International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 12 | Dec 2022 www.irjet.net p-ISSN: 2395-0072

A REVIEW: DESIGN AND DEVELOPMENT OF INTEGRATED 2 & 3-WHEELER ELECTRIC VEHICLE

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Abstract - *Electric bicycles have grown in popularity in recent years, particularly among the elderly. More recently, people with disabilities are also showing interest in this product because of the ease of moving from one place to another. According to the literature, the electric bicycle has either two or three wheels, with the possibility of developing an integrated two- and three-wheel electric bicycle in the future. The proposed design could be used by normal persons as a 2-wheeler and by persons with disabilities as a 3-wheeler. Also, the electricity consumption and charging pattern of the proposed design were investigated. The proposed design of a 2- and 3-wheel electric bicycle with a motorized handle attachment shows better mobility solutions for disabled and non-disabled persons.*

Keywords: *Charging, Design, Electric Bicycle, Motorized, Mobility.*

1. INTRODUCTION

In recent years, electric bikes have been used by all riders, primarily older people, as part of a shift toward sustainable and active transportation in many countries to address the problem of air pollution and as a mode of physical exercise. Ongoing research studies revealed that cycles with two wheels are being used by non-disabled persons, and cycles with three or four wheels are being used by disabled persons. Riders aged 40 and up are experiencing knee pain, joint pain, and other muscular issues. So both disabled and non-disabled riders are using two- and three- or four-wheeled cycles separately. If the above-mentioned disabled and non-disabled riders belong to one family, they need to have two cycles. With this background, the current paper aims to develop a bicycle with an electrical drive that is adaptable for both the above-mentioned disabled and non-disabled riders.

2. ELECTRIC WHEELCHAIR

George Klein created the first electric wheelchair in order to aid injured World War II veterans. It has changed over time to take on numerous styles and shapes. The power chairs come with a variety of features, including chin and hand controls, tilting, seat elevation, and many more. Some of the models can be disassembled and transported when travelling because they are portable. Three general categories can be used to classify electric wheelchairs:

- The front-wheel powered chair: A power chair designed for indoor use. This chair has four wheels and is the most adaptable of the bunch.
- The rear wheel powered chair: An outdoor-friendly power chair. They are suitable for rocky roads because they are rear-wheeled.
- Mid-wheel powered wheelchair: This electric wheelchair is suitable for indoor use but has reliable steering capabilities.

A wheelchair that uses an electric motor to move itself, typically via differential steering, is known as a motorised wheelchair, power chair, electric wheelchair, or electric-powered wheelchair (EPW). People who are unable to push a manual wheelchair or who may need to use a wheelchair across rough terrain or over long distances may find motorised wheelchairs handy. They may also be utilised by persons who have diseases related to the heart and exhaustion, in addition to those with "conventional" mobility disabilities. [1]. Table 1 below gives a description of the many types of electric wheelchairs.

Table 1: Different Types of Electric Wheelchair

TYPES OF WHEELCHAIR	DESCRIPTION	IMAGE
Manual self-propelled wheelchair	The chassis of a self-propelled manual wheelchair, the seat, one or two footplates (footrests), and four wheels—typically two main wheels and two caster wheels—are included. Additionally, a separate seat cushion is typically included. The larger rear wheels typically have push-rims of a slightly smaller diameter protruding just past the tyre. The user can move the chair by pushing on these instead of holding onto the tyres.	
Manual attendant-propelled wheelchairs	In general, an attendant-propelled wheelchair resembles a self-propelled manual wheelchair, but it has smaller front and rear wheels. A person standing at the back and pressing on handles built into the frame moves and controls the chair. The attendant, who is typically equipped with a foot- or hand-operated parking brake, provides the braking immediately.	
Mobility scooters	Mobility scooters and power chairs have certain similarities, although mobility scooters are primarily targeted at those who have trouble walking but might not otherwise consider themselves disabled. Smaller mobility scooters normally have three wheels, a platform on which a seat and tiller are attached in the back, and three wheels in the front. Larger scooters often have four wheels and a considerably larger seat.	
Single-arm drive wheelchairs	A manual wheelchair can be self-propelled by a user using a one-arm or single-arm drive. Two concentric hand rims, one smaller in diameter than the other, are attached to the main wheel on the same side as the arm that will be used. The chair can be moved straight forward or backward by grasping both hand rims at once. Only one wheel is used when either hand-rim is moved independently, and the chair will turn left or right in reaction to the hand-rim.	
Reclining wheelchairs	Wheelchairs that recline or tilt in space feature tilt-adjustable seating surfaces. Hugh Barclay, an orthoptist who worked with crippled children, came up with the initial idea after noticing that postural deformities like scoliosis may be supported or partially rectified by enabling the wheelchair user to relax in a tilted position.	
All-terrain wheelchairs	Access to terrain that would normally be completely inaccessible to a wheelchair is possible with all-terrain wheelchairs. There are now two formats available. One combines mountain bike and wheelchair technologies; it often takes the form of a frame on which the user sits, with four mountain bike wheels on the corners. Generally speaking, push rims are not used, and pressing directly on the tyres is how propulsion and braking are accomplished.	

Heavy duty wheelchair	It can be tailored based on specific requirements and is made with outdoor use in mind. It can be used to move through rough terrain. Only ramps and elevators can be used to transfer these power chairs.	
Transportable wheelchair	Due to the minimal weight of this type of electric wheelchair, disassembly may be done quickly and without fuss. It is suitable for narrow doorways and halls because of its modest size.	
Powerbase wheelchair	The larger battery array on these electric wheelchairs is primarily what makes them special. Due to its unfolding ability, it needs lifts when traveling. Both outdoor and indoor travel are appropriate. This wheelchair guarantees a solid and easy transition.	
Sports wheelchair	These chairs have been specifically designed for sports including basketball, tennis, and bowling.	

Many scientists and academics have examined the electric bike and wheelchair throughout the years, conducting studies and analyses on motorised wheelchairs. It is claimed that mechanical principles helped improve wheelchair design by helping to understand where the centre of gravity was. More emphasis has been placed on the design and construction components. Figure 1 depicts a two-dimensional diagram of a wheelchair. The golden ratio, or 1:1.5, should be used for chair height and weight. It is crucial to the chair's appropriate balance. [2].

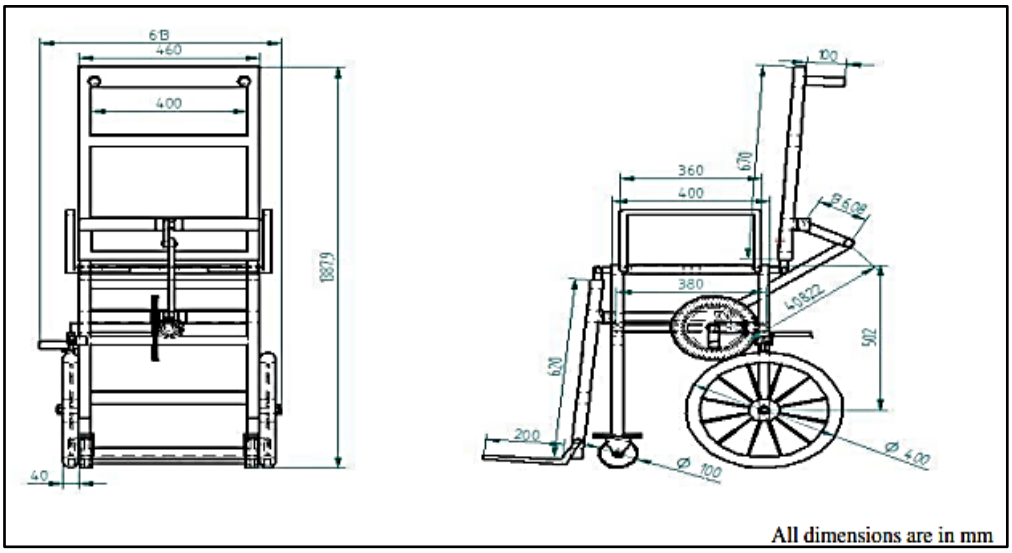

Figure 1: 2D Diagram of Wheelchair

The steering wheel of a wheelchair used for indoor stair climbing in this paper, various stair climbing mechanisms—including crawler-type, leg-type, hybrid-type, and wheeled-type—are evaluated. MSC Visual Nastran 4D (VN) design software is used to create the model of a two-wheeled stair climbing wheelchair. Using the necessary anthropometric data, the humanoid model is created. The wheelchair is subjected to a variety of forces and torques as it ascends the stairs. The chair's outer support assembly should ideally have wheels on both sides. Figure 2 depicts the structure of an electric wheelchair's control system. The inner support assembly helps to keep the seat assembly more closely aligned with the chair's centre of gravity. [3].

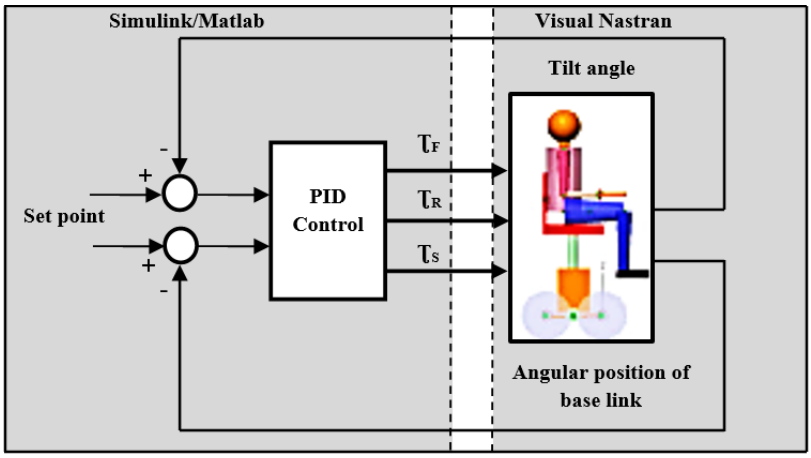

Figure 2: Control System Structure

The wheelchair-cushion stretcher's idea was validated. The primary goal of this design was to conserve space. It contains an arm rest and handle that are ergonomically built for patients to operate the wheelchair comfortably. For the comfort of the patient, certain additional features have also been incorporated. The cushioning component and the base on which it is mounted are also given top importance. Patients should be provided with comfort by employing a better cushion, and the base should be used in a way that allows for simple folding. [4]. Figure 3 shows that all dimensions are considered according to Indian anthropometric data.

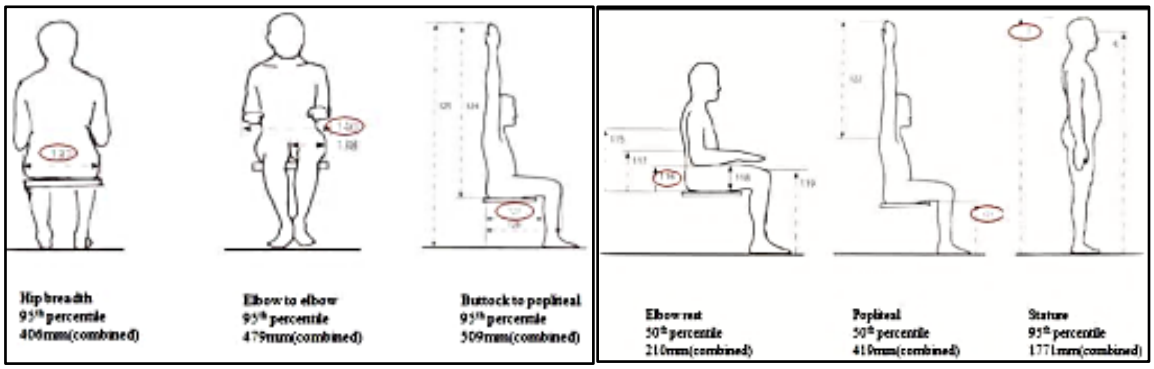

Figure 3: Anthropometric data

The creation and use of an electric chair that can automatically ascend stairs for those with disabilities. The chair can be moved in any direction and raised and lowered to various degrees. The chair's DC voltage source (battery) can be recharged so it can operate for extended periods of time. The suggested design can support users weighing up to 90 kg and is the right size to be used in homes, hospitals, and public spaces (width = 88 cm and length = 125 cm). This study used hydraulic jacks with electrical control and angle measuring equipment to tackle the stability issue. The earlier research and designs were complex and expensive, but this design is specialised to be simple and affordable. [5].

The creation of a solar-powered tricycle for people with disabilities, with solar panels mounted on top so they may use the power produced for propulsion. In the absence of sunshine, this system's functionality is lacking, and it also increases the

wheelchair's cost. The weight of the chair and the amount of space it occupies are somewhat increased with the addition of solar plates. [6].

Based on the data acquired, a wheelchair that is affordable and accessible to the lower and middle classes was designed. It is appropriate for someone who is legless. The battery-operated wheel chair that was built can turn in either direction (left or right) through the handle, has bicycle-style brakes, and operates at a speed of 6 km/hr on curbs, steep inclines, and regular highways, covering 32 km in 5.32 hours at a stretch. The wheel chair has a safety belt feature for the user's protection. [7].

3. ELECTRIC BIKE

The e-bike has transformed from a sporting and leisure item to a frequently used mode of transportation. Improvements in areas like range and energy efficiency are therefore crucial. This paper presents experimental efficiency models for an e-bike's charger, battery, controller, motor, and reduction gears subsystems. These models are combined with elaborate models for the chain transmission system to produce an overall efficiency map for the e-bike. By fusing the system's efficiency map and mathematical model of performance, the range of the electric bicycle is examined. The equations given above are used to create a management approach that can choose the best level of assistance and chain transmission ratio, optimising range while maintaining speed. Using computer analysis, the driving strategy was compared to alternative driving methods. This allowed for the discovery that the suggested strategy increased system range by consuming less battery power. [8].

It also emphasises the design aspects of the bike. There is a provision for charging the battery by connecting to a charger. The electrical power generated, which is used to run the bike, can provide better fuel economy compared to conventional vehicles, better performance, and less pollution. The design and fabrication of electric bikes that use electricity as the primary energy source and solar energy when possible by attaching solar panels. According to calculations, a bike may go at a speed of roughly 15 to 25 kph when the engine is removed, making it lighter and easier to operate. Figure 4 shows an E-bike and its components. This is done to create an eco-friendly bike with improved efficiency, lower energy consumption, less maintenance, and good battery chargeability. [9].

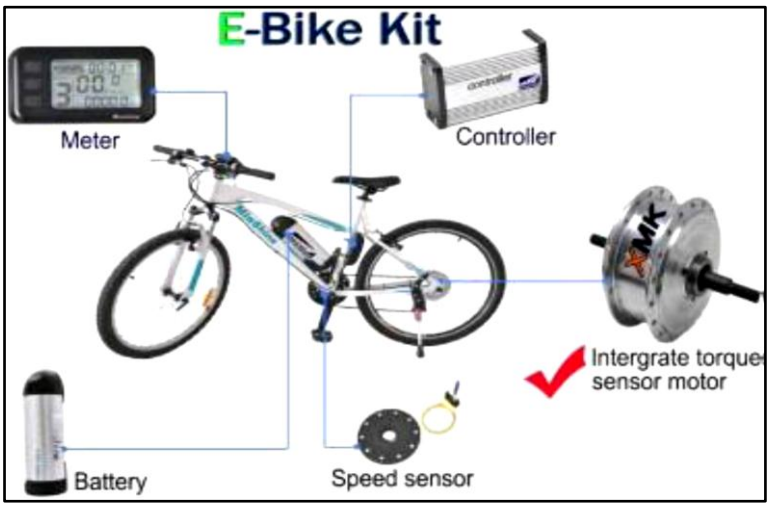

Figure 4: E-bike and its component

Based on the specifications for the selection of materials, the design and analysis of the frame were completed. The data gathering includes a number of variables, including accessibility, machinability, affordability, dependability, feasibility, and ergonomics. Additionally, taken into account were the total length, height, and weight. The choice of rake angle is an important consideration when constructing a bike frame. The angle formed by the neck and the vertical axis of the wheel axle is known as the rake angle, also known as the steering head angle. It establishes the vehicle's kind, such as whether it is a sport or cruise type. It has a significant impact on the vehicle's stability. The length of the e-bike may be best served by the front neck's 19-degree angle with regard to the vertical axis. [10].

4. SELECTION BATTERY

The investigation of three equivalent circuit models for lithium-ion batteries used in electric vehicles. The dynamic stress test data was used to generate all of the model parameters, not the conventional hybrid pulse power characteristic (HPPC) test method. All three models can simulate the dynamics of the battery well, but the first-order model with one-state hysteresis appears to be the best option for lithium iron phosphate batteries used in electric vehicles, according to the comparison of voltage error between the simulation result and test data. Different battery types are used in electric cycles, as shown in table 2 below. [11].

Table 2: Different Types of Battery used in Electric Cycle

TYPES OF BATTERY	FEATURES	ADVANTAGE	DISADVANTAGE
Lead-acid battery	It consists of a lead-based negative electrode and a lead-oxide positive electrode. Sulphuric acid serves as its electrolyte. During the discharge process, the lead in the negative plate and the lead dioxide in the positive plate react with the electrolyte of sulphuric acid to produce water, lead sulphate, and energy. An external electric source electrochemically transforms the water and lead sulphate into sulphuric acid, lead dioxide, and lead for charging.	Batteries made of lead acid are inexpensive and easily recyclable. Additionally, lead-acid batteries are tolerant of overcharging, have minimal internal resistance, and can provide extremely high currents. Additionally, they offer a wide variety of sizes and capacities. Additionally, they are easily distributed to customers because of a large global supplier base.	Lifting a lead-acid battery, which is heavier than other batteries, could result in user harm. Both the energy-to-weight and energy-to-volume ratios are poor. Lead sulphate crystals that cause insulation on the negative electrode may lower its operating performance. Additionally, it could produce combustible gases and provide risks, including chemical burns to the skin.
Nickel-cadmium battery	It is a type of rechargeable battery having an alkaline electrolyte, a separator, a positive nickel oxide-hydroxide electrode plate, a negative cadmium electrode plate, and other components (potassium hydroxide). To generate a significantly greater maximum current than an equal-sized alkaline cell, the positive and negative electrode plates, which are separated by the separator, are rolled in a spiral shape inside a metal casing (the jelly-roll design).	It has more capacity than a lead-acid battery. Besides, it offers a faster charge rate and fewer maintenance requirements. It can operate with a wide temperature range. NiCd batteries have a number of benefits, including easy storage and transportation as well as a long lifespan. In addition, it can be generated in a wide range of sizes depending on performance.	It contains cadmium, which is a toxic metal and hard to recycle. For the same capacity, its cost is higher than that of a lead-acid battery. One of the big disadvantages of this battery type is the memory effect, in which NiCd batteries gradually lose their maximum energy if they are repeatedly recharged after being only partially discharged.
Nickel-metal Hydride battery	It is a rechargeable battery type in which the chemical reaction at the positive electrode is similar to that of the NiCd battery; however, its negative electrode employs a hydrogen-absorbing alloy instead of cadmium. Hydrogen ions are stored in a metal-hydride structure that is the negative electrode of the nickel-metal hydride battery. Polyolefin nonwovens are used as a typical material for the separator.	Similar to NiCd batteries, it is straightforward in transportation and storage. However, it is more environmentally friendly and less susceptible to the memory effect than a NiCd battery. In addition, it also gives higher energy per unit volume or weight than similar NiCd battery kinds.	It is more expensive than a NiCd battery. Its service life could be reduced if a deep discharge occurs. Aside from the limited service life, it has a high self-discharge rate, which is also affected by ambient temperature. In addition, it requires a complex charging algorithm.

Lithium-ion battery	Lithium ions move from the negative electrode to the positive electrode during discharge and back again during charging in this type of rechargeable battery. A lithium-ion cell's negative and positive electrodes are typically made of metal oxide and carbon, respectively. The lithium salt in an organic solvent serves as the electrolyte for Li-ion batteries. Li-ion batteries are one of the most popular rechargeable batteries on the market, with great sales.	Li-ion batteries are lighter than other rechargeable batteries in terms of battery capacity. Additionally, it has a very low memory effect and a high energy density. Compared to NiCd and NiMh batteries, it self-discharges at a much slower rate. It does not require maintenance because it is nearly unaffected by the memory effect. Additionally, due to its high energy efficiency, it is perfect for use in EBs.	It could be damaged due to overheating, overcharging, and over discharging. In addition, it requires protection to assure its safe functioning within its limitations. Aging is also one of the downsides of the Li-ion battery, which depends on the number of charge discharge cycles.
Lithium-ion polymer battery	It is a rechargeable battery type using lithium-ion technology. However, unlike Li-ion batteries, which use a liquid electrolyte between the negative and positive electrodes, LiPo batteries use polymers with high conductivity that are semisolids (gel) to form an electrolyte. In addition, the LiPo battery can use a solid polymer electrolyte such as poly (acrylonitrile), poly (vinylidene fluoride) (PVdF), or poly (ethylene oxide) (PEO).	It has a high energy density, is lightweight, and can be created in a wide range of sizes. Because a LiPo battery's charging capacity is not significantly reduced when compared to a Li-ion battery, its life span is longer. Aside from its high energy density and lightweight nature, it has good safety performance and can be used as an E-cycle power source.	The price of LiPo batteries is higher than that of Li-ion batteries. LiPo batteries have a lower energy density and cycle number than Li-ion batteries. In addition, it has no standard shape and requires specific attention during storage, charging, and discharging.

5. CONCLUSION

In this review, we get an idea of integrated system for modelling electric bike designs. It is ideally suited to the needs of the young, old, and disabled members of the economically underprivileged section of society. The fact that this e-bike can be used as an electric wheelchair as well as a bicycle and that it doesn't require expensive fossil fuels means that it is its most useful feature. It gives disabled people the chance to use an electric wheelchair with a front wheel attachment so they can move from one location to another without the aid of an outside helper. The use of a bevel gear in an electric bike for the transmission of motor power through a gear for propulsion.

6. REFERENCES

[1] https://www.innovacareconcepts.com/en/blog/power-wheelchair-types/

[2] Amos Winter, “Mechanical principle of wheelchair design”, Massachusetts Institute of Technology, US, retrieved on 24th Sept. 2010.

[3] N.M. Abdul Ghani, M.O. Tokhi, A.N.K Nasir, S. Ahmad., 2011. Control of a Stair Climbing Wheelchair 1 (4) 204-208.

[4] Sreerag C.S et al., “Design and development of conceptual wheel chair cum stretcher”, Ramaiah school Bangalore 2011-september.

[5] Abdal-RazakShehab, “Design and Implementation Electrical Wheel Chair for Disable able to Stairs Climbing by Using Hydraulic Jack”, IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), Volume 7, Issue 3 (Sep. - Oct. 2013).

[6] Ravikumar Kandasamy et.al., "Design of Solar Tricycle for Handicapped Person," IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Vol: 5, Issue 2, Jan-Feb. 2013).

[7] Iqbal Ahmed Khan, 'Motorized Wheel Chair for Physically Challenged Person', https://www.researchgate.net/publication/283436442 (2015).

[8] Arango, I.; Lopez, C.; Ceren, A. Improving the Autonomy of a Mid-Drive Motor Electric Bicycle Based on System Efficiency Maps and Its Performance. World Electr. Veh. J. 2021, 12, 59. https://doi.org/10.3390/wevj12020059.

[9] Mohammed Hassan Khan, Mohammed Habeeb Ullah Shareef, Md Jameel Ahmed Shakeel, Mohd Faiz Ahmed, Mohammad Umair Ansari, "Fabrication of E-Bike", International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 05 | May 2020.

[10] Vignesh. M, D. Mohan Kumar, K.Prithviraj, Reuban David. "DESIGN AND FABRICATION OF FOUR WHEELED ELECTRIC VEHICLE" (2018). International Journal of Pure and Applied Mathematics Volume 119 No. 12 2018, 10355-10361.2012.

[11] Huachun Han, Haiping Xu, Zengquan Yuan, Yingjie Zhao.,2014, "Modeling for Lithium-ion Battery used in Electric Vehicles," Key Laboratory of Power Electronics and Electric Drive, Inst. Of Electrical Engineering(IEE), Chinese Academy of Science(CAS), China, pp. 1-3.