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DESIGN AND FABRICATION OF ELECTRIC BIKE WITH SLIDING FRAME

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Transportation is important for humans. Generally, the means of transportation use machines that can pollute the environment. The use of fuel oil which is used as a driving force for vehicles can be the main cause of the release of various pollutants. Emissions generated by internal combustion engines can cause many losses. Losses due to emissions include losses on health, the environment, and economic impacts. Besides, the amount of fuel oil resources is decreasing every year. For that to anticipate this need development electric bike. The campus environment, especially that of the more established universities, has entered the public consciousness as being a haven for electric bike use. The main advantages of electric bikes are economical and environmentally friendly. The objectives of this study were (1) to design an electric bike, (2) to analyze the strength of the sliding frame of an electric bike, (3) to test the distance traveled by an electric bike. The research method used research and development. The results of the research are (1) an electric bike design with a sliding frame has been created, (2) the results of the frame analysis using iron material, the von mises stress 49.98 MPa, a maximum displacement of 0.125 mm, and a safety factor is 3. (3) Based on the test track, an electric bike using a sliding frame can travel a distance of 75 km with a maximum speed of 25 km/hour.

Key words: transportation, design, fabrication, electric bike, frame, sliding frame

INTRODUCTION

An energy crisis is one of the major concerns in today's world due to the fast depleting resources of petrol, diesel, and natural gas. In combination with this, environmental decay is an additional factor contributing to the depletion of resources and to become attention [1]. Much research worldwide has been conducted on electro-mobility solutions, especially during recent years of increased awareness of CO₂ emissions and the environmental consequences of profligate consumption of fossil fuels. However, the common term electric vehicles has become almost synonymous with electric cars, apart from some prominent niche examples which will be explored. Cars are only one example of practical electric transportation. Sustainable and practical personal mobility solutions for campus environments have traditionally revolved around the use of bicycles, or the provision of pedestrian facilities. However, many campus environments also experience traffic congestion, parking difficulties, and pollution from fossil-fuelled vehicles [2].

The campus environment, especially that of the more established universities, has entered the public consciousness as being a haven for bicycle use [3]. Emissions generated by motor vehicles can cause many losses. Losses due to emissions include losses on health, environmental, and economic impacts. The main reason to design the electric bicycle/ electric bike is to overcome the problem with the pollution and with the economy [4-5]. Cycling as a mode of transport is a low-cost, health-improving way to travel and offers environmental benefits [6]. The main advantages of electric bikes are econom-

ical and environmentally friendly. Among the economic benefits, we can find the total cost per kilometer traveled by an electric bicycle (including energy, purchase, and maintenance) [7]. Electric bike as an alternative means of transportation can save an average of 8.5 liters of gasoline per 100 km [8]. Electric bikes are widely used in developed countries such as China and the Netherlands. Electric bikes, which are driven by a combination of pedaling and a battery-powered electric motor, are a promising alternative to car transportation. Their main advantages include the lower purchase and operating costs than cars, the ability to travel long distances and with less physical effort compared to traditional bicycles, and zero emissions during operation [9].

The objectives of this study were (1) to design an electric bike, (2) to analyze the strength of the sliding frame of an electric bike, (3) to test the distance traveled by an electric bike.

THEORY AND EXPERIMENTAL

The electric bike (e-bike) components consist of a DC motor, frame, platform, battery, chain drive, braking system, and sprockets. The electric motor used has 250 watts of power with a DC motor type. The research shows that with the calculation of shaft design, Design of sprocket and chain for electric bike, selection of pitch of sprockets, calculation of the value of factor of safety, and calculating maximum tension of chain [10-11]. A typical e-bike battery requires strictly 8 hours or something similar to completely charge it, and that power is sufficient to

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carry an e-bike up to the distance of 48 to 60 km, at the average speed of around 20 km/h [12].

Standard e-bike frames need to be able to accommodate the extra mass of electric bicycle components (motor, controller, and battery). Common locations for batteries are on some kind of rack above the rear wheel, between the rear wheel and seat post, below a crossbar, or above the front wheel. At least one electric bicycle conversion kit locates batteries as panniers carried either side of the rear wheel [2]. The electric bicycle that owns the acceleration system is equipped with an electric motor driven by an accelerator lever [13].

To analyze the strength of the frame can use the FEA model [14]. FEA models have been created and frame analysis is carried out for various speeds and types of collisions indicating that the design is safe even at maximum speed (80 Kmph). The materials AISI 4130 can use frame e-bike. [15]. Analyzed stress and optimized a custom bicycle frame design using Pro/Engineer software. This research tries to verify the stress response and displacement of several types of bicycle frames using a wireframe model and then analyzes its solid structure [16]. Design and analysis frame can simulation using the help of ANSY software. This research used AISI 4130 material. With a yield strength of 460 MPa. The highest safety factor value is 2.54 in the torsion test. with a design that is made of a lightweight and safe frame [17].

Electric bikes use a DC motor as their main driving force. Electric bikes are electrically operated and can also be pedaled. Based on the calculation of the no-load speed of 20.66 km/h with a power requirement of 391.69 watts [18]. The motor power generally ranges from 200 W to 1000 W. The weight ranges from 20kg to 45kg, and the range can be as high as 150km on a single charge. Speeds are generally less than 45km/h [19]

Designing an electric bicycle powered by a lithium-ion battery, the electric bicycle can cover a distance of 60 km, and charging takes approximately 3.5 hours [20]. The Waterloo WeBike project: a field trial in which more than 30 sensors equipped with e-bikes were provided to members of the University of Waterloo for personal use. Our dataset includes nearly three years of e-bike rides and battery charging sessions. Our main finding was that the main purpose of e-bikes in our trials was for travel, with most trips lasting less than 20 minutes and most trips taking place in the summer months. Our charging analysis revealed no evidence of range anxiety, and our analysis of survey results showed little correlation between anticipated and actual use. Furthermore, when asked their opinion on various modes of transportation, our participants rated regular bicycles higher than e-bikes even after becoming familiar with e-bikes through field trials. Based on our analysis, we draw several conclusions, including the fact that the general public in Canada is still unaware of e-bikes and their potential [9].

Electric bicycles, of many types, were surveyed by and on a semi-open basis at the Nanyang Campus of the Tech-

nological University in Singapore. According to him, this campus is a well-known and useful administration, with several models of electric bikes very widely used. Electric bicycle riders can be both fun and engaging at the same time making the most of it and are perfect for campus trips. Understanding and the general public alike viewed the plan without hesitation, and the creators have seen a decline in the number of motorists on the ground [21].

The platform is designed with a solid base so that it can withstand loads together with the weight of the person driving uniformly. It is made of mild steel at a certain angle in cross-section and is welded with sheet metal of a certain thickness. The alignment of the platform is made horizontal regardless of whether it is loaded or unloaded and it is directly bolted and welded to the frame [22]. Batteries vary according to voltage, total charge capacity (amp hours), weight, number of charge cycles before performance deteriorates, and ability to handle over-voltage charging conditions [23]. Electric bicycle batteries can be recharged by plugging in a power supply or pedaling. Besides, certain electric bicycles take 6-8 hours to charge the battery. Generally, the travel distance ranges from 35-50 km with a speed of about 20 km/hour (depending on the rider's weight) [24]. Designed the E-bike with some special modifications which include phone charging port, led light, system electric horn, tachometer with Foldable E-Bike. The components used include led lights-2, tachometer, friction generator, hub drive, electric motor with gear & pedal system, shock absorbers, battery, USB port, locking system, brakes & clutch, and wheels [25].

Some specifications of electric bicycles from various countries are shown in Table 1.

The state of the art of this study is an electric bicycle with a sliding frame platform, namely an electric bicycle with a frame that can be adjusted according to your needs and comfort. Besides, electric bicycles can be operated using two modes. If the battery is still fully charged, an electric motor drive can be used. If the battery runs out, the bicycle can still be operated like a scooter with a foot-

Table 1: Specifications of electric bikes from various countries [22]

Country	Type	Max. speed km/h	Power (W)	Load	Age
Australia	Pedal (P)	25	250	-	-
Canada	Hand (H)	32	500	-	-
China	P/H	30	200	20	-
China	P/H	30	500	-	-
Norway	Pedal	25	250	-	-
Israel	Pedal	25	250	30	14
UK	Hand	27	250	40	14
Taiwan	Hand	25	200	-	-
US	Hand	25	750	-	-

rest instead of pedaling like a normal bicycle. With the right design, an electric bicycle that is environmentally friendly, portable, and low in price will be produced if it is mass-produced for campus transportation.

This study uses a Research and Development (R & D) approach. The research method used three-step, observation, development, and application. The observation stage was carried out on the existing electric bicycle designs. The development stage is carried out by designing a portable electric bicycle with stylish stages, power simulation, frame analysis, and engineering drawing. Before application, the bicycle was tested to be ridden and driven on roads that were uphill and downhill with inclines not reaching 30 degrees. The application stage is the application of designs and calculations that have been carried out on the real road and used as a means of campus transportation.

RESULT AND DISCUSSION

Design Procedure For E-Bike With Sliding Frame

The design includes analysis of bicycle needs, calculation of electric motor power, making frames with a sliding frame platform, and brake systems. To calculate the power requirements of an electric motor. first, calculate the force acting on an electric bicycle. The force calculated includes the rolling resistance, aerodynamic drag, hill-climbing force, and acceleration force.

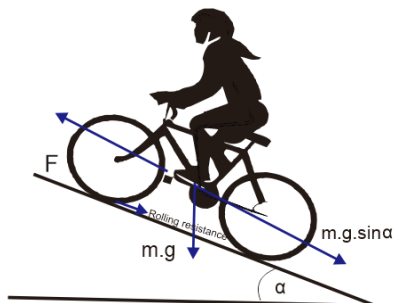


Figure 1: The force that acts when climbing

As long as you ride an electric bike, the wheels will rotate and friction against the road. The force acting on the bicycle when it is running is called rolling resistance. To calculate the working force, you can use equation (1). Where F_r is the rolling resistance force, m is the mass of the electric bike with the passenger (kg), g is the force of gravity (m/s^2) and f_r is the friction coefficient. The coefficient value of asphalt/concrete roads is 0.013, gravel is 0.02, the soil is 0.05, and fields is 0.1 [18].

The hill-climbing force can be calculated using equation (2), where F_g or the gradient (uphill) force, α is the angle or slope of the road.

As long as an electric bike is running, it will be upwind. This drag is often referred to as aerodynamic force. The aerodynamic drag force is calculated using equation (3). Where F_{Ad} is the aerodynamic drag force, ρ is the density of the air, C_A is the coefficient of aerodynamic resistance,

and V is the speed of the electric bike. To change the speed of an electric bike, a force that can overcome drag and give linear acceleration to an electric bike is needed, this force is called the acceleration force. The acceleration force is calculated using equation (4). Where F_{Ac} is the acceleration force, and a is the acceleration of the electric bike.

$$F_r = m \cdot g \cdot f_r \tag{1}$$

$$F_g = m \cdot g \cdot \sin \alpha \tag{2}$$

$$F_{Ad} = 0.5 \rho C_A V^2 \tag{3}$$

$$F_{Ac} = m \cdot a \tag{4}$$

To calculate the power required by adding the equations (1), (2), (3), and (4) multiplied by the speed of the electric bike. Based on the results of calculations and various considerations with a maximum passenger load of 100 kg, and road conditions on the Universitas Negeri Semarang campus area, 500 watts of electric motor power is used. The type of electric motor used is BLDC. The choice of this electric motor is because it has high motor efficiency, and is easy to maintain. The electric motor used is shown in Figure 2. The working voltage on the electric motor is 48 V.



Figure 2: BLDC Motor

The need for electric motor power required battery energy which is greater than electric motor power. To calculate the power requirements for an electric motor, you can determine the battery capacity. Battery capacity can be calculated using equation (5).

$$E_{batt} = V \cdot C_{battery} \tag{5}$$

Where E_{batt} is battery energy in units of Wh, V is battery voltage, and $C_{battery}$ is battery capacity (Ah). The battery used is a VRLA type. Using equation (5) the energy in the battery is 576 Wh. This energy will be sufficient to meet the power usage requirements of the e-bike.

Ebike design used Autodesk Inventor software. Using Autodesk Inventor software, the researchers analyzed the strength of the frame. The design of an electric bicycle that is created is shown in Figure 3. The results of the analysis include von mises stress, displacement, and safety factor. The which are shown in Table 2.

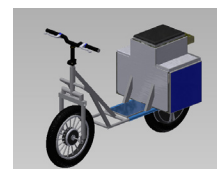


Figure 3: Design of an electric bike with a sliding frame

The main components of an e-bike include frame, battery, controller, electric motor, brake system. The electric bicycle diagram is shown in Figure 4.

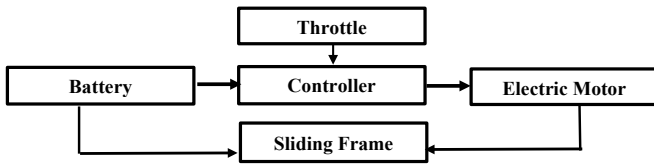


Figure 4: E-bike block diagram

Based on the calculation and design results of the electric bike design are shown in Table 2.

Table 2: Specification e-bike with sliding frame

Type	Max. Speed km/jam	Power (W)	Max. Load (kg)	Age	Brake system
hand/walking (H/W)	25	500	100	-	Drum brake

The distribution of loads on the bicycle frame is shown in Figure 5. The simulation results on an electric bike frame are shown in Figure 6. The results of the finite element method simulation using the Autodesk Inventor application with iron material and get the von mises stress of 49.98 MPa, a maximum displacement of 0.125 mm, and a safety factor is 3. Based on the simulation results, the prone areas on the sliding frame are at the connection between the front and rear frames, but the safety factor can still > 3 and can be categorized as safe.

The BLDC motor is used as the main driver of an electric bike. The electric motor used has a power of 500 watts. The BLDC motor is an electric motor that has high efficiency and is maintenance-free and does not cause noise. The battery used has a voltage of 48 volts 12 Ah.

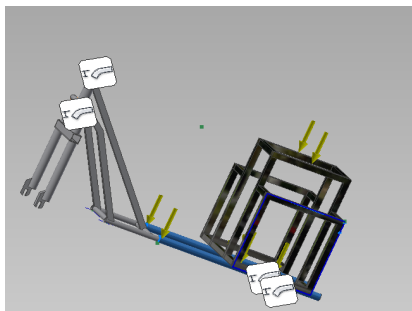


Figure 5: Load distribution

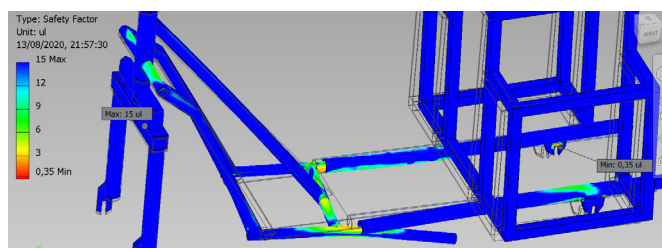


Figure 6: Sliding frame simulation

Electric bike batteries can be recharged by plugging in a power supply. The electric bike takes 7 hours to charge the full battery. An electric bike the test track chart with a battery indicator is shown in Figure 8.

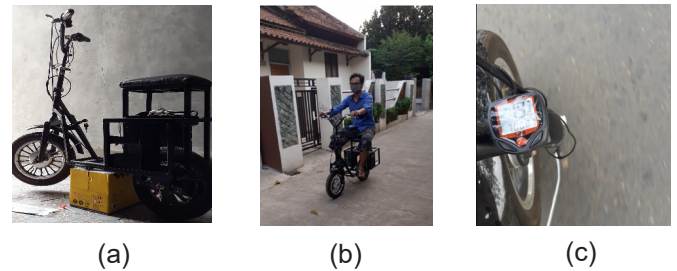


Figure 7: (a)The process of fabricating an e-bike with sliding frame, (b) & (c) The test track

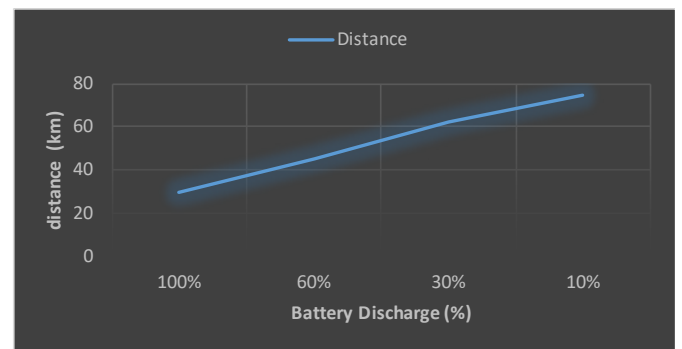


Figure 8: Battery discharge vs distance

The test track used an odometer. The odometer used can calculate vehicle speed, operating time, average speed, and distance traveled. Based on the results of testing electric bikes on the road, electric bikes can operate for 3.5 hours with an average speed of 20 km/hour and can travel a distance of 75 km.

The advantages of the designed sliding frame are: (1) a lightweight frame that increases the mileage (2) the length of the bicycle can be adjusted according to the comfort of the rider, (3) the production process is cheaper. (4) the battery uses VRLA and can be replaced with a lithium battery ion so that the vehicle load is reduced so that the distance is even further.

Weaknesses on electric bikes include: (1) on the side, reducing vehicle comfort when the bicycle is operated as a scooter, (2) the maximum speed is not more than 25 km/hour, (3) the area prone to breaking the frame in the sliding area between the frame and the back.

CONCLUSION

Based on the results of the study the conclusion in this article (1) an electric bike with a sliding frame design has been created. (2) the results of the analysis of the frame using iron material have a von mises stress of 49.98 MPa, a maximum displacement of 0.125 mm, and a safety factor of 3, and this value is technically safe. (3) based on the test track, an electric bicycle using a sliding frame can be travel for a distance of 75 km with a maximum speed of 25 km/hour. In the future, to increase the

distance and reduce electric bike weight, electric bicycle batteries can use lithium-ion, battery system engineering for fast charging, for the e-bike frame can be optimized using aluminum alloy or composite materials.

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