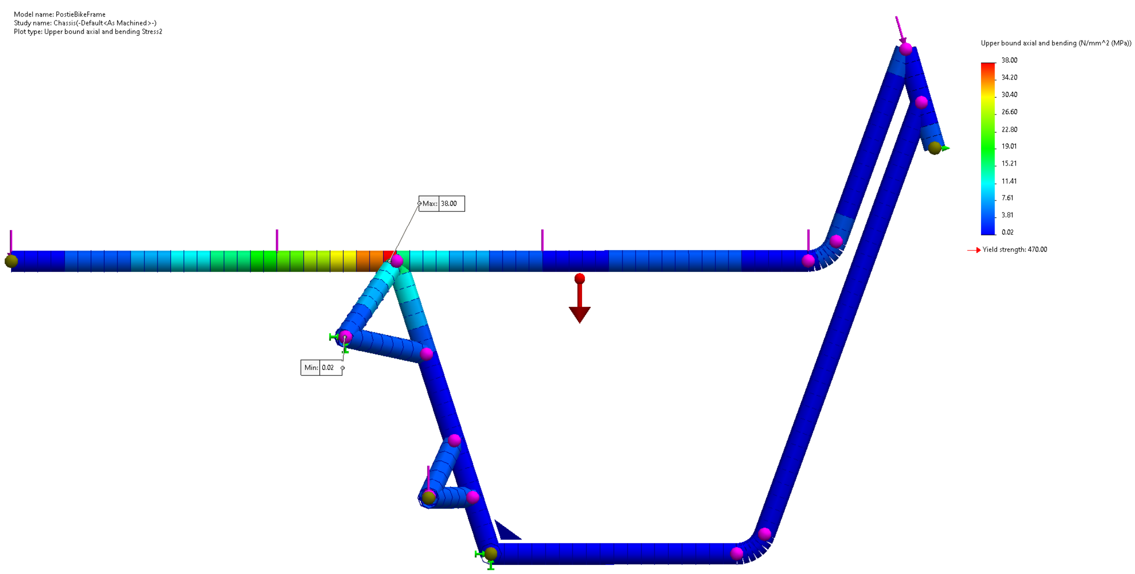

Fig. 8.2 - Stress plot for frame

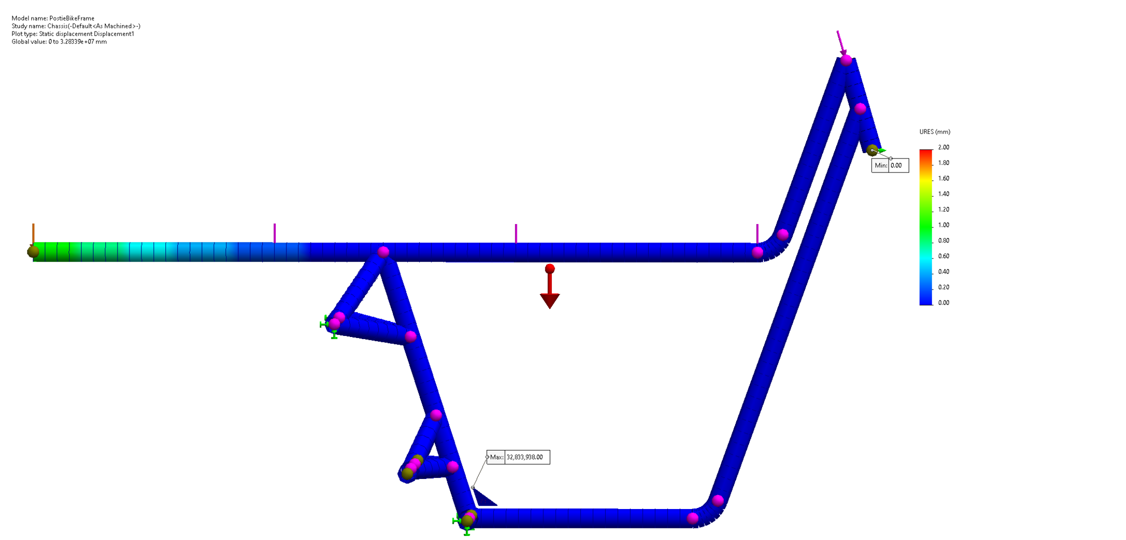

Fig. 8.3 - Displacement plot for frame

These results confirm that while AISI 4340 is a functional material for frame applications, it has an unnecessarily high stress resistance. With a safety factor of ~12.4, it is recommended to implement design changes to the geometry, such as reducing the pipe diameter or thickness, or to consider using a material with a lower yield strength. Resultantly, the subsequent section will conduct a design study to further compare this material to the others outlined in table 2.

8.3.2 Frame design study

This section evaluates the most suitable material for the postiebike frame, between AISI 1015, 1020 and 4340 using a design study. For the full design study report see appendix 5.1.2.

AISI 1018, while considered in table 2.1, is not investigated in the design study due to its unavailability in SolidWorks material library. In the study, the mass of the frame was monitored, and the beam stress and Safety Factor were set as goals. Beam stress was set to maximize while factor of safety was set to minimize. The results; seen in table. 8.4, saw AISI 1015 regarded as the optimal choice

Table 8.4 Extract from design study outlining optimal material change.

		Optimal	Scenario 1	Scenario 2	Scenario 3
Material	List of Materials	AISI 1015 Steel, Cold Drawn (SS)	AISI 4340 Steel, annealed	AISI 1015 Steel, Cold Drawn (SS)	AISI 1020 Steel, Cold Rolled
Mass1	Monitor Only	30003.799211 g	29927.550675 g	30003.799211 g	30003.799211 g
Beam Stress1	Maximize	38.001 MPa	37.997 MPa	38.001 MPa	38.001 MPa
Minimum FoS	Minimize	8.552	12.369	8.552	9.210

AISI 1015 was selected as it saw the highest reduction in safety factor, from 12.369 to 8.552, for the highest beam stress. While in this case beam stress could have been monitored instead of maximised, if the materials weren't all similar alloy steels they would have acted differently under the loads, generating different stresses making this measurement maximisation valuable.

8.3.3 Frame sustainability

The frame materials sustainability was evaluated through SolidWorks Sustainability, with the following section summarising the results in respect to our material selection. AISI 4340 was chosen as the baseline material, and two reports were generated comparing it to AISI 1015 and AISI 1020; detailed reports can be found in appendix 5.1.3 and 5.1.4, respectively. These studies involved various assumptions about the materials' construction, lifespan, and end-of-life (EOL) properties. Specifically, the manufacturing process was assumed to be extrusion, the material was designed to last 3 years with a use case of 5 years, which is typical for motorbike applications. Additionally, the EOL cycle was set with 71.61% recycled, 0% incinerated, and 28.39% sent to landfill, reflecting the post-shredder waste efficiencies of the Australian vehicle market [22].

The summarised graphical comparison can be seen in Figures 8.5 and 8.6, which determine that AISI 1015 and 1020 see the same ecological and economic reductions. Decreasing carbon footprint by 14%, energy consumption & air acidification by 14%, and water Eutrophication by 62%, both these materials would be recommended substitutes.

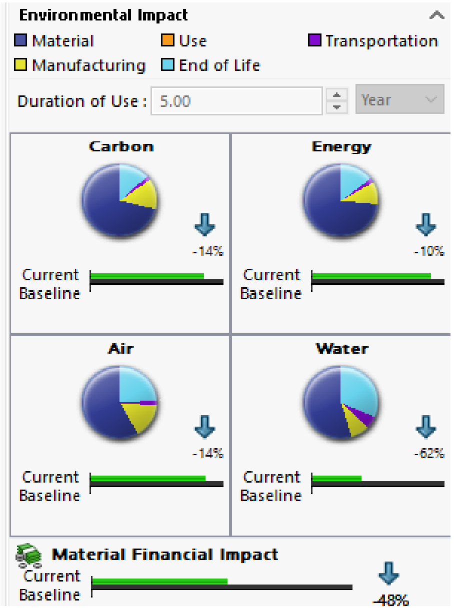

Fig. 8.5 – Comparison of AISI 1015 to AISI 4340

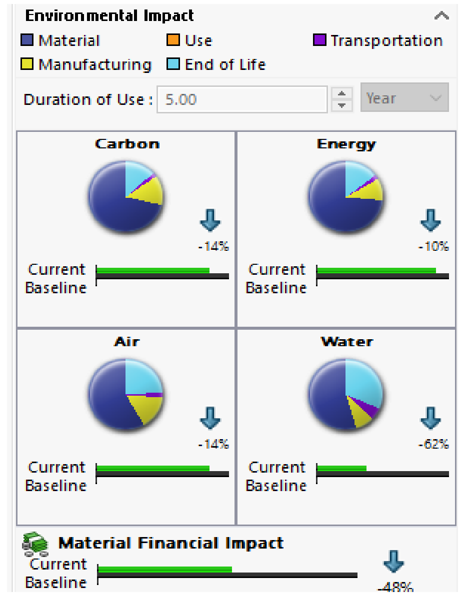

Fig. 8.6 – Comparison of AISI 1020 to AISI 4340

8.3.4 Tail finite element analysis

The component completed by the student is the tail portion. Since this is a sheet metal part, additional FEA should be conducted to differentiate the stresses in the weldments. The comprehensive FEA report is available in Appendix 5.1.5, with the following summary highlighting the key results. The stress plot in Figure 8.7 shows a maximum stress of 59.43MPa at the top bend location. This stress result produces a safety factor of ~5.9 The displacement plot in Figure 8.8 indicates a maximum displacement of 12mm in the bottom of the tail, which is very large and cause for design changes.

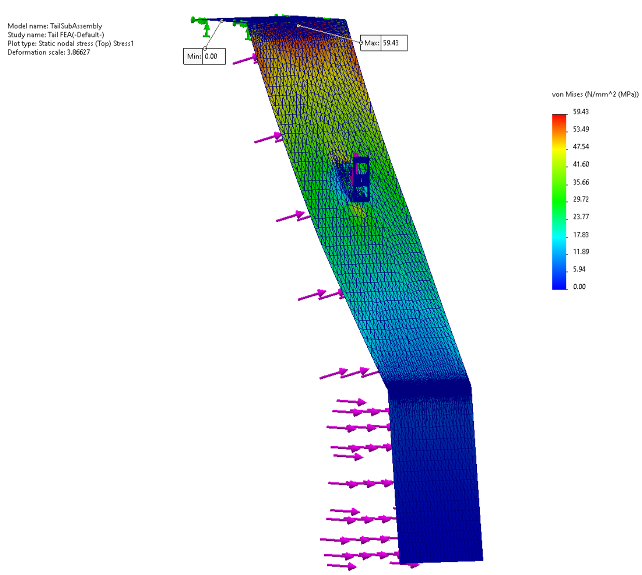

Fig 8.7 - Stress plot for tail

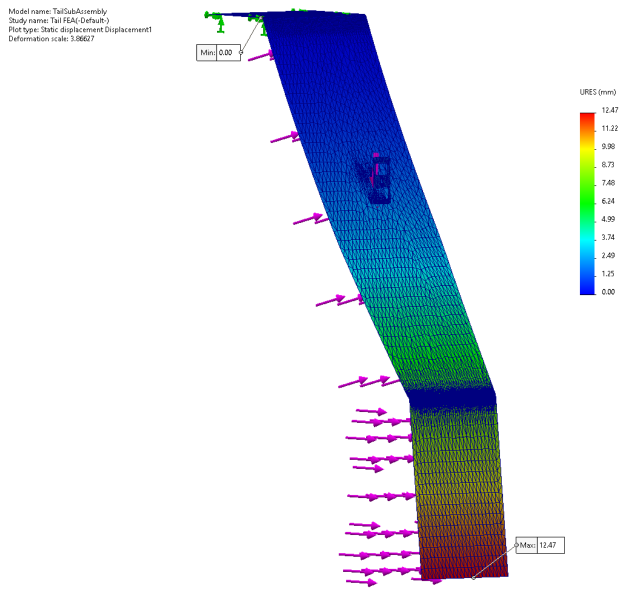

Fig 8.8 – Displacement plot for tail

The applied force to the backside of the tail was calculated using a flow study, the results of which are available in Appendix 5.1.6. An image of the flow simulation can be seen in Figure 8.9

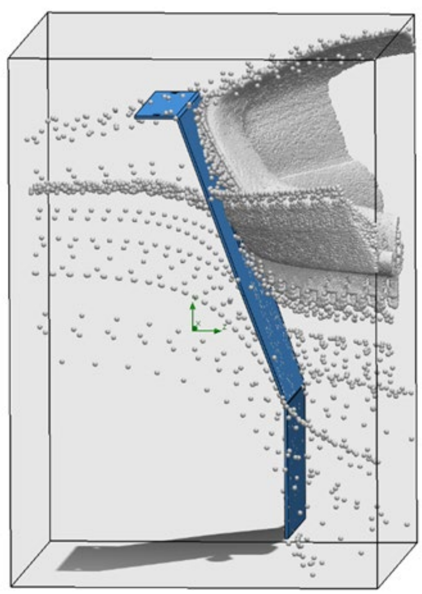

Fig. 8.9 – Flow simulation showing air trajectory

Overall, these results confirm that AISI 4340 is a functional material for tail applications in terms of stress capacity. While it has a redundant high stress resistance, with a safety factor of ~5.9, its deflection is significant, meaning without geometric adjustment an alternate materials may not be recommended. Accordingly, it is advised to implement design changes to the geometry, such as reducing the thickness to decrease the safety factor, while providing some additional struts or supports to hold the bottom of the sheet metal in place and avoid significant deflections.

8.4 Conclusions

It is recommended to transition away from AISI 4340 as the selected material. While is strength qualities are attractive, such are unnecessary for the application of our postie bike, as validated by the FEA results obtaining high safety factors of 5.9 -12.4. Accordingly, the combination of the design study as well as the sustainability report indicate that AISI 1015 would be the most suitable material, lowering the safety factor significantly, while reducing environmental impacts and material costs.

9. Sustainability & Finite element analysis – 103105940

9.1 Introduction

After the completion of the handlebars and front suspension design the optimal material had to be selected for these parts and assemblies. This was done through the SolidWorks software. Analysis on the properties of selected materials will be conducted through FEA testing and a sustainability report on the materials used. The testing is done to confirm whether the selected material will be suitable for the final production of the postie bike or must be changed to improve it before final production.

9.2 Discuss material selection.

The material used was 6061 Alloy, which is commonly used in bike frames. Below is a table of other potential alloys that could have been used.

Table. 9.1 – Materials from SolidWorks library

Material	Yield Strength (MPa)	Mass Density (kg/m^3)	Shear Modulus (MPa)	Elastic Modulus (MPa)
6061 Alloy	55.1485	2700	26000	69000
1060 Alloy	27.5742	2700	27000	69000
2014 Alloy	96.5098	2800	28000	73000
2018 Alloy	317.104	2800	27000	74000

After evaluating each material 6061 Alloy was selected due to its common use in bike frames.

9.3 Validation through FEA and Sustainability testing

To determine if the selected material was sufficient for the handlebars a Finite Element Analysis (FEA) was conducted to determine if the handlebars could handle a 500N load applied to either side of the bars. The 500N load was selected to simulate 50% of a 100kg rider with gravity acting on it. The FEA report can be found in Appendix 5.2.1 The test results concluded that the material had a factor of safety of ~ 0.2 which is below the recommended factor of safety of 1.4-2, this means that a higher yield strength material or thicker piping in the handlebars must be used to achieve the desired factor of safety.

Stress1	Upper bound axial and bending	0.00e+00N/mm^2 (MPa) Element: 56	2.30e+02N/mm^2 (MPa) Element: 119

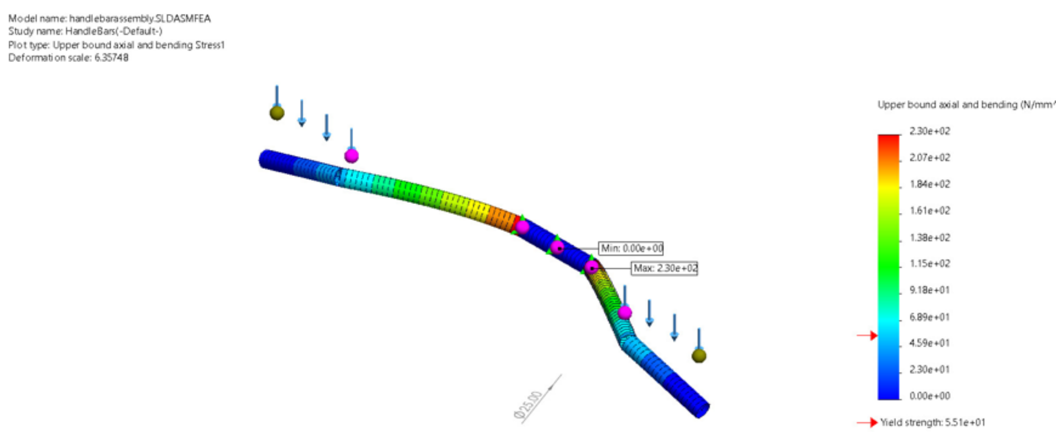

Fig. 9.2 - Depicts the stress throughout the handlebars.

Fig. 9.3 – Depicts the displacement in the handlebars.

A sustainability report was conducted to compare the selected material to other materials considered for the handlebars. See Appendix 5.2.2 for the sustainability report. This figure depicts the effects of 6061 Alloy.

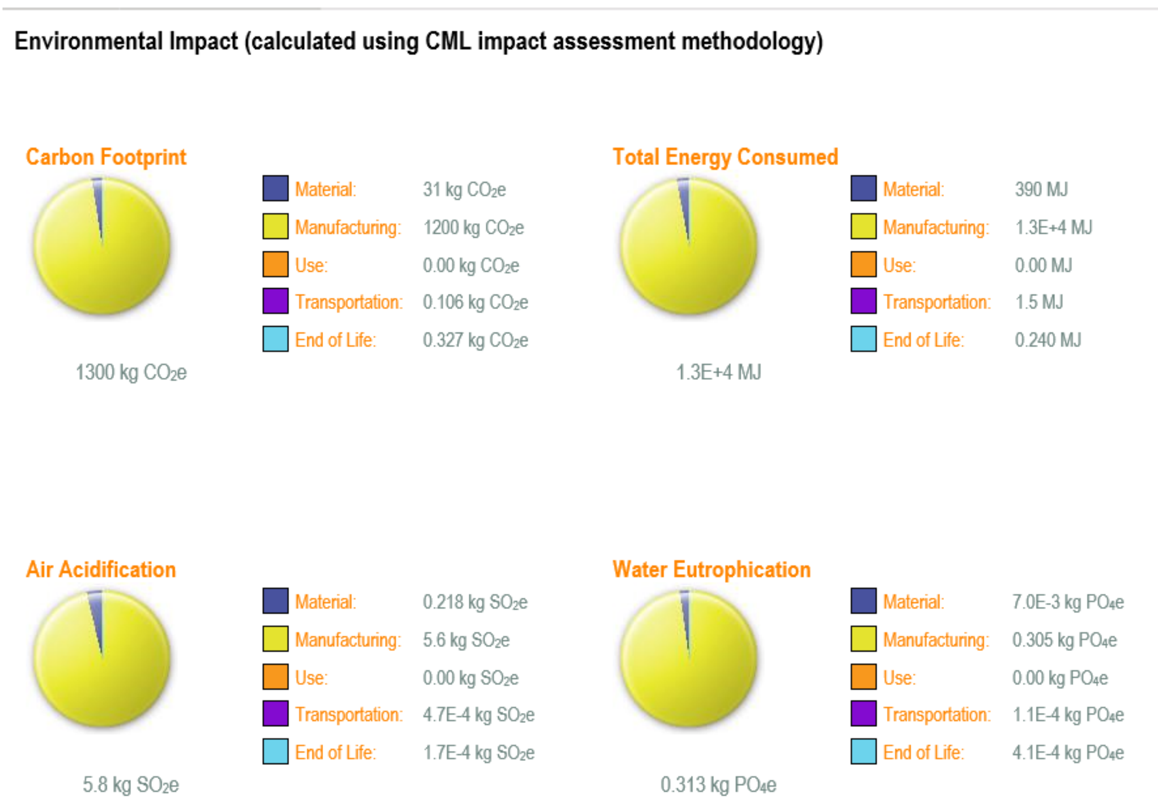

Fig. 9.4 – Sustainability for 6061 Alloy

9.4 Conclusions

The FEA analysis conducted on the handlebars concluded that a higher yield strength material would be required to fulfill the desired factor of safety of 1.4-2. Further research would need to be carried out to find the desired material that would satisfy these needs. The sustainability report recorded that the material would affect the environment the most during its manufacturing.

10. Sustainability & Finite element analysis – 103597864

10.1 Introduction

With the design of the wheels and rear shock absorbers completed, it was important to determine the optimal material for these parts and determine the validity of the design choices through the use of the SolidWorks software. Material selection would be accomplished through research into commonly used materials for the specific parts, as well as through static and sustainability analysis. Through this analysis, changes to the current design could be suggested.

10.2 Discuss material selection.

Rim and Wheel Hub:
When looking into common materials used for bicycle wheel rims, it was found that most vehicle rims utilise carbon fibre, steel, titanium or some kind of aluminium. It was determined that aluminium would be ideal as it is relatively cheap and light, as discovered by comparing the properties of these materials in the SolidWorks software. The particular type of aluminium chosen for the rim and wheel hub was Al 6061-T6.

Spokes:
Stainless steel was chosen as the material for the spokes, with the specific type of stainless steel chosen being AISI-304.

Rear Suspension:
AISI 4130 steel, annealed at 865 degrees Celsius was chosen as the material for the rear suspension system.

10.3 Validation through FEA and Sustainability testing

10.3.1 Rim finite element analysis

In order to determine the viability of the design choices, finite element analysis (FEA) was conducted on the rim through the use of the SolidWorks software. The results and details of this analysis can be found in the FEA report for the rim Appendix 5.3.1. To conduct this analysis, it was assumed that a maximum load of 950N would be applied to the top of the rim, based on a maximum rider weight of 100kg and maximum payload weight of 45kg (described in the project brief) as well as a chassis weight of approximately 45kg (found through SolidWorks analysis), shared between both wheels. This analysis concluded that the current design of the rim has a factor of safety of approximately 53, suggesting that many compromises could be made to reduce material use and manufacturing costs. This could be achieved through the use of a cheaper material with a lower yield strength, or through reducing the thickness of the rim.

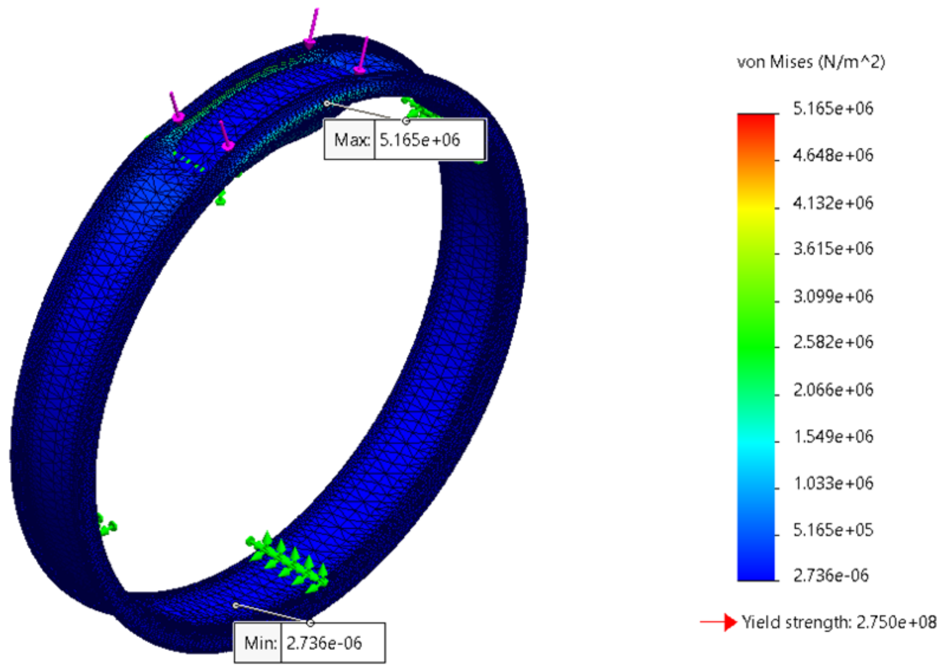

Fig.10.1– Stress plot for rim

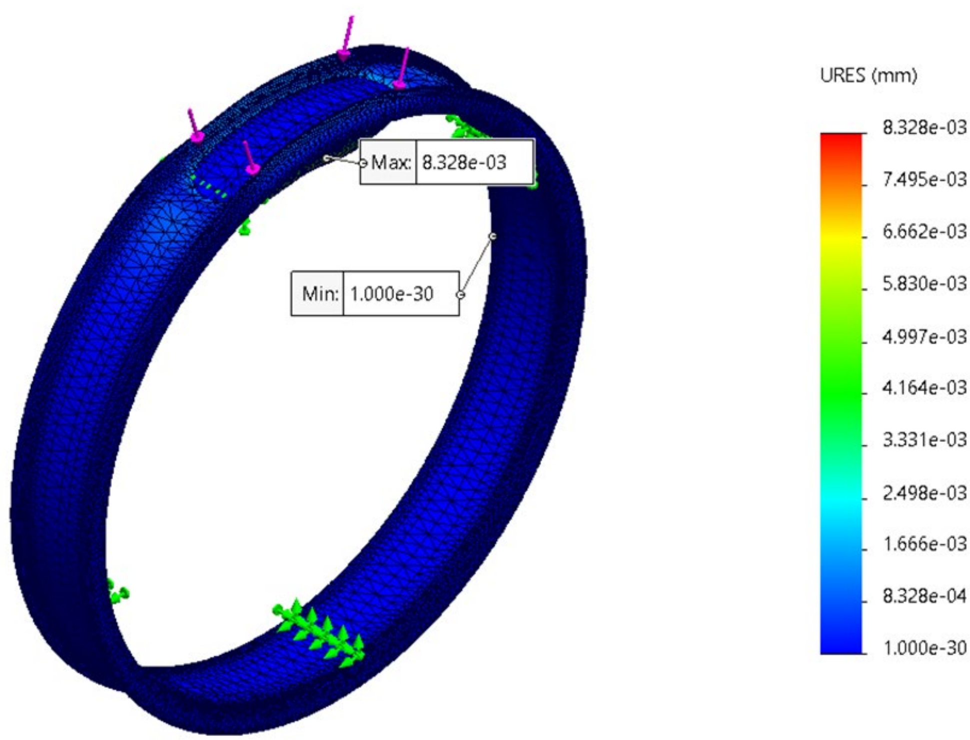

Fig. 10.2 – Displacement plot for rim

10.3.2 Rim sustainability

Through the SolidWorks sustainability analysis tool, different materials can be applied to a part to compare their effect on the environment, as well as other factors such as price and strength. Though by the time of the completion of this analysis, Aluminium 6061-T6 had already been chosen as the material for the rim part, this tool could still be utilised to determine different materials which could improve the overall effectiveness of the design. By using the sustainability tool to search for materials with a similar density but higher yield strength than Al 6061-T6, it was found that the use of Al 4032-T6 could significantly improve the sustainability of this design. Al 4032-T6 was found to have a slightly better environmental impact than Al 6061-T6 (with improvements between 0% and 4% in each of the 4 categories), as well as a slightly higher yield and tensile strength. The biggest advantage of using Al 4032-T6 however was found to be the price in comparison to Al 6061-T6, being 76% lower according to the sustainability analysis tool.

The sustainability of Al 4032-T6 in comparison to Al 6061-T6 can be seen in Figure 10.3 below. For more details, see the sustainability report for the rim using Al 6061-T6 in Appendix 5.3.2, and using Al 4032-T6 in Appendix 5.3.3.

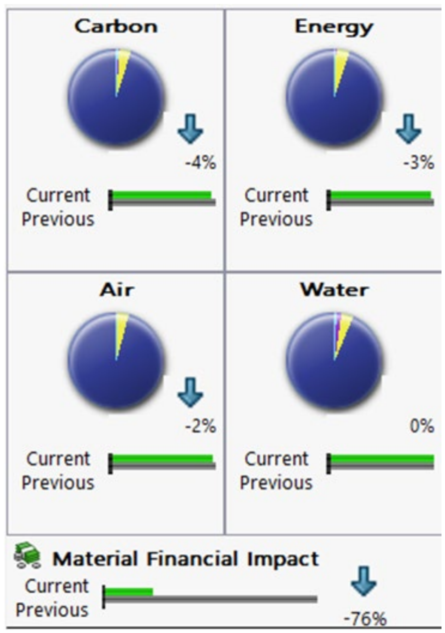

Fig. 10.3– Sustainability of rim using Al 4032-T6 compared to Al 6061-T6

10.4 Conclusions

While the current design of the rim utilises aluminium 6061-T6 due to its relatively low price and density, as well as its adequately high strength, the Solidworks sustainability tool indicates that Al 4032-T6 may be a better rim material choice overall. This is due to the lower price and environmental impact of this material compared to Al 6061-T6. Through finite element analysis, it was also found that the current rim design has a very high factor of safety (approximately 53), indicating that many changes could be made such as using a material with a lower strength and cheaper cost, or decreasing the width of the rim to lower material use.

11. Photo Rendering and Animation – 104006361

In this chapter, we present photorealistic renderings and animations to illustrate the application of the bike chassis for engineering practice.

11.1 Photo Rendering

Photorealistic rendering, or photo rendering, is crucial in engineering for creating high-quality, realistic images from 3D models. It enhances design visualization, allowing stakeholders to see proposed designs and compare iterations, thereby facilitating better decision-making. It also aids in simulation and analysis, such as lighting and material studies, and supports virtual prototyping to reduce costs and identify issues early. Additionally, photo rendering is used in technical manuals and training materials to provide clear, detailed guidance. By leveraging advanced SolidWorks Photo render 360, realistic visualizations were created of our postie bike; see Figure's 11.1 and 11.2, to improve communication and enhance our overall design process.

Fig. 11.1 – Postiebike Render: Front View

Fig. 11.2 – Postiebike Render: Rear View

11.2 Animation

The animation, available in Appendix 6.3, includes the postiebike assembly rotated, as well as in exploded and collapsed views. These animations enhance understanding of the assembly process and internal workings of our design. The exploded view, which forms the basis of this animation, can be seen in Figure 11.1.

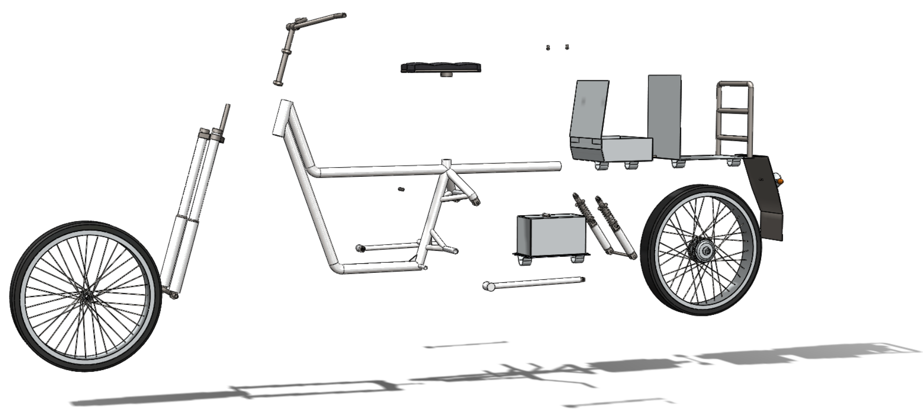

Fig. 11.3 – Exploded view of Postiebike

11.3 Conclusions

The photorealistic renderings and animations presented in this section provide a comprehensive visual representation of the bike chassis, demonstrating its design and functionality in an engineering context. The detailed animation views, including rotation options and exploded and collapsed perspectives, offer valuable insights into the assembly process and internal mechanisms. These visual tools, enhance the overall understanding of the model's design, validating its structural integrity and practical application. This integration of advanced rendering and animation techniques significantly contributes to the robustness of the engineering analysis and the clarity of the presentation.

12. Summary – 103597864

12.1 Project Overview

The goal of this project was to produce an effective hydrogen-powered electric bike design for use by Australia Post in delivering packages. This team was provided with a list of specifications which the bike would need to meet in order to fulfil its role successfully and was tasked with designing a vehicle which could meet these requirements. To complete this project, the team would first compare basic preliminary postie bike designs devised by each member. Once a basic bicycle design was finalised, each member would be tasked with the in-depth design of separate sections of the vehicle, which would be accomplished through research into the ideal design and material of each component, subsequent planning and modelling of the parts based on this research and testing of these designs to determine potential improvements. Both the modelling and testing of these parts would be accomplished using the SolidWorks software.

12.2 Final Design

Through comparing and scoring a variety of postie bike design concepts based on a range of important attributes (**see Appendix 2.4**), it was concluded that this group would follow through with the design of a two-wheeled electric motorcycle with multiple storage spaces, and a relatively light and simple to produce steel pipe frame (**see Appendix 2.1**). Through further research, each member was able to devise fleshed-out designs for their individually assigned parts, which are summarised briefly below:

- Frame: A sturdy pipe structure with a space designed to store the hydrogen fuel cell and battery. AISI 4340 Alloy Steel was chosen as the frame material due to its affordability, strength and relatively light weight.
- Rear Wheel Arm: Pipe structure designed to connect the rear wheel axle to the chassis of the vehicle, utilising standard bearings to reduce the amount of custom parts necessary. Uses 4340 Alloy Steel.
- Tail and Lights: Uses sheet metal to connect break and indicator lights to the rear of the vehicle, which is required for road legal lighting. Uses 4340 Alloy Steel.
- Handlebars: Designed for comfortable rider handling and utilising 6061 Aluminium Alloy due to its common use in bicycle designs.
- Front Suspension: A forked design with integrated springs to allow for the connection and steering of the front wheel while reducing vibrations in the chassis. Uses 6061 Aluminium Alloy.
- Front Wheel: A 36-spoked wide-rimmed wheel designed to support the combined weight of the chassis, rider and payload. The rim and hub of the wheels use Aluminium 6061-T6, due to its low cost compared to other materials and sufficient strength. The wheel spokes utilise AISI-304 stainless steel.
- Rear Wheel: Utilises the same rim and tyre as the front wheel, but integrates a hub motor to reduce the weight of having a separated motor.
- Rear Suspension: Consists of dual shock absorbers to reduce the vibrations felt in the main chassis. This assembly uses AISI 4130 Steel, annealed at 865 degrees Celsius.

12.3 Design Analysis

Once the designs were completed and materials chosen, analysis could be done on these parts using the finite element analysis and sustainability tools provided by SolidWorks to determine potential improvements and superior material selection.

Through FEA testing, it was found both the frame and rim had very high factors of safety, suggesting that possible changes could be made such as switching to materials with lower yield strengths or reducing the thickness of the designs, both of which would reduce material costs. FEA testing however also found the handlebars to have a very low factor of safety, only being around 0.2, suggesting that the material should be switched to one with a higher yield strength or that the pipes making up the handlebar should be made thicker.

Utilising the SolidWorks sustainability tool, materials could be compared for the parts mentioned above to discover alternate choices which would reduce the environmental and financial impact of the design. This tool was used to compare the 4340 Alloy Steel applied to the frame to similar materials and found that using AISI 1015 or AISI 1020 instead would greatly reduce both the environmental impact and cost of the part. It was also found that Al 4032-T6 may be a better rim material choice than the previously chosen Al 6061-T6 as, while it would only mildly decrease the overall environmental impact of the design, the reduction in cost would be significant.

12.4 Future Scope

Continuing the design of this motorcycle concept into the future would likely necessitate far more in-depth FEA testing, as this so far has only included a basic force analysis of three individual sections of the design. The front and rear suspension systems would be important sections of the design to continue these tests on as they experience a significant amount of force and must be able to reduce the vibrations reaching the chassis for the comfort and safety of the rider and payload. More testing could also be done to determine the ideal material for each part, as current FEA tests have shown many of the current materials to be undesirable. Eventually, it is possible that a physical prototype of this bicycle could be manufacturing, but doing so before reaching an ideal theoretical design through thorough modelling and digital analysis would likely be unproductive and needlessly expensive.

13. Appendix

Appendix 1 Fully dimensioned drawings according to the Australian standard AS1100 for parts, sub-assembly, and main assembly.

Appendix 2 Preliminary concept ideas/sketches

Appendix 3 Specifications of motor drive system, battery, controls, and any other relevant items.

Appendix 4 Any relevant calculations

Appendix 5 FEA report /Sustainability report

Appendix 6 VR rendered models and animated video files.

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