SIEP E BIKE CHALLENGE 2024

Team Name: LIION Racing

Team ID: SIEP-4.0-2086-SIEP-24-30

Report Title: Design and analysis of a self-manufactured class electric motorcycle for SIEP E bike challenge

Report Subtitle: Group A design report

ABSTRACT:

Team LIION Racing from New Horizon College of Engineering presents this design report focusing primarily on the two core working systems of an electric motorcycle: the mechanical and electrical systems. In this comprehensive report, we delve into intricate details regarding the chassis, steering, braking, and suspension systems of the e-bike. Additionally, the electrical system is thoroughly explored, encompassing motor controllers, batteries, and essential wiring diagrams. Our approach adheres strictly to the regulations and criteria set forth by the SIEP E-Bike Challenge, ensuring that all calculations and considerations align with their established norms. This report offers a holistic view of our design, highlighting our commitment to excellence in both the mechanical and electrical aspects of our electric motorcycle. The design and modeling was done in CATIA and Fusion 360. The analysis of the components were performed in ANSYS.

INTRODUCTION

In an era marked by urbanization, environmental concerns, and a focus on sustainable transport, electric vehicles have become a beacon of innovation and environmental responsibility. As engineering enthusiasts deeply committed to addressing global climate challenges, we embarked on a journey to create a self-manufactured electric bike, emblematic of efficient and eco-conscious personal mobility. This project report chronicles our collective efforts, blending technical expertise with innovative thinking. It represents more than just an academic pursuit; it reflects our dedication to eco-friendliness, sustainable urban transit, and the future of electrified mobility. This endeavor melds theoretical knowledge with hands-on experience, nurturing not only our technical skills but our commitment to a greener, more sustainable world.

Within this report, we'll explore the design, manufacturing, and testing processes that culminated in our electric bike prototype. We'll delve into the engineering principles, components, and technologies underpinning its creation while sharing the challenges and insights gained along the way. Our aspiration is for this report to illuminate our journey, inspiring future students and enthusiasts to explore innovative, sustainable transportation solutions. In the ensuing sections, we provide a detailed account of our electric bike project, sharing experiences that have transformed classroom learning into real-world application.

I. CHASSIS DESIGN REPORT

Rulebook Constraints& Dimension Parameters

In compliance with the stringent guidelines of the SIEP E-Bike Challenge, our design adheres to a set of crucial specifications and regulations. The wheelbase of our electric motorcycle falls within the range of 48 to 62 inches, ensuring optimal stability and maneuverability. To maintain safety and performance, we guarantee a minimum ground clearance of 5 inches, preventing any unwanted obstacles on the road. Additionally, our design ensures that the bike's length does not exceed 80 inches, and its width remains under 40 inches, thus ensuring its suitability for various riding conditions.For maintaining an aesthetically pleasing and functional design, the maximum height of the bike, without a rider, is restricted to 60 inches. To meet performance standards, our e-bike is designed with a minimum weight of 150 kg, ensuring durability and control. The minimum tire diameter of 16 inches provides the necessary traction for both efficiency and safety.

Furthermore, we strictly adhere to the utilization of seamless tubes for all components requiring tube-like structures. Our team focuses on the manufacture of a double cradle frame, consisting of two main pipes, to meet the challenge's structural requirements. To guarantee the utmost safety and quality, we ensure a minimum wall thickness of 1 mm for tube cross sections, and teams have the flexibility to choose their frame material, whether it be steel, aluminum, or carbon fiber.

In the case of steel, we pay close attention to the minimum carbon percentage, which should not fall below 0.1%. It is imperative that teams produce material composition and strength test certificates from certified laboratories, accompanied by GST purchase bills, with testing conducted by NABL Accredited Labs. These certificates must bear the date of testing and should precede the purchasing date, thus assuring the integrity and reliability of the

materials used in our electric motorcycle's construction. These specifications and regulations underscore our commitment to designing a high-performance, safe, and efficient electric motorcycle for the SIEP E-Bike Challenge.

Design Considerations

When designing a chassis, several crucial considerations come into play, including the need to prioritize strength, weight, cost, material properties, and the factor of safety. The chassis serves as the backbone of the vehicle, providing structural integrity and support. It must be robust enough to withstand various stresses and strains encountered during operation while being lightweight to ensure optimal performance and fuel efficiency. Cost-effectiveness is essential in maintaining the project's budget, and the careful selection of materials is pivotal, as the choice impacts the overall durability and performance of the chassis. Additionally, factoring in the appropriate safety margin ensures that the chassis can withstand unforeseen loads and dynamic forces, safeguarding the vehicle and its occupants from potential hazards.

Material Selected

Selected C.S. Seamless Pipe with AISI 4130 material specification for our electric motorcycle's construction due to its outstanding strength and durability, essential for safety and longevity. The chosen material size, featuring a 28.60 mm outer diameter and 1.60 mm thickness, strikes a balance between structural stability and weight, ensuring a robust frame without unnecessary bulk. These dimensions also facilitate easy fabrication, simplifying the manufacturing process while maintaining competitive efficiency. This thoughtful choice ensures our electric motorcycle meets the stringent standards of the SIEP E-Bike Challenge, offering both performance and safety in a cost-effective package. In summary, our choice of C.S. Seamless Pipe with AISI 4130 material specification and the specific size of 28.60 mm OD x 1.60 mm thickness is a well-considered decision that prioritizes strength, durability, ease of fabrication, and overall performance. These material attributes are essential in ensuring that our electric motorcycle meets the rigorous standards and challenges set forth by the competition while maintaining a high level of safety and functionality.

Properties	values
Density	7.85 g/cm^3
Melting point	1432°C

Table 1.1 Physical properties

Table 1.2 Mechanical Properties

Methodology

Refer different journals and literature papers

Factor out the requirements

CAD Modelling

FEA Analysis

Check for improvement in the design

Dimension Parameters

Weight	132Kg
Wheel base	57inch
Length	80.5inch
Width	31.88inch
Height	43.3inch
Diameter of tyre	457mm
Chassis type	Dual cradle
Wall thickness	1-2mm
Rake angle	23°

Table 1.3 dimension parameters

All views of chassis

Properties	values
Tensile strength, ultimate	560 MPa
Tensile strength, yield	460 MPa
Modulus of elasticity	190-210 GPa
Bulk modulus (Typical for steel)	140 GPa
Shear modulus (Typical for steel)	80 GPa
Poisson ratio	0.27-0.30

Analysis & Simulation

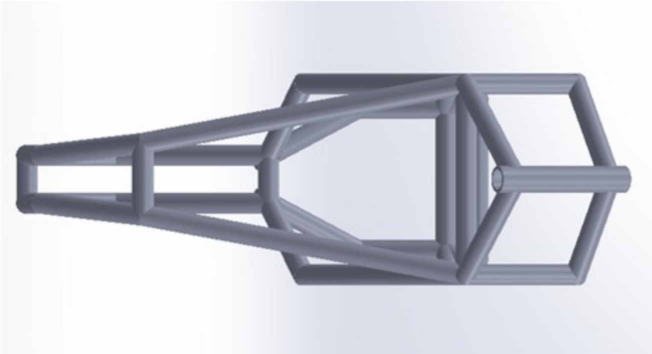


Figure 1.1 Front View

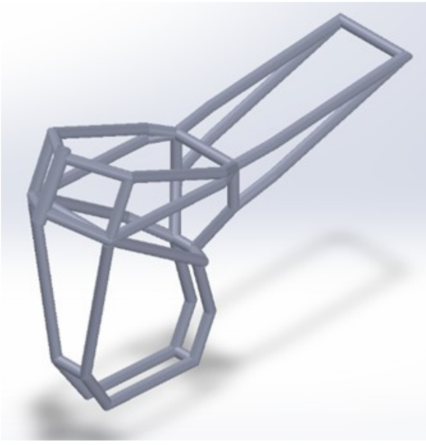


Figure 1.2 Isometric Front View

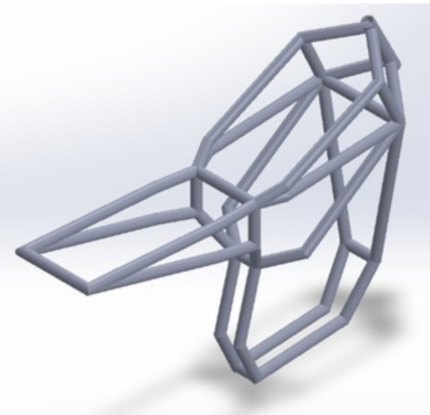


Figure 1.3 Rear View

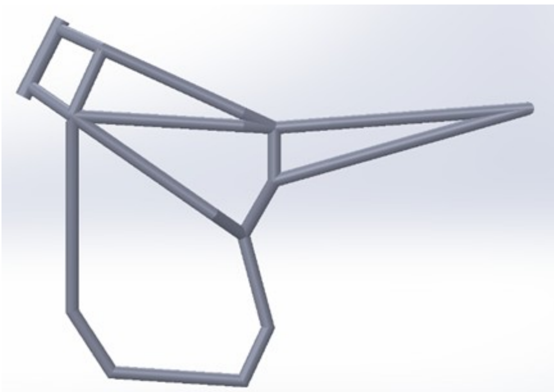


Figure 1.4 Side View

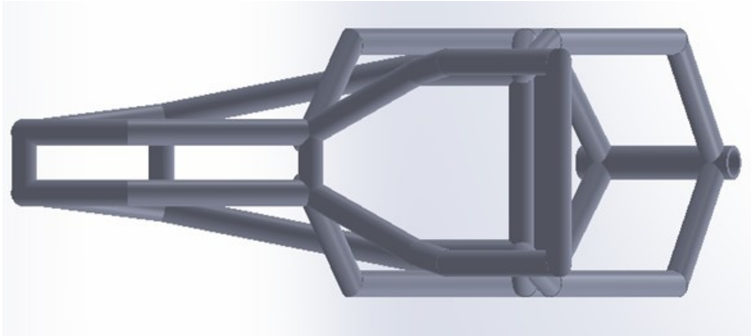


Figure 1.5 Top View

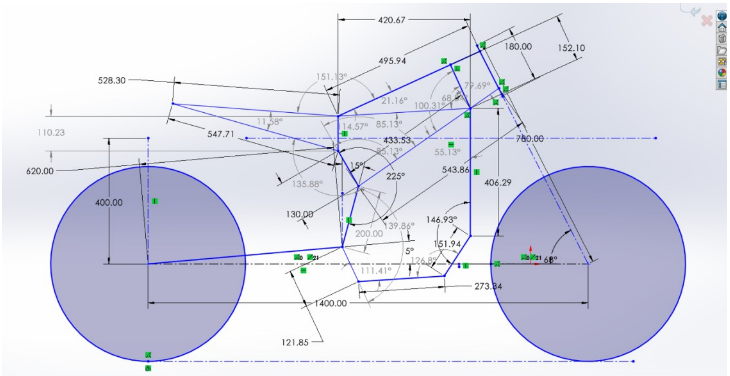


Figure 1.6 Basic Geometry

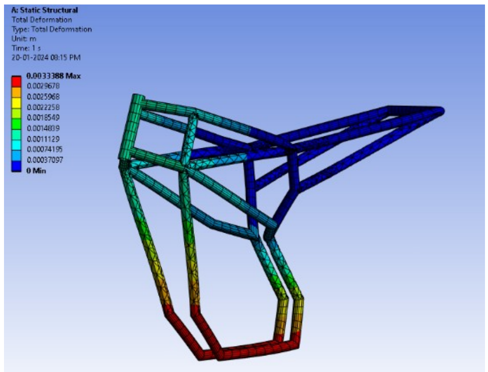


Figure 1.1 Front Impact

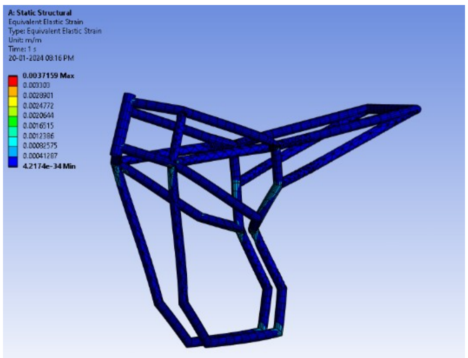


Figure 1.2 Front Impact

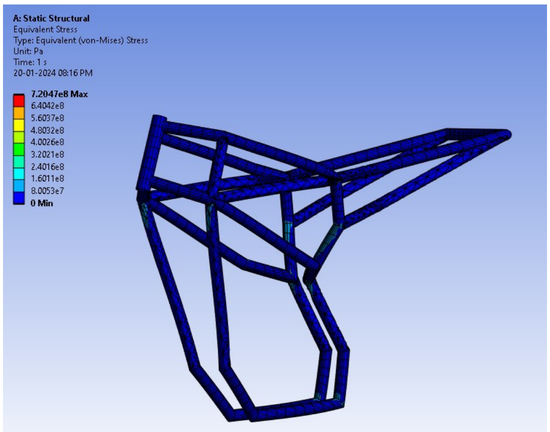


Figure 1.3 Front Impact

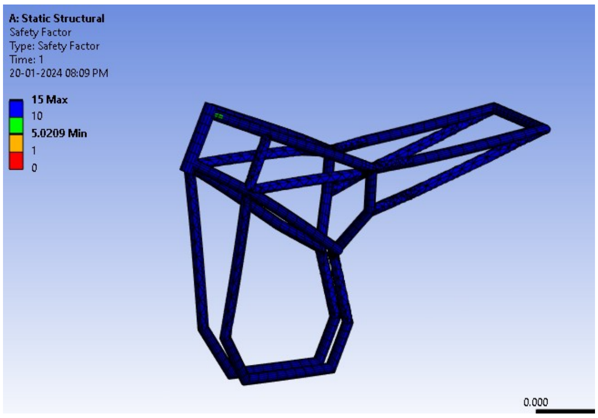


Figure 1.1 Gen Loading

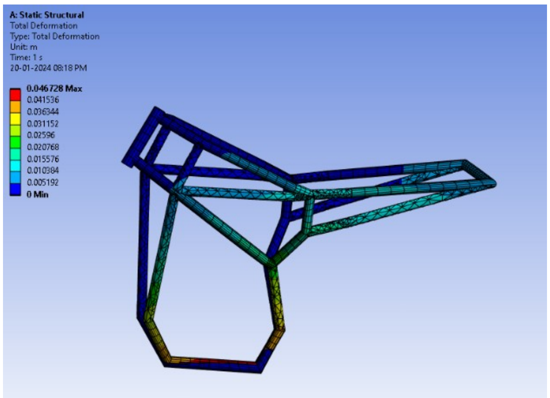


Figure 1.1 Side Impact

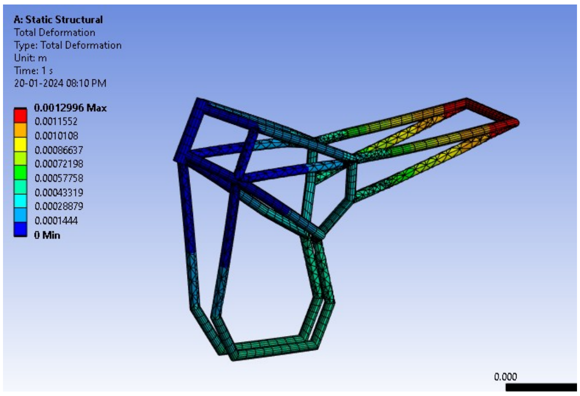


Figure 1.2 Gen Loading

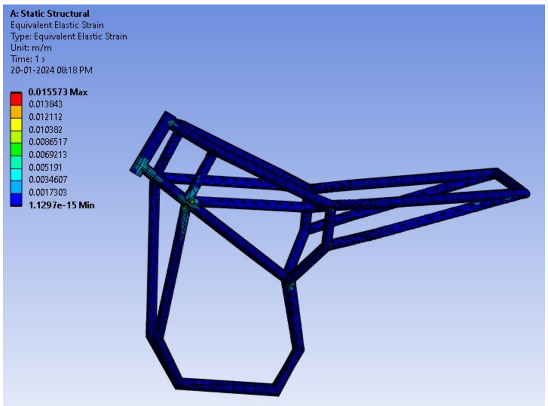
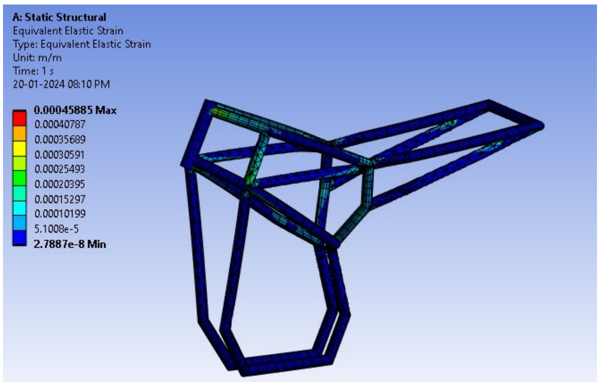


Figure 1.2 Side Impact



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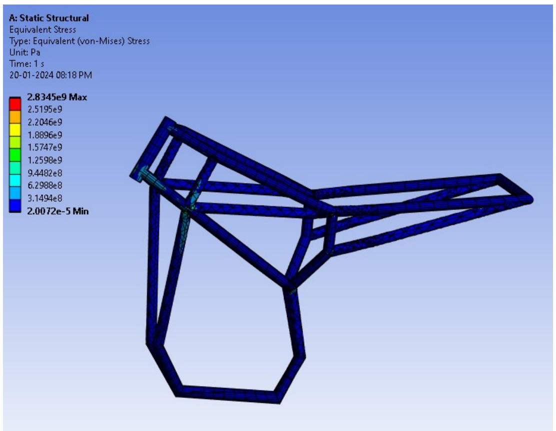


Figure 1.3 Side Impact

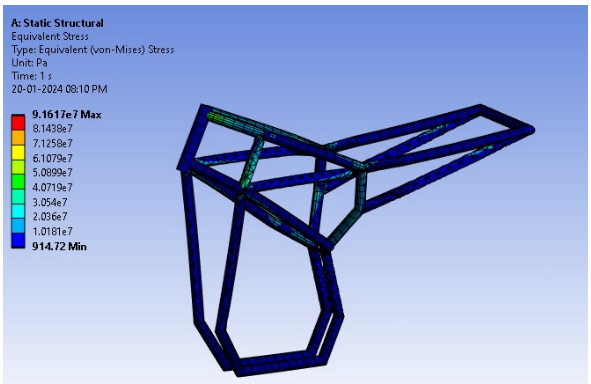


Figure 1.4 Gen Loading

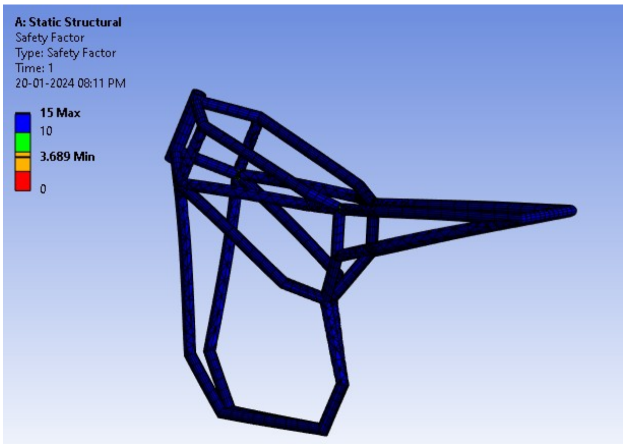


Figure 1.1 Rear Impact

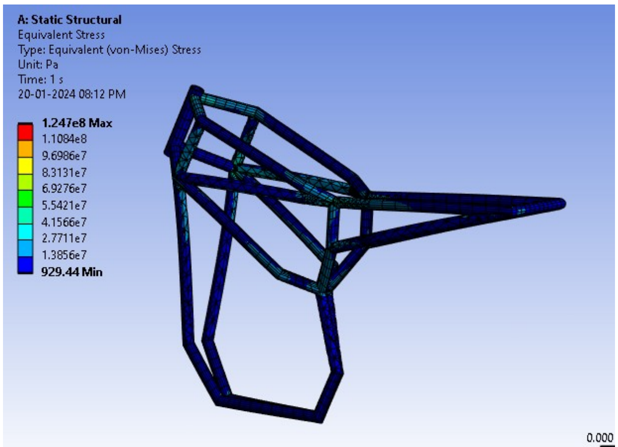


Figure 1.2 Rear Impact

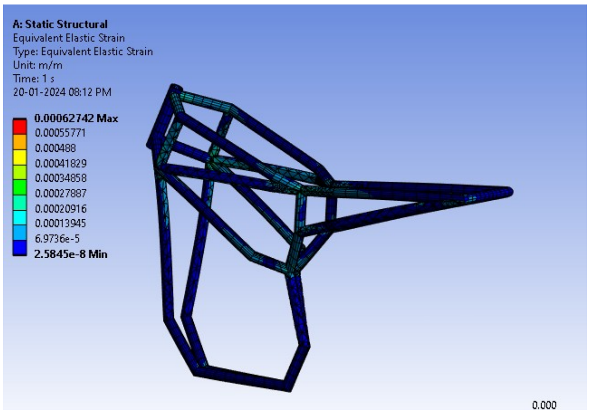


Figure 1.3 Rear Impact

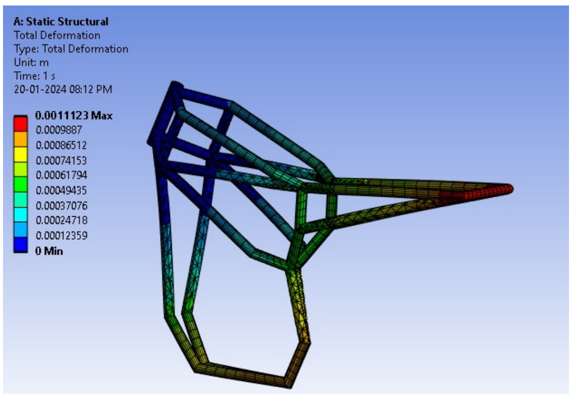


Figure 1.4 Rear Impact

Calculations

I. Weight:

Chassis mainframe: 21Kg Swingarm: 6-8Kg

Electrical systems (motor, controller &battery: 40Kg

Other Auxiliary systems with wheels&tyres: 65Kg

Total weight: 132Kg

II. Front impact analysis

Weight of bike = 132Kg

Weight of rider = 100Kg

Total = 232Kg

Velocity = 60Km/s = 16.66m/s

Time of contact = 0.5s

F X t = m.V

F = 6666N

$$FOS = \frac{yeild\ stress}{working\ stress} = \frac{560}{70.2} = 7.83$$

Similarly Rear impact; FOS= 7.85

Side impact; FOS= 5.09

Results.

Impact	Load N	Stress MPa	Deformation mm	FOS
Front	6666	70.2	0.0439	7.83
Rear	6666	70	0.0547	7.85
Side	6666	108	0.22	5.09

Table 1.4 chassis result

II. STEERING DESIGN REPORT

Introduction

Bike steering is the fundamental mechanism that allows a bicycle to change direction and maintain balance while in motion. It typically consists of handlebars connected to the front fork, which holds the front wheel. When a rider turns the handlebars, it causes the front wheel to pivot, allowing the bike to steer in the desired direction. Bike steering is essential for controlling the bike's path, making turns, and maintaining stability while riding.

Rulebook Constraints

Teams participating in both classes of the competition are permitted to use pre-fabricated bike handles. However, they have the flexibility to modify these handles to suit their specific needs, provided that they document these modifications in detail within their Design Report. To ensure safe steering, there are limitations on the turning angle, with stoppers made of specified materials, like nylon or aluminum, placed on both sides. It's crucial to note that neither the chassis nor any other part of the prototype may function as a steering stopper. The steering system must maintain a minimum turning angle of 15° on either side of the prototype's longitudinal axis. Additionally, the allowed rake angle falls within a range of 22 to 32 degree. Importantly, the Steering Axis Inclination should exhibit offset with the front wheel center, and a positive steering stop system must be in place to prevent the steering linkages from locking up, ensuring safe and controlled maneuverability.

Design Considerations

When designing a motorcycle handle, critical considerations revolve around ensuring optimal performance and rider comfort. This entails prioritizing ergonomic design to minimize rider fatigue during long journeys, while also emphasizing a firm and comfortable grip to guarantee precise control over the motorcycle, particularly during complex maneuvers and turns. Effective vibration damping features must be integrated to enhance rider comfort by reducing the impact of vibrations transmitted to the handlebars. Careful selection of durable materials that also offer a comfortable grip is essential for ensuring the handle's longevity and the rider's safety. Furthermore, aligning the handle's design with the motorcycle's overall aesthetic appeal is crucial, contributing to the vehicle's visual allure and brand identity. Providing customization options, such as adjustable handlebar positions or the capability to incorporate accessories, allows riders to personalize their riding experience to their preferences and style. Lastly, incorporating safety features like integrated switches, anti-slip grips, and optimized dimensions for clear instrumentation visibility all contribute to a safe and enjoyable riding experience.

Component Selection.

Selecting a KTM Duke handle for a student bike project is a well-justified decision based on several key merits. Renowned for its proven performance and durability, the KTM Duke handle ensures optimal control and maneuverability, offering students a reliable and thoroughly tested component for their project. Leveraging the industry expertise of KTM, a prominent name in the motorcycle industry, enables students to glean insights from industry standards and best practices, fostering a comprehensive learning experience. The advanced engineering and ergonomic design embedded in the KTM Duke handle prioritize rider comfort and control, providing students with exposure to cutting-edge technology and design principles in motorcycle manufacturing. Moreover, KTM's steadfast commitment to safety underscores the project's emphasis on rider safety and aligns with established industry standards. Working with such a reputable brand offers students a valuable educational opportunity to delve into the intricacies of high-performance motorcycle components, fostering practical knowledge and skills that can be instrumental in their future pursuits in the field.

Working principle

Motorcycle steering operates through the handlebars, which are connected to the front wheel via the front fork and triple tree. When a rider turns the handlebars in either direction, it initiates a movement in the front fork, causing the front wheel to turn accordingly. This action alters the direction of the motorcycle, allowing the rider to navigate through turns and corners. The front fork's geometry, often including the rake and trail, influences the motorcycle's stability and handling characteristics, ensuring a balance between maneuverability and straight-line stability. Additionally, the integration of steering dampers in some motorcycles helps absorb vibrations and oscillations, contributing to a smoother and more controlled steering experience.

Figure 2.1: KTM duke Handle

Formulation and Calculations.

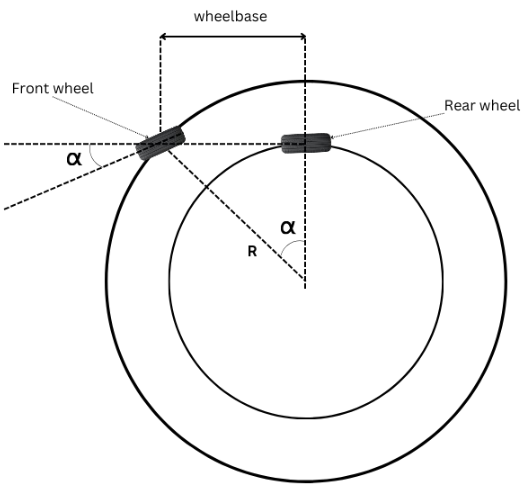


Figure 2.2: Steering angle

A=angle=65°

W=wheelbase=1.44m

R=minimum turning radius

r=radius of turning of rear

$$R=\frac{W}{\sin\propto}=\frac{1447}{\sin 65°}=1596.58mm$$

$$r=\frac{W}{\tan\propto}=\frac{1447}{\tan 65°}=674.74mm$$

Results. (Rake Angle, Turning Radius, etc.)

Wheel Base	57m
Rake angle	23
Min. Turning radius	1596.58mm

III. BRAKING SYSTEM DESIGN REPORT

Introduction

Braking the negative force needed for a positive cause. This bike to be built will be fitted with hydraulic disk braking system.

Disc brakes in motorcycles are a vital component of the braking system, replacing traditional drum brakes in many modern bikes. They operate on the principle of clamping a flat metal disc (rotor) between two brake pads to create friction, which slows down and stops the motorcycle. Disc brakes offer significant advantages over drum brakes, including better stopping power, heat dissipation, and consistent performance in various weather conditions. They have become the industry standard, enhancing safety and control for motorcycle riders.

Rulebook Constraints

In motorcycle design, safety is paramount, and to ensure this, certain standards and specifications must be met. One crucial aspect is the braking system, which should incorporate two independent hydraulic circuits, guaranteeing that in the event of a leak or failure at any point, effective braking power is maintained on at least one wheel. Each circuit must possess its own fluid reserve, achieved through either separate reservoirs or the use of a dammed, OEM-style reservoir.

For motorcycles in the Self-Manufactured Class, it's imperative to note that "Brake-by-wire or Mechanical" systems are not allowed. Furthermore, the brake system must demonstrate the capability to lock the wheels simultaneously during brake testing, ensuring optimal control and safety. In addition to these requirements, it's essential to maintain bike stability; thus, the motorcycle should not yaw more than 30 degrees while braking, further underscoring the significance of safe and controlled braking performance.

Force consideration.

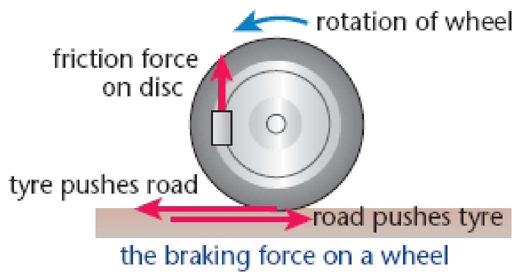


Figure 3.1: forces during braking

Frictional force on disc:-

The force that resists the motion of the revolving disc on a disc brake ultimately causes it to slow down or stop. A set of brake pads are forced against the revolving disc (sometimes referred to as a rotor) attached to the wheel when the brakes are applied to a vehicle. The force required to slow down or stop the wheel is produced by friction between the brake pads and the disc.

- Tyre push road force:-

The term "tyre pushes road force" describes how a vehicle's tire interacts with the road surface, specifically the force that the tire applies to the surface. A common name for this force is "road force" or "road contact force.Several forces are at work when a vehicle's tire makes contact with the ground, including

  - Vertical force
  - Lateral force
  - Longitudinal force

- Road pushes the tire:-

The force that a road applies to a tire can be described by several key factors related to the interaction between the tire and the road surface:

  - Frictional Force
  - Normal Force
  - Adhesion and Traction
  - Road Surface Properties
  - Tire Design and Tread
  - Driving Conditions
  - Inflation Pressure

- Rotation of wheel force:-

The rotation of a wheel on a vehicle involves various forces and dynamics that influence its movement and behavior. Here are some key aspects related to the forces involved in the rotation of a wheel:

  - Centripetal Force
  - Angular Momentum
  - Torque
  - Frictional Torque
  - Rolling Resistance
  - Gyroscopic Effect
  - Alignment and Balance

Working principle

Hydraulic brakes work on the principle of Pascal's law. According to this law whenever pressure is applied on fluid it travels uniformly in all the directions. Therefore, when we apply force on a small piston, the pressure gets created which is transmitted through the fluid to a larger piston. As a result of this larger force, uniform braking is applied on all four wheels. As braking force is generated due to hydraulic pressure, they are known as hydraulic brakes. Liquids are used instead of gas as liquids are incompressible.

Design Considerations

Coefficient of friction between tire and rod	
1.Dry Asphalt	0.8
2.Wet Asphalt	0.6
3.Snow	0.3
4.Ice	0.1

Table 3.1: Coefficient of friction

Component Selection.

Selecting the hydraulic disc brakes from the renowned KTM Duke for the construction of the electric bike in this student project is a deliberate choice that embodies a commitment to performance, safety, and integration. Leveraging the proven track record of the KTM Duke's braking system ensures reliable stopping power and precise control, elevating the safety standards of the electric bike prototype. Additionally, the compatibility of these brakes with the overall design facilitates a streamlined assembly process, while providing access to expert support from a reputable motorcycle manufacturer. Furthermore, this decision contributes to the market recognition of the project, fostering a sense of credibility and reliability, which is essential for showcasing the electric bike's potential to stakeholders and industry professionals.

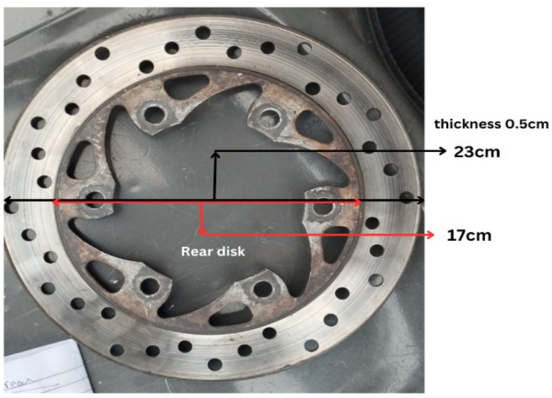


figure 3.2: Dimensions of rear disk

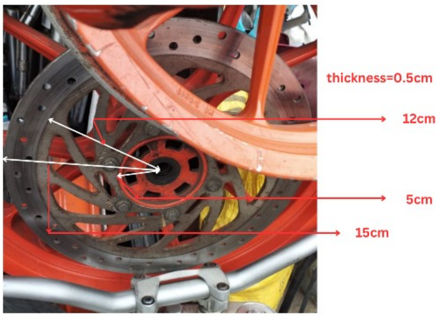


figure 3.3: Dimensions of front dis

Formulation and Calculations.

1. Front Disk Brake Calculation

$R_0 = outer\ radius\ of\ pad\ (mm) = 150\ mm$

$R_i = inner\ radius\ of\ pad\ (mm)$=120mm

$\theta = angular\ dimensions\ of\ pad\ (radians)$

$Material\ of\ disc = stainless\ steel$

$Average\ pressure\ [P_{avg}] = 2\ mpa$

$max\ torque\ capacity\ of\ the\ disc\ brake$

$M_t = MP\,R_f\,[N - mm\}$

$M = coefficient\ of\ friction$

$P = actuation\ force\ (N)$

$R_f = friction = radius\ [mm]$

$$R_f = \frac{1}{3}\left(\frac{D^3 - d^3}{D^2 - d^2}\right) R_f = \frac{2}{3}\left(\frac{R_0^3 - R_1^3}{R_0^2 - R_i^2}\right)$$

$$R_f = 135.55\ mm$$

$$P = average\ pressure\ x\ area\ of\ pad$$

$P = p_{avg}.\ A$

$$A = \frac{1}{2}\theta\left[R^2{}_0 - R^2{}_i\right]$$

$$\theta = 75° = 75 \times \frac{\pi}{180}$$

$$\theta = 1.308\ rad$$

$$A = 5297.4\ mm^2$$

$P = 10594.8\ N$

$$M_t = M\,P\,R_f = 0.58\ X\ 10594.8\ X\ 135.55$$

$$M_t = 832952.58$$

$$M_t = 832.95\ N.m$$

II. Rear Disk Brakes

1) Rf=$\frac{2}{3}\left[\frac{R_0^3 - R_i^3}{R_0^2 - R_i^2}\right]$

$\begin{pmatrix} R_o = 115\ mm \\ R_i = 85\ mm \end{pmatrix}$

Rf=$\frac{2}{3}\left[\frac{115^3 - 85^3}{115^2 - 85^2}\right]$ = 100.75mm

2) P= Average pressure× area of pad

A=$\frac{1}{2} \times \theta\left[R_o^2 - R_i^2\right]$

A=$\frac{1}{2} \times 1.308\left[115^2 - 85^2\right]$=3924$mm^2$

M_t=0.58×7848×100.75

M_t=458.59 N-m

3) Stopping distance

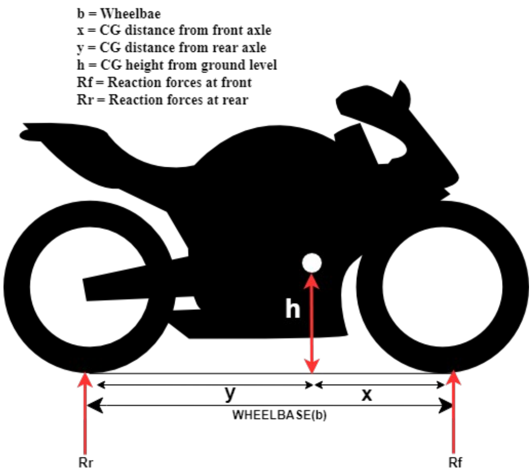


Figure 3.4 bike parameters

- S = $\frac{[V]^2}{2F}$

  [V = vehicle speed (m/sec)]

  [F = deceleration(m/sec^2)]

- Braking efficiency – deceleration/acceleration due to gravity

  Braking efficiency = $\frac{F}{g} \times 100$

1.condition [when brake applied to front wheel]

$$\frac{f}{g}=\frac{\mu \times y}{b-\mu h}$$

[
μ *is the coefficient of friction* (0.58), $g = acceleration($

f = $\dfrac{0.58 \times 9.81 \times 0.52}{1.3-[0.58 \times 0.65]}$

f =3.205 m/sec^2

S = $\dfrac{V^2}{2f}=\dfrac{6.94^2}{2\times 3.205}=7.51\,m$

t = $\sqrt{S \times 0.204}$

t =$\sqrt{7.51 \times 0.204}$

t =1.23sec

2. condition [when rear brakes are applied]

$$\frac{f}{g}=\frac{\mu x}{b+\mu h}$$

f = 2.692 m/m^2

S = $\dfrac{V^2}{2f}=\dfrac{[6.94]^2}{2\times 2.692}=8.94\,m$

t =$\sqrt{S \times 0.204}$

t = $\sqrt{8.94 \times 0.204}$

t = 1.35sec

3.condition [when both the brakes are applied]

$$\frac{f}{g}=\mu$$

f = 0.58$\times$ 9.81

f = 5.688 m/s^2

S = $\dfrac{V^2}{2b}$ = $\dfrac{[6.94]^2}{2\times 5.688}=4.23\,m$

t = $\sqrt{S \times 0.204}$

t = $\sqrt{4.23 \times 0.204}$

t = 0.92sec

Braking energy = [$\frac{1}{2} \times mass \times velocity^2$

Considering the weight to be around 250kg , V=6.94

Braking energy = [$\frac{1}{2} \times 250 \times 6.94^2$

Braking energy = 6020.45 J

Heat flux(q_o)=1-(φx 2x mg x v x z x 2 x $A_d X \in_p$)

Where,

φ: - rate distribution of the braking forces between the front and rear

m:- mass(kg)

g:- acceleration due to gravity(9.81 m/s)

V: - initial speed of the vehicle(m/s)

Z: - braking effectiveness

a: - deceleration of the vehicle (m/s)

A_d: - disc surface swept by a brake pad (m^2)

$\in_p$: - factor load distribution on the disc surface

Material	Total Heat Flux (W/mm^2)	
	Min	Max
Stainless steel	1.2645e-6	706624

Table 3.2; material

Force require to move the vehicle: -

TTF= $F_{rolling}+F_{gradient}+F_{aerodynamic}$

Rolling resistance

$$F_r = C_{rr} \times mass \times gravity$$

[m = 200kg , g =9.81 , $C_{rr = coefficient\ of\ rolling\ resistance}$]

F_r =0.004$\times 200 \times 9.81$

= 7.84N

Grade resistance [assuming the vehicle is on flat ground]

$F_{grad} = M \times g \times sin\theta$
= $200 \times 9.81 \times \sin 0$
= 0 N

[assuming the vehicle is on a grade of 40°]

$F_{grad} = M \times g \times \sin 40$

= $200 \times 9.81 \times \sin 40$

= 1261.15 N

Aerodynamic drag

$F_A = 0.5 \times C \times density \times V^2$

Where

[F_A = force due to acceleration, C = coefficient of drag ,V=velocity (m/s) , d = density of air]

F_A = $0.5 \times 0.5 \times 1.2 \times 16.6^2$

F_A = 82.668N

[Note: Considering the aerodynamic drag condition]

<u>The total tractive force required to move the vehicle from still condition at a grade of 0°</u>

TTF =7.84 + 0 + 82.668

= 91N

The total tractive force required to move the vehicle at a grade of 40°

TTF = 7.84 + 1261.15 + 82.668

= 1351.658 N

[Note: Considering the acceleration force]

TTF= $F_{rolling} + F_{gradient} + F_{acceleration}$

- F_a = m×a

Where,

a = $\frac{final\,velocity - initial velocity}{time \in sec}$ = $\frac{16.6 - 0}{60}$
= 0.2766

F_a = 200×0.2766 = 55.32 N

The total tractive force required to move the vehicle to move the vehicle from the still condition at a grade of 0°

TTF = 7.84 + 0 + 55.32 = 63.16 N

The total tractive force required to move the vehicle to move the vehicle at a grade of 40°

TTF = 7.84 + 1261.15 + 55.32 = 1324.31 N

Torque required to move the vehicle

Torque = $R_f \times TTF \times r_{wheel}$

Where,

R_f = frictional resistance = 0.7

r_{wheel} = radius of the drive wheel = 0.228 m

Torque = 0.71×91×0.228 = 14.7 N-m

[If the acceleration force is taken into consideration then for the TTF of 63.16 N the torque required is 10 N-m]

<u>Results.</u>

Stopping distance (front)	7.51m
Stopping time (front)	1.23s
Stopping distance (rear)	8.94m
Stopping time (rear)	1.35s
Stopping distance (both)	4.3m
Stopping time (both)	0.92s
Pedal ratio (front)	5:1
Pedal ratio (rear)	4:1
Braking energy	6020.45J
TTF at 0°(aerodynamic drag)	91N
TTF at 40°(aerodynamic drag)	1351.658N
TTF at 0°(acceleration force)	63.16N
TTF at 40°(acceleration force)	1324.31N

Table 3.3: braking results

IV. SUSPENSION DESIGN REPORT

<u>Introduction</u>

Motorcycle suspension is a critical component that plays a pivotal role in ensuring rider comfort, safety, and overall handling performance. It serves to absorb shocks from uneven road surfaces, maintain tire contact with the ground, and provide stability and control during acceleration, braking, and cornering. By effectively managing the interaction between the motorcycle and the terrain, suspension systems contribute significantly to the overall riding experience, making them an essential aspect of motorcycle design and engineering.

Rulebook Constraints

In the pursuit of designing and building innovative motorcycles, teams are granted the flexibility to utilize pre-fabricated suspension systems from existing bikes, both at the front and rear. However, the mounting of the front suspension must align with the specific rake/caster angle of the bike, ensuring optimal performance and stability. For the rear suspension, teams have the choice of employing either a mono-shock or twin shock system. To meet the competition's standards, there are specific calculations teams must undertake, including the determination of Spring or Damping Lag on both suspension systems, the evaluation of Squat and Dive that occur during bike operation, and comprehensive calculations related to the spring to guarantee that the motorcycle's suspension functions effectively and safely. These regulations allow for creativity and adaptability while maintaining a focus on precision and performance in motorcycle design.

Force consideration.

Designing a motorcycle suspension system involves crucial considerations related to various forces. Firstly, analyzing static loads ensures the appropriate spring rates and damping characteristics to support the motorcycle and rider's weight. Dynamic forces during acceleration, braking, and cornering impact weight distribution and overall stability, necessitating precise tuning. The suspension must effectively absorb impact loads from rough terrain, ensuring a smooth ride and minimizing mechanical stress. To manage cornering forces, optimizing suspension geometry and stiffness is essential for maintaining tire contact and stability during turns. Additionally, the system should handle braking and acceleration forces to prevent excessive diving or squatting, ensuring efficient braking and acceleration performance. Implementing damping systems to control vibrations and oscillations contributes to stable handling and rider comfort. By accounting for rider input and feedback, the suspension system can be tailored to provide responsive handling, instilling a sense of control and confidence during motorcycle operation.

Working principle

Motorcycle suspension typically involves a front setup with two telescopic tubes, while the rear utilizes a swingarm equipped with either twin or single shock absorbers. In contemporary motorcycle design, the preference for a monoshock or single shock absorber at the rear has increased due to its enhanced performance and sporty appearance. The dual objectives of a motorcycle's suspension system are to ensure stability and balance during braking and to provide a comfortable ride for both the rider and passenger, especially over uneven surfaces and bumps.

1. Front Suspension: The most prevalent form of front suspension is the telescopic forks, comprising hydraulic tubes with internal coil springs. These forksconnect to the motorcycle's frame via a T-clamp and to the front wheel's axle on the other end. Their sliding motion absorbs road imperfections, and the inclusion of oil within the forks facilitates smooth operation, effectively sealed by an oil seal.

2. Rear Suspension: The motorcycle swingarm can be visualized as a quadrilateral component linking the frame and the rear wheel axle. Over time, the adoption of monoshock absorbers gained traction due to their superior performance compared to traditional twin shock absorbers. In this configuration, a single shock absorber is connected to the swingarm via a linkage, offering a rising rate of damping to the rear. Monoshocks efficiently counteract swingarm torque, improving handling and stability while offering ease of adjustment compared to twin shock absorbers.

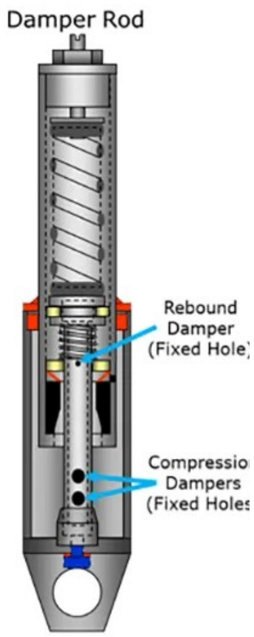
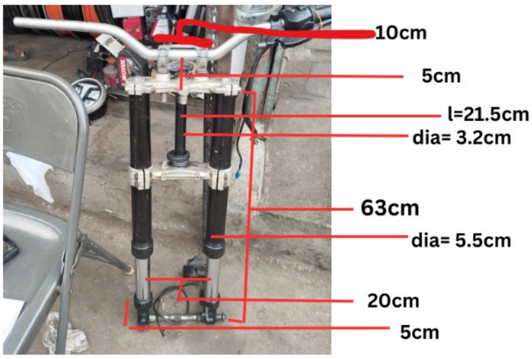


Figure 2: Figure 4.1: cut section of a shock

Design Considerations

Figure 4.2: CAMD of a mono shock

Figure 4.3: Rear shock



figur
e 4.4: Front fork:

Free Length	17cm
Pitch	4cm
Wire diameter	1.75cm
Outer diameter	10cm
Inner diameter	6cm
Number of active coils	7

Table 4.1 dimentions of rear mono shock

Component Selection.

Opting for the rear and front suspension components from the KTM Duke for the student-built electric vehicle (EV) project is a deliberate choice rooted in various advantages. The proven performance and durability of the KTM Duke's suspension system, tested under demanding road conditions, ensure heightened stability and control for the EV prototype. With advanced engineering tailored for superior handling and responsiveness, integrating these components promises a comparable standard of precision and control, elevating the overall driving experience and safety of the EV. The seamless compatibility and integration of the KTM Duke's suspension components with other vehicle parts streamline the assembly process, facilitating a cohesive design and efficient resource utilization. Moreover, this decision adds a layer of industry recognition to the student project, signifying a commitment to quality and performance that instills confidence in the EV prototype's capabilities.

Include the pictures of design, Components, assembly. (If any)

Formulation and Calculations.

Rear suspension calculation:

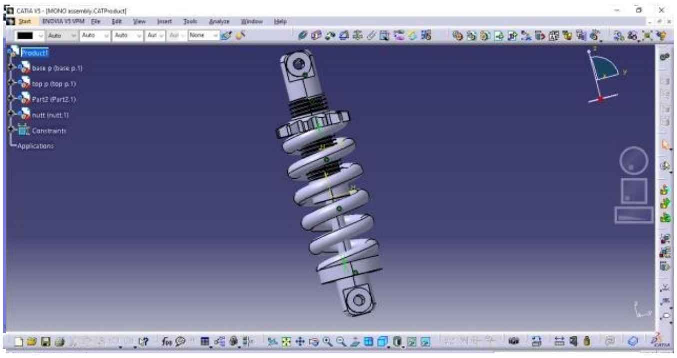


Figure 4.4; CAMD of assembled mono shock

Spring-

inner dia=60mm

outer dia=100mm

coil dia=17.5mm

1) D= $\frac{Do+Di}{2}$
2) Spring index[c]= $\frac{D}{d}=\frac{80}{17.5}$ =4.57
3) Wahls stress factor[k]= $\frac{4c-1}{4c-4}+\frac{0.615}{c}$

$$=\frac{4[4.57]-1}{4[4.57]-4}+\frac{0.615}{4.57}$$

=1.33

4) Max shear stress[$\tau = \frac{K\,8\,PD}{\pi\, d^3}$

$$\tau = \frac{1.33 \times 8 \times 1912.95 \times 80}{\pi \times 17.5^3}$$

$\tau = 96.709$ mpa

5) FOS=2

Considering load with rider

$$\tau = \frac{1.33 \times 8 \times 3188.25 \times 80}{\pi \times 17.5^3}$$

$\tau =$ ¿161.1mpa

Results

Center of gravity	0.67m
Wheel base	1340mm

Table 4.2: result suspension

V. TRANSMISSION DESIGN REPORT

Introduction

Transmission plays a crucial role in motorcycles, whether powered by internal combustion engines (IC engines) or electric motors (EVs).The integration of a transmission in electric motorcycles (EVs) offers a range of advantages. Firstly, it significantly enhances energy efficiency. While electric motors inherently possess a broad power band, a transmission allows for the precise adjustment of gear ratios to match different speeds, thereby reducing power consumption at higher speeds and extending the motorcycle's overall range. Additionally, EVs can harness regenerative braking to recapture energy during deceleration, and a transmission enhances the control and effectiveness of this energy recovery system. Furthermore, for riders who appreciate a more conventional experience, a transmission in an electric motorcycle can replicate the sensation of shifting gears, providing a familiar and enjoyable riding experience. Finally, akin to their internal combustion engine counterparts, transmissions in EVs contribute to superior acceleration and responsiveness, elevating the overall performance of electric motorcycles.

Rulebook Constraints

In the realm of motorcycle design for this competition, several essential specifications and liberties define the drivetrain. Firstly, teams are obligated to employ a rear-wheel drive configuration, ensuring optimal traction and control. Secondly, there is versatility in the choice of transmission and drive train, permitting the use of chain, CVT (Continuously Variable Transmission), or belt drive systems, enabling innovation and adaptability in motorcycle design. Importantly, there are no restrictions on the sprocket ratio, allowing teams to make adjustments as necessary to optimize performance. Moreover, a direct transmission between the motor's output shaft and the rear wheel is permitted, enhancing efficiency and power transfer in the pursuit of designing high-performance motorcycles. These regulations strike a balance between standardized requirements and creative freedom, encouraging ingenuity in motorcycle drivetrain design.

Force consideration.

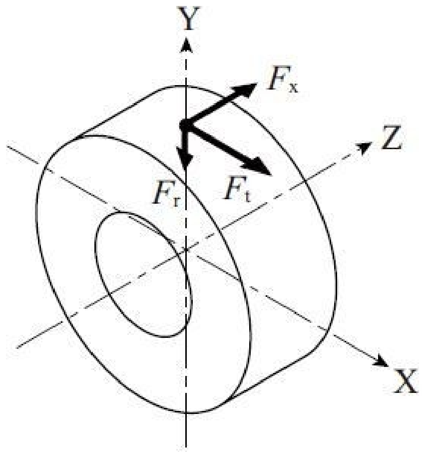


Figure 5.1: force consideration on a shaft

If the Z-axis of the orthogonal 3-axes represents the gear shaft, then forces acting on the gear teeth during the transmission of power are described as follows:

Tangential force is the term used to describe the force that operates along the X-axis. Radial force is defined as the force that operates along the Y-axis. Axial force Fx (N), often known as thrust, is the force that acts in the Z-axis direction.

It is crucial to analyze these forces while designing gears. It’s crucial to consider the forces affecting the gear teeth, shafts, bearings, etc. while building a gear.

Sprocket ratio

$$SR = \frac{OUTPUT}{INPUT} = \frac{Rear\ Sprocket}{Front\ Sprocket}$$

$$\frac{42}{14} = 3\,(Losses\ upto\ 1\,\%)$$

$$No\ of\ links\ been\ used = 112\,(Approximate)$$

Results.

i/p torque	30 Nm
o/p torque	8.16 Nm
i/p speed	2000 rpm
o/p speed	612 rpm

Table 5.2: transmission results

VI. MOTOR DESIGN REPORT

Introduction

Electric vehicles (EVs) have taken the automotive industry by storm, offering a sustainable and eco-friendly alternative to traditional internal combustion engine vehicles. At the heart of these revolutionary vehicles lies a crucial component: electric motors. These motors are responsible for converting electrical energy into mechanical motion, propelling EVs forward. Among the various types of electric motors employed in EVs, the Brushless Direct Current (BLDC) motor stands out as a key player. In this discussion, we will delve into the world of electric vehicle motors, with a special focus on the BLDC motor and its significant role in powering the next generation of transportation.

Rulebook Constraints

The motor is a BLDC motor with a power range of 1250 to 2000 watts and an IEC 60529 IP67 certification.

Motor and motor drive will be securely fastened and adequately protected, and the motor controller will be tuned to the motor. No rider body part is exposed to the motor

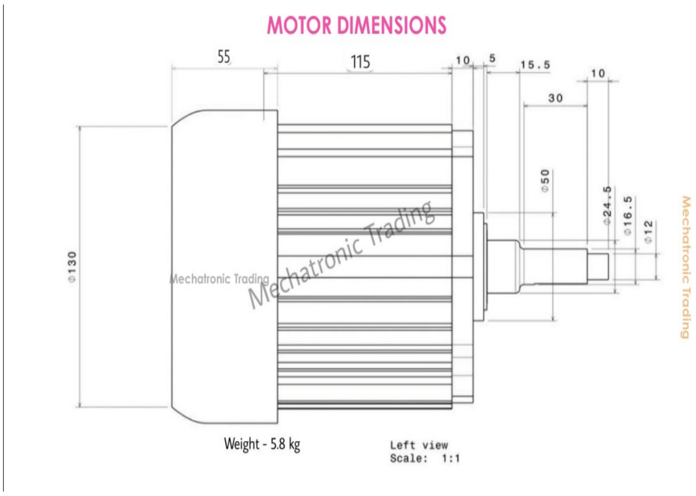
Type of gear(spur gear)	F_t= tangential force	F_x= axial force	F_r= radial force
Formula used	$\frac{2000\,T}{d}$	$F_t \times tan\beta$	$F_t \times tan\alpha$

The motor we are using has a power rating of 2000 watts, a voltage rating of 60 volts, and a current rating of 50 Amps.

Max. Weight of Motorcycle	150Kg
Max. weight of Rider	100Kg
Total	250Kg

Working principle

A brushed DC motor and a BLDC motor operate on a similar theory. The current-carrying conductor suffers a force anytime it is placed in a magnetic field, according to the Lorentz force law. The magnet will experience an equal and opposite force because of the reaction force. The permanent magnet is moving while the current-carrying wire is stationary in a BLDC motor.



Component Selection.

The brushless motor's great efficiency, exceptional torque, longevity, and little maintenance needs are just a few of the many benefits. However, the motor must match the intended function, necessitating careful consideration while selecting one.

The operating characteristics for power, voltage, speed, torque, and other factors are shown in the brushless DC motor specifications. Typically, the ratings are listed in the specifications sheet, shown on the motor, or made available online on the manufacturer's website. The crucial ones are:

TORQUE: Brushless DC motor torque values change depending on the operating environment. Peak torque and sustained torque are also included in the torque parameters. Continuous torque refers to the specified torque at any speed, whereas peak torque typically refers to the maximum number for a brief duration, such as when starting.

RPM rating (speed): Applications requiring high speeds call for BLDC motors with higher RPMs, and vice versa. Usually, the specs sheet will provide a KV value that indicates the speed. Higher numbers indicate higher RPM levels. The greatest speed of a brushless DC motor is obtained by multiplying the voltage by the Kv rating.

Rated Voltage: The figure here denotes the rated terminal voltage needed by the motor to function. The manufacturer will generally indicate this.

Rated Power: Watts are typically used to express the power rating. A more powerful motor corresponds to a higher power rating, and vice versa. It's crucial to choose a motor whose power rating is sufficient for your requirements, but not so high as to exceed the need of application.

Types of motor: There are numerous types of brushless DC motors available. Each of them has advantages and disadvantages depending on the setting in which it is utilized.

Due to the lack of brushes, there is quiet operation (or low noise). high weight to power ratio, the Splash Proof, less complex motor geometry, increased heat dissipation with forced air cooling, Long life because the commutator system doesn't need to be inspected or maintained, silicon steel, a material with low hysteresis loss, neodymium magnet with high power, used sealed high-quality bearing Keyway slotted hardened shaft with a 1mm air gap Its lack of a mechanical commutator and related issues Due to the lack of brushes, which would otherwise limit operation speed, the machine operates at a high pace both when loaded and when empty. No lubrication is necessary, lower inertia results in a higher dynamic responsiveness, less electromagnetic noise

Formulation and Calculations.

m Mass of the system: 250Kg (With the rider)

a Acceleration due to gravity: 9.81 m/s^2

C_r (Rolling resistance Coefficient): Rolling resistance Coefficient Assume 0.01

$F_{rolling} = m \times a \times C_r$

$F_{rolling} = 250 \times 9.81 \times 0.01$

$F_{rolling} = 24.525$ N

Power Required to Drive in a fair terrain:

$P = F_{rolling} \times$ Speed (in m/s) (Theoretical)

Power	Speed
476.525W	70Kmph
545.015W	80Kmph

Elevation Not Considered for this calculation.

Distance = range (Meta)

Power = torque×angular speed = T×W

Where,

- T = 7.6 N-m
- Speed = 3300 rpm

$$\text{Power in watt} = \frac{(7.6 \times 3300)}{9.55} = 2625.26 \text{ w}$$

(Where to convert into watt it is divided by 9.55)

Calculation the time required to consume the energy from battery

T (hrs) = battery capacity (watt)/rated power

Battery capacity 60 V and 41.6 Ah

= 60×41.6 = 2496 w hr

$T = \frac{2496}{2625.26}$ at rated conductivity = 0.952 hrs

Range (meta) = speed (m/s) × time (sec)

[Assuming that the vehicle is going at a speed of 70 km/hr = 20 m/s]

Range = 68400 m

Tabulations.

Voltage V	Current A	Speed RPM	Torque NM	Power W
63.5	3.5	3200	0.07	88.9
63	6.4	3186	0.86	182.88
62.5	10.5	3175	1.76	33.75
62	14.1	3170	2.56	611.4
61.5	19.9	3162	2.2	917.88
61	23.3	3145	3.56	1137
60.5	2.29	3125	3.86	1413
60	34.6	3109	4.77	1764
59.5	39.1	3095	5.06	177.4
59	24.3	3081	6.72	1996
58.5	46.2	3060	7.6	2162

Results.

Power: 2000watt	Efficiency: Greater than 87%
Voltage: 60 volts	Protection class: IP 67
Current: 50 Amps	Motor Weight: 5.8kg
Speed: 3300 RPM	-

VII. MOTOR CONTROLLER DESIGN REPORT

Introduction

In the realm of electric propulsion systems, the successful operation of powerful motors, such as the 2KW Brushless Direct Current (BLDC) motor, hinges on the intricate coordination of electrical and mechanical components. To ensure precise control, optimal performance, and efficiency, motor controllers play a pivotal role. These electronic devices serve as the brain of the electric propulsion system, regulating the power input to the motor, managing speed and torque, and providing a seamless interface between the operator and the motor itself. In this discussion, we will explore the essential role of motor controllers in the context of a 2KW BLDC motor, shedding light on their capabilities and the critical function they perform in powering a wide range of applications, from electric scooters to industrial automation.

Rulebook Constraints

The motor controller, a pivotal component of the High Voltage System (HVS) and potentially part of the Low Voltage System (GLVS), is responsible for governing the speed and torque of an electric motor. Teams have the freedom to utilize any commercially available controller or undertake the development or adaptation of a controller to meet the specific requirements of the project. It is imperative that the hardware components of the controller are compatible with the prescribed working voltage and current values. Furthermore, the controller must adhere to all applicable regulations, ensuring compliance with safety standards. Notably, the controller is mandated to offer essential protective features such as over and low voltage protection, over-temperature protection, over-current protection, and brake protection for the motor. It is crucial that the controller's voltage aligns with the battery and motor, and the current rating does not surpass the continuous current output of the battery. The system should be meticulously designed to ensure seamless synchronization and optimal performance of all its interconnected components.

Working principle

A BLDC motor controller determines the location of the rotor either without sensor or utilizing sensors (such as a Hall-effect sensor). The sensors take rotor position measurements and transmit this information. The information is sent to the controller, which then instructs the transistors to switch the current and energize the necessary winding of the stator at the appropriate moment.

Design consideration

LxBxH = (270x130x70) mm

Weight= 1.5Kg

Component Selection.

The anti-theft protection system is a standout feature of this product, ensuring the security of your equipment. It offers versatility with three-speed modes, giving you the flexibility to adapt to various needs. Additionally, the rotation direction reversing functionality adds convenience to your operations, especially with the capability to reverse at half speed. The inclusion of hard start/soft start functionality enhances motor control and prolongs the lifespan of connected devices. You can easily monitor your usage with the speed output for the digital meter. For added safety, an ignition lock facility is provided for easy on and off control. This device is compatible with a range of battery types, including SMF, automotive, tubular, and lithium batteries. Its heavy-duty aluminum heat sink ensures efficient heat dissipation, while the compact dimensions (270x130x70) mm and lightweight design (1.5kg) make it a practical choice for various applications.

The motor controller incorporates a comprehensive set of safety features to ensure smooth and reliable operation. It is equipped with over-heating protection to prevent excessive temperature build-up, which can be detrimental to both the controller and the motor. Additionally, it includes battery low voltage protection to safeguard against depleting the battery beyond safe levels. Overcurrent protection is another vital aspect of its design, preventing damage caused by excessive electrical current. To further enhance safety, the controller incorporates throttle error protection, ensuring that the throttle input operates accurately and without errors. The system also includes Hall sensor failure protection to address potential sensor malfunctions. Furthermore, the motor controller is equipped with fault detection LED indicators, which serve to promptly alert users to issues related to the motor, throttle, or overload, thereby allowing for timely troubleshooting and resolution of any problems. These protective features collectively contribute to a more secure and efficient motor control system.

Results

Voltage 60V

Power 3000 W

Rated current 50A

Over Voltage Cut-off (Volts):- 58/72

Under Voltage Cut-off (Volts):- 41/52

Commutation Angle (Degrees):- 120

Operating Temperature (℃):- -20 to 8

VIII. BATTERY DESIGN REPORT

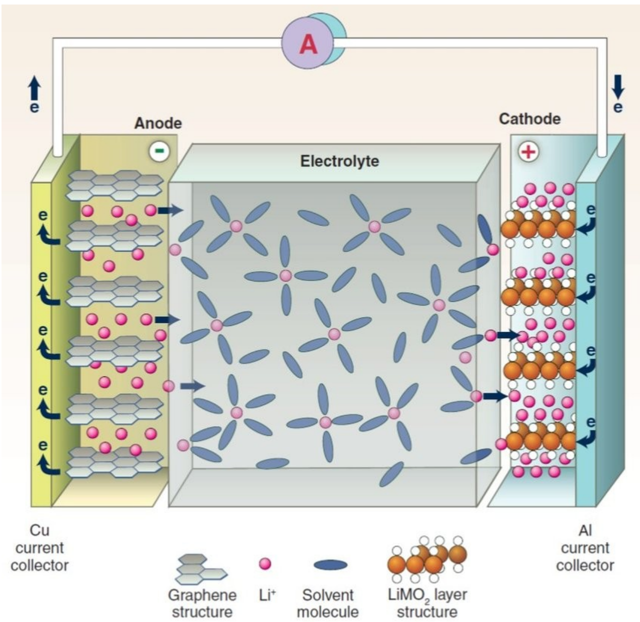
Introduction

The adoption of electric motorcycles represents a transformative shift in the world of two-wheeled transportation, offering riders an eco-friendly, efficient, and thrilling alternative to traditional internal combustion engine bikes. Central to the success of electric motorcycles are their power sources, with Lithium-ion (Li-ion) batteries emerging as the go-to energy storage solution. These advanced battery systems have revolutionized the way electric motorcycles operate, offering improved range, performance, and charging capabilities. In this discussion, we will delve into the world of Li-ion batteries and their indispensable role in propelling electric motorcycles, while highlighting the key advantages they bring to this exciting and sustainable mode of transportation, such as high energy density, longer lifespan, rapid charging, and reduced maintenance.

Rulebook Constraints

To meet the outlined specifications, the proposed design entails selecting a pre-manufactured Li-ion battery pack with a capacity of 2.5 kWh and a nominal voltage ranging from 48V to 72V. The chosen battery pack must hold an IEC 60529 IP67 certificate, ensuring robust protection against dust and water ingress. Integral to the battery system should be a reliable Battery Management System (BMS) for efficient and safe cell monitoring. In lieu of liquid cooling, passive cooling techniques should be employed to regulate the battery temperature effectively. Adherence to these guidelines necessitates careful selection and integration of a suitable pre-existing Li-ion battery solution, guaranteeing compliance with the outlined requirements.

Working principle



A battery is made up of an anode, cathode, separator, electrolyte, and two current collectors (positive and negative). The anode and cathode store the lithium. The electrolyte carries positively charged lithium ions from the anode to the cathode and vice versa through the separator. The movement of the lithium ions creates free electrons in the anode which creates a charge at the positive current collector. The electrical current then flows from the current collector through a device being powered (cell phone, computer, etc.) to the negative current collector. The separator blocks the flow of electrons inside the battery.

CHARGE/DISCHARGE

While the battery is discharging and providing an electric current, the anode releases lithium ions to the cathode, generating a flow of electrons from one side to the other. When plugging in the device, the opposite happens: Lithium ions are released by the cathode and received by the anode.

Design Considerations

Designing a Li-ion battery system at 60V entails crucial steps. Firstly, select high-quality cells considering energy density and discharge rates. Incorporate a reliable BMS for monitoring and managing cell parameters. Implement safety features for protection against overcharging, over-discharging, and short-circuits. Develop a robust enclosure for mechanical protection. Ensure an efficient cooling system to regulate temperature during operation. Choose an appropriate charging infrastructure and establish intelligent monitoring and control systems. Lastly, ensure compatibility with the application and compliance with industry standards for optimal performance and safety.

Component Selection.

This electric motor is meticulously designed for exceptional performance and reliability. With a brushless design, it operates quietly, ensuring a noise-free environment. Its compact size and high power-to-weight ratio make it suitable for various applications. The motor's splash-proof feature enhances its durability in challenging environments, while the use of high-quality materials like Neodymium Magnets and Silicon steel reduces energy losses and ensures efficient operation. The incorporation of forced air cooling promotes effective heat dissipation, enabling sustained high-speed operation without compromising on performance. The absence of a mechanical commutator not only extends its lifespan but also minimizes the need for maintenance, making it a cost-effective and low-maintenance solution.

Additionally, the motor's advanced construction, including sealed high-quality bearings, hardened shaft with keyway slot, and high-temperature resistive coated wires, contributes to its robustness and longevity. Its optimal current consumption and higher dynamic response, facilitated by low inertia, guarantee energy efficiency and precise control. Moreover, the absence of the brush system enables the motor to achieve high speeds, even under heavy loads, ensuring consistent and reliable operation. With no requirement for lubrication and reduced electromagnetic interference, this motor offers a streamlined and hassle-free solution for applications demanding high efficiency, torque, and precision.

Formulation and Calculations.

Total energy requirement: 2500 Wh

Motor Voltage: 60 V.

Battery Voltage: 60 V.

Capacity = 2500Wh/60V = 41.6Ah

Cell Configuration:

Individual Cell Capacity 3.6V 5200 mAh.

To get 60V we need 60/3.6=16.66≈ 16cells in series

C rating of the battery: 1C.

To get 41.6Ah, 5200 mAh /1000 = 5.2Ah.

41.6Ah/5.3Ah = 8 cells in parallel.

As a result, the battery is organized as 16S8P, with 16 cells in series and 8 cells parallel

The configuration that should be used to obtain 60 V and 41.6 Ah is provided in the data sheet. Because each 16S8P cell is nominally 3.6volts, 60/3.6 will produce 16 cells in series, which is why 16s is used for the supplied cell. The battery has a C rating of 1C. 5200 mAh / 1000 = 5.2 Ah to obtain 41.6 Ah. 8 parallel cells at 41.6Ah/5.3Ah

Results.

Energy: 2500 Wh

Voltage 60 volts

Current: 41.6 Ah

Max Continuous Discharge Current: 50A

IX. WIRING DIAGRAM AND ACCESSORIES DESIGN REPORT

Introduction

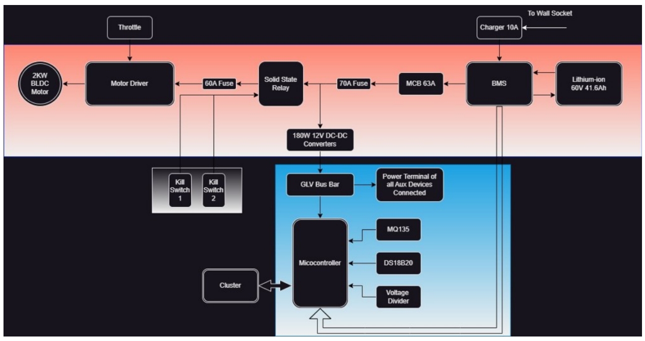
The electrification of motorcycles has ushered in a new era of two-wheeled transportation, blending the thrill of riding with eco-conscious innovation. However, the successful development of an electric motorcycle extends beyond the propulsion system alone. It necessitates meticulous planning and design in various aspects, including the wiring diagram and accessories. These elements are the unsung heroes behind the seamless operation and functionality of electric motorcycles, ensuring safety, convenience, and connectivity for riders. In this discussion, we will delve into the world of wiring diagram and accessories design for electric motorcycles, exploring the crucial role they play in enhancing the riding experience and the intricate balance between form and function.

Rulebook Constraints

- All conducting wires and connectors must be covered with insulation material.
- Areas with high electric risk should be protected
- The recommended protection degree is IP-65.
- The wire length must be exact, and therefore it in not allowed to roll excessive wire.
- Any possible interference between the electric installation and any mechanic system of the bike must be considered and avoided, in any possible geometry range (during the complete route of the steering, suspensions, etc.).

Components selection

1. **Use High-Quality Wiring**: We are using HV wire for powering the motor, which can withstand high currents during the operation of the motor.
2. **Proper Insulation**: We are using heat shrinks to minimize the chance of short circuit.
3. **Secure Mounting**: We will monitor the performance of the battery regularly and make sure the parameters are well within the range.
4. **Waterproofing**: Our battery pack is IP67 rated for better protection.



X. ERGONOMICS REPORT

Ergonomic Triangle

The ergonomics triangle is how the ergonomist describes the human-machine interfaces on the motorcycle. These interfaces are the points where the individual comes into direct physical contact with their motorcycle. This includes the seat and handlebars, specifically the handlebar grips and the footrests. Regular commuter motorcycles or even performance-Naked's have slightly lower set handlebars and the footrest position is ideally below the rider's elbows. The rider's triangle faces forward in this case. This riding position once again does not put much pressure on a rider's back and neck, but allows for more control over the motorcycle, especially when riding in a sporty fashion.

Ergonomics plays a crucial role in enhancing both the comfort and performance of motorcycle riders. The advantages of ergonomic design on the rider and the subsequent impact on motorcycle performance are multifaceted:

1. Comfort and Reduced Fatigue:

- Proper ergonomic design ensures that the rider's body is positioned in a natural and relaxed posture. This reduces muscle strain and fatigue during long rides.

- Comfortable seating, well-placed handlebars, and adjustable footpegs contribute to a more enjoyable and less physically taxing riding experience.

2. Improved Control and Handling:

- Ergonomically designed motorcycles allow riders to maintain better control over the bike. This is achieved through appropriately positioned handlebars and foot controls, enabling precise steering and maneuvering.

- A well-aligned riding posture contributes to better weight distribution, improving stability and handling, especially during challenging riding conditions.

3. Enhanced Visibility and Awareness:

- Ergonomics also influence the rider's field of vision. Properly positioned mirrors and an unobstructed view of the instrument panel contribute to improved awareness of the surroundings, promoting safety.

- A comfortable riding position allows riders to focus on the road without distraction, contributing to increased attention and reaction time.

4. Optimized Aerodynamics:

- Ergonomically designed motorcycles take into account the rider's body position concerning wind resistance. This contributes to improved aerodynamics, reducing drag and enhancing fuel efficiency at higher speeds.

- Streamlined designs not only enhance performance but also minimize rider fatigue by reducing the effects of wind resistance on the body.

5. Personalized Riding Experience:

- Adjustable components, such as seats and handlebars, allow riders to customize their riding positions to suit their body dimensions and preferences. This personalization contributes to a more enjoyable and individualized riding experience.

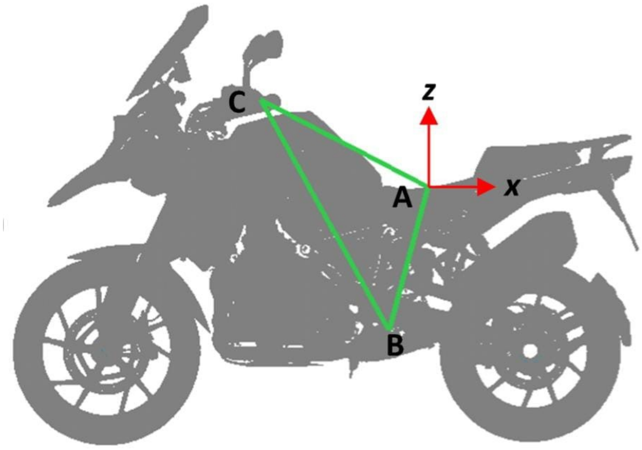
6. Reduced Risk of Injury:

- Proper ergonomics can reduce the risk of musculoskeletal injuries by promoting a natural alignment of the rider's body. This is especially important during sudden accelerations, decelerations, or unexpected maneuvers.

7. Efficient Energy Transfer:

- Ergonomic designs ensure that the rider can efficiently transfer energy to the motorcycle's controls, promoting a responsive and agile riding experience. This is crucial for quick acceleration, braking, and overall performance.

In summary, integrating ergonomic principles into motorcycle design not only enhances the rider's comfort and reduces fatigue but also has a direct and positive impact on the motorcycle's performance, safety, and overall riding experience.



AC=530 mm
AB=475 mm
BC=810 mm

Seat to Handle = AC = 530mm

Seat to Footpeg = AB = 475mm

Footpeg to Handle = BC = 810mm

Distance between foot boards = 280 mm

Distance between footpegs = 500 mm

XI. REFERENCES

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