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

Manikandan Murugesan[a*], M. K. Murthi[b]
[a*]Post Graduate Student, Department of Mechanical Engineering, Nandha Engineering College, Erode-638 052, Tamil Nadu, India
[a]ssociate Professor, Department of Mechanical Engineering, Nandha Engineering College, Erode-638 052, Tamil Nadu, India

ABSTRACT
In recent years, electric bicycles have become more and more popular, especially with older people. Due to the convenience of travelling from one location to another, people with impairments have recently begun to express interest in this device. The literature research informs us that there are different electric vehicles for people with disabilities and people without disabilities that have two or three wheels and are offered on the market. The idea of creating an integrated two- and three-wheel electric car as a single product is demonstrated in this essay. The proposed design might be utilised for multiple purposes by both normal people and people with impairments as a 3-wheeled vehicle with two wheels. It is now possible to construct an integrated vehicle after the development and testing of the electric vehicle prototype model. In this study, a wheelchair can be transformed into a two-wheel electric bicycle that a regular person can use, or it can be transformed back into a wheelchair.
Keywords: Electric vehicle; Wheelchair; Integrated; Development; Transformed

1. INTRODUCTION
In many nations, a move towards sustainable and active transportation has resulted in a rise in the use of electric bikes in recent years among all riders, mostly elderly people looking to combat air pollution and get some exercise. According to ongoing research, non-disabled people ride two-wheeled bicycles, whereas disabled people ride three- or four-wheeled bicycles. Knee discomfort, joint pain, and other musculoskeletal problems are common among riders over the age of 40. Hence, riders with and without disabilities use two-, three-, and four-wheeled cycles independently. In consideration of this, the current study proposes to create an electrically powered bicycle that can accommodate both the aforementioned disabled and non-disabled riders.

1.1 Background
The electrical wheelchair has already been the subject of much investigation. The classic electrical wheelchair might be an alternative to non-electric wheelchairs, but due to its high price and rider comfort, it is difficult for the user to travel vast distances since the user's posture puts too much strain on their back, shoulders, and neck. Because city life moves too quickly, this makes the rider dependent on others and causes them to pause when riding. We learned that it is possible to convert a conventional trike into an electric trike without the need for the rider to balance it after doing some research on electrical cycle conversion kits. Now, in order to ensure that the rider is as comfortable as possible and that their posture when riding the

vehicle does not put any stress on their bodies**[1].** Wheelchairs have advanced quickly throughout time, moving from manual wheelchairs to motorized wheelchairs. Yet, these wheelchairs are still unable to meet the demands of those with disabilities. So, it is crucial to comprehend the issues facing the disabled so that wheelchairs can be created to meet their requirements. The creation of a multi-purpose wheelchair that could carry out all necessary tasks led to the creation of this idea. A wheelchair is, to put it simply, a chair that is coupled to a frame with wheels. A wheelchair is a piece of equipment that can empower and allow a disabled person to live a normal, independent life by choosing the right kind of mechanism to lower the cost and perform effectively in a variety of operational circumstances **[2].** Wheelchair Connection in order to provide patients and persons with impairments with effective and simple transportation, wheelchair automation was developed. The attachment uses a system of metal rods and pipes that are intended to clamp onto the front wheelchair rods and attach to them**[2].** In this research, it is suggested that a mathematical performance model and a system efficiency map be combined to estimate the range of an electric bicycle. With the help of the aforementioned equations, a management approach is created that may choose the ideal level of assistance and chain transmission ratio, maximising range while preserving speed. Using computer analysis, the driving strategy was compared to several other driving methods. This made it feasible to determine how the recommended approach increased system range while consuming less battery power **[4].**It created a solar-powered wheelchair prototype and put it to the test using LAB VIEW. For monitoring purposes, this effort also used solar panels, an infrared sensor, a pulse sensor, temperature sensors, and a GSM system **[5].**This have suggested utilising an Arduino UNO board for a smartphone to power electric vehicles for people with disabilities. A mobile app was also developed to follow the location and guarantee a secure journey **[6].** It has created and put into use a voice-activated control system, sensors, and an electric wheelchair design. Disabled individuals use it for safe raids **[7].**This essay discusses the creation of an electric bicycle that recharges its battery by producing power through pedalling. E-bike suspension systems utilise redemption springer forks **[8].**Have developed an e-bike with a self-charging battery that can operate on both electricity and solar power. The suggested solution has the option of using an AC converter to charge batteries in an emergency **[9].**A design for transforming a hand-operated mechanical wheelchair into an electric one for people with disabilities. It makes getting from one place to another easier. The prototype has been applied successfully **[10].** It proposed a methodology for the selection of motor, battery, material, controller, and suspension for electrical vehicles **[11].** It has been developed an electric bike that can be driven both mechanically and electrically. The prototype model has two separate gearboxes. Also, the prototype model's appropriateness was confirmed**[12].**

1.2 Statement of Problem

The Statement of problem for the project is arrived based on the literature review is an integrated multi-functional electric cycle design is not implemented.

2.COMPONENTS USED

2.1 Mild Steel Square Pipe

MS Pipes may readily be welded and moulded into a variety of forms and sizes for use in pipelining and tubing since they are made of mild steel. Hence, the complete body frame of a vehicle is designed using MS square pipes, and mild steel with dimensions of 25 X 25 X 2 mm

square steel hollow section (1.43 Kg/M) as fig. 1 shows.

Fig. 1.*Mild Steel Square Body Frame Work*

2.2 Tyre

In order to transfer a vehicle's weight from the axle through the wheel to the ground and to provide grip on the surface the wheel travels over, tyres are ring-shaped parts that encircle a wheel's rim. The majority of tyres, including those for cars and bicycles, are pneumatically inflated units that also offer a flexible cushion to absorb stress as the tyre travels over uneven surfaces. For e-bikes, pneumatic tyres are used. Its functions include supporting the vehicle's weight, absorbing road shocks, transmitting transaction, torque, and breaking forces to the road surface, as well as preserving and altering the direction of motion. Tires are comprised of durable rubber and inflated with compressed air to perform these four fundamental tasks.Diameter of tyre is 400mm (Fig. 2).

Fig. 2.*Tyre*

2.3 Spur Gear

The gear's primary job was to transfer power from the back tyre shaft to the additional shaft while switching rotational polarity to accommodate the brush's need for anticlockwise rotation from clockwise spin. On the sides of the front and back wheels, it is attached (Fig. 3).

Fig. 3.*Spur Gear attached with BLDC Motor*

2.4 Sprockets

Sprockets of varying diameters have been used to transmit power acting as a spur gear varying speeds and torque to further shafts via chain drives. The sprocket of the rickshaw was selected. The smaller sprocket was selected from the cycle shop. In this prototype model, two sprockets are used in the front and rear wheels, which are connected to a BLDC motor in each wheel (Fig. 4).

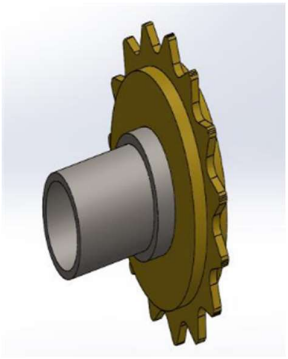


Fig. 4.*Sprocket*

2.5 BLDC Motor

Due to its permanent (long-lasting) magnets, electronic drive, lack of rotor twisting, lack of friction, lack of disturbance, and more consistent (uniform) torque, brushless DC motors (BLDC) are preferred over mechanically operated DC motors. In this prototype model, (Fig. 5) the front and back wheels are powered by two motors that are connected by a chain drive and sprockets.

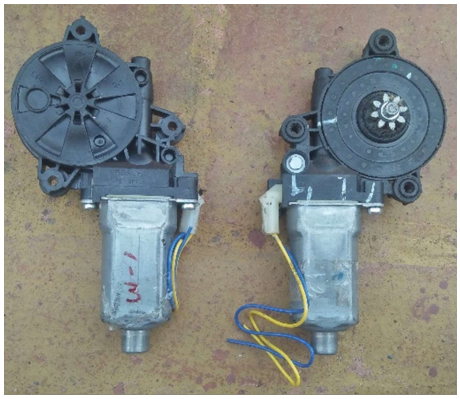


Fig. 5.*BLDC –Cardone 47-1383 Power Window Motor*

2.6 Battery

High-power lead-acid batteries are feasible, affordable, secure, and dependable. However, their employment is limited by their low specific energy, poor cold-temperature performance, short calendar, and short lifecycle. A battery is chosen using a power calculation, which considers the load. The lead acid battery used is a 12V/8AH battery (Fig. 6).

Fig. 6.*Lead-Acid Battery (12V)*

2.7 Chain Drive

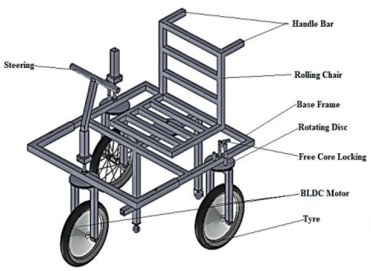
A chain is made up of a number of connected links that are fastened together by steel pins. A chain's strength, longevity, and efficiency at transferring rotary motion from one gear to the next are improved by this configuration. Chain drive has certain advantages over traditional gear, but its ability to transfer rotary motion over a long distance with only two gears and a chain outweighs these disadvantages. Traditional gear requires a complex mesh of numerous gears to transmit motion. There is a chain connecting the two sprockets. One of the sprockets is the driver's. The other sort of sprocket is called a driven sprocket. From one shaft to the next, the chain can transfer motion and force from one sprocket to the next.Power transmission chains are chains that are used to convey motion and force from one sprocket to another side of wheel (Fig. 7).

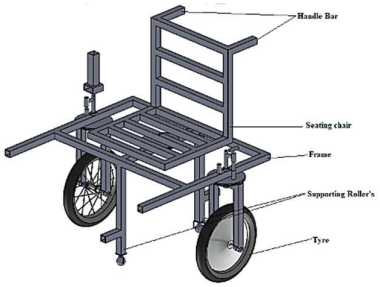
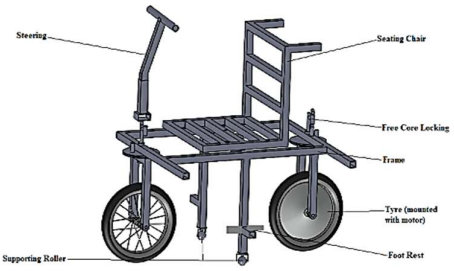
Fig. 7.*Chain Drive*

3. DEVELOPMENT OF PROTOTYPE MODEL

CAD Modelling is done using the SolidWorks 2017 software package.

Table 1.0. *Different views of Model*

3D MODELLING	DESCRIPTION	SPECIFICATION
	It is a tricycle. Those who are unable to walk can ride this kind of e-bike. Moreover, the e-tricycle system's front wheel is simply adjustable and removable.	1) Material type – Mild steel hallow section used.

Tricycle View	A BLDC motor's front wheel is fixed. The design cycle is drastically shortened for people with disabilities.	2) Tyre – Pneumatic tyre. 3) Dimensions of Tricycle = 830mm (L) * 965mm (B) * 900mm (H).
 **Wheelchair View**	A wheelchair is used to help someone who is unable to walk due to an illness, injury, old age, or handicap. Wheelchair users can sit comfortably in this setup.	1)Material type – Mild steel hallow section used. 2) Tyre – Pneumatic tyre. 3) Dimensions of wheelchair = 710mm (L) * 660mm (B) * 812mm (H).
 **Bicycle View**	Bicycle riding is accessible to all age groups. It's also an electric bicycle with a BLDC motor in the back wheel. Simple is the design.	1)Material type – Mild steel hallow section used. 2) Tyre – Pneumatic tyre. 3) Dimensions of wheelchair = 660mm (L) * 950mm (B) * 900mm (H).

The above table 1.0 shows a different views of prototype model developed by using CAD software with description and specification.

4. WORKING MECHANISM



Fig.8.*Electric Tri-cycle Model***Fig.9.***Electric Bi-cycle Model***Fig.10.***Wheelchair Model*

- ✓ **AN ELECTRIC TRI-CYCLE**IS RIDDEN BY A PERSON WHO IS UNABLE TO WALK; THEY CAN USE THIS KIND OF E-BIKE (FIG. 8). WITH AN E-TRICYCLE, THE FRONT WHEEL MAY BE SIMPLY ADJUSTED AND REMOVED. FOR THE RIDER'S SUPPORT, THE BLDC MOTOR HAS A FIXED FRONT WHEEL. THOSE WITH IMPAIRMENTS WILL APPRECIATE THE CYCLE'S DESIGN. THE FRONT WHEEL IS SIMPLY ATTACHED AND DISENGAGED, AS DEPICTED IN FIG. 11.

- ✓ **AN ELECTRIC BICYCLE**CAN BE USED BY RIDERS OF ALL AGES. AND THE BIKE HAS A BLDC MOTOR AT THE BACK WHEEL (FIG. 9). HERE, CYCLISTS CAN OPERATE AN E-BIKE WITH A LOW SPEED AND A FOOT REST FOR SAFETY. FOR INEXPERIENCED RIDERS, THE BIKE'S DESIGN IS INCREDIBLY STRAIGHTFORWARD. FIG. 12 DEMONSTRATES HOW TURNING A WHEELCHAIR'S WHEELS UP TO 90 DEGREES WOULD TRANSFORM IT INTO A BICYCLE.

- ✓ **A WHEELCHAIR** IS USED TO HELP SOMEONE WHO IS UNABLE TO WALK DUE TO AN ILLNESS, INJURY, OLD AGE, OR HANDICAP (FIG. 10). A WHEELCHAIR CAN BE BALANCED SO THAT A DISABLED PERSON CAN RIDE SAFELY. WHEELCHAIR USERS CAN SIT COMFORTABLY IN THIS SETUP. FIG. 13 ILLUSTRATES HOW REMOVING THE FRONT WHEEL ALLOWS A TRICYCLE TO BE TRANSFORMED INTO A WHEELCHAIR.

FIG.11. *FRONT WHEEL ATTACHMENT*

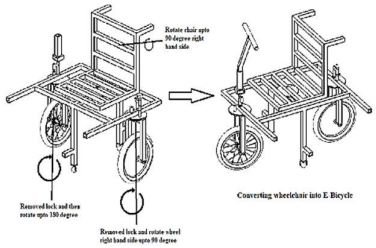


Fig.12.*Bicycle wheel Rotation (90 Deg.)*

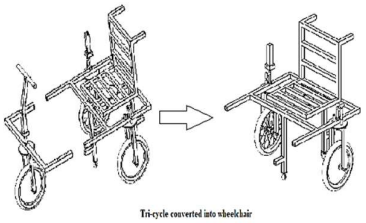


Fig.13.*Wheelchair Detachable Wheel*

5. CALCULATION

5.1 Calculate range of Lead Acid battery (Ampere)

Let's consider to run vehicle with 12V, 80 Watts BLDC motor.

Step-1: Find out the current (in amps) consumed by the motor to run?

Power (P) = Voltage (V) * Current (I)

80 W = 12V * I

I = 80 / 12 => 6.66 Amps (Theoretical)

Here, to run an 12V, 80 W BLDC motor required minimum 6.6 Amps (i.e., 7 Amps).

Step-2: Find out the Watts hour of the battery?

To run the 80 W motor for 1 hour,

80 W * 1 hr = 80 W.hr.

Let us take efficiency of 80% for battery (remaining 20% remains to charge the battery). Then,

80 W.hr. / 0.8 = 100 W.hr.

(Should be take above W.hr. capacity required)

Step-3: Convert Watt hour of battery into Ampere hour of battery?

Power = Voltage * Current

Watts. Hour = Voltage * Ampere hour

100 W.hr. / 12 V = 8.3 Amp. Hr.

Here, Maximum required to run the 80 Watts motor for 1 hr. needs 12V, 8 Amp. Hr. Lead Acid battery is needed.

5.2 Stress & Strain calculation

Let's, take Max. load = 60kg => 589 N, Area = L * B = 0.985m * 0.835m => 0.822475 mm^2.

- Stress (σ) = Load / Area

= 589 / 0.822475

σ = 716.13 N/m^2.

- Strain (ε) = Stress (σ) / Young's Modulus (E)

= 0.00071613 / ($2*10^5$)

ε = 3.6 * 10^{-9}.

5.3 Torque calculation

Torque (T) = Radius of wheel (r) * Force (F) * sin θ

Where,

Force (F) = Mass (m) * Acceleration (A)

(Mass = 60 kg, 4

Acceleration (A) = (Final velocity – Initial velocity) / Time => (0.2-0) / 60 = 0.0033 m / sec)

F = 60 * 0.0033

F = 0.2 N

Then, T = 0.15 * 0.2 * Sin (90°)

T = 0.3 Nm.

5.4 Motor RPM calculation

Vehicle speed = (Wheel RPM * Tyre Diameter * π * 60) / 1609.34

2 = (RPM * 0.30m * π * 60) / 1609.34

RPM = 56.9 (i.e., equal to 60rpm).

5.5 Gear Ratio calculation

Gear Ratio = No. of teeth in driving gear / No. of teeth in driven gear

= 18 / 36 => 1 / 2

Gear Ratio = 1: 2.

6. RESULT AND DISCUSSION

THE TESTING OF INTEGRATED E-CYCLE, WE HAVE CALCULATED THE CYCLE PERFORMANCE IN A DIFFERENT LOAD CONDITIONS AS SHOWN IN BELOW TABLE 2.0.,

TABLE 2.0. *PERFORMANCE IN DIFFERENT LOAD CONDITIONS*

S.NO	LOAD (KG)	RUNNING SPEED(RPM)	CURRENT (A)	VOLTAGE (V)	POWER CONSUMPTION	RUNNING (KM)
1	10	60	5.0	12	60 W	2.5
2	20	57	5.3	12	63.6 W	2.3
3	30	54	5.7	12	68.4 W	2
4	40	50	6.1	12	73.2 W	1.7
5	50	46	6.5	12	78 W	1.3

FROM ABOVE ANALYZING TABLE CLEARLY, IT SEEMS THAT THE EFFICIENCY IS CONTINUOUSLY REDUCING WHEN A CYCLE CARRIES THE EXTRA LOADS AND POWER CONSUMPTION ALSO INCREASING. HENCE, AS THE RESULT DEPENDING UPON LOAD, MOTOR CAPACITY, BATTERY POWER ACT AS A MAJOR PORTION TO IMPROVING PERFORMANCE OF E-CYCLE.

7. CONCLUSION

The development and testing of electric wheelchair and vehicle prototypes with two and three wheels went smoothly. The prototype bicycle has a carrying capacity of 50 kg and a top speed of 2 km/h. A successful integrated, multi-functional electric vehicle has been created as a result. Future improvements can include a hub motor in place of a BLDC motor, a solar panel for backup power, sensors, and lightweight materials to increase efficiency. As a result, this kind of integrated electric bicycle can be utilised by elderly people as well as people with disabilities in places like residences, parks, and hospitals.

References:

1] Vikas Singh, Viraj Chaudhary, RavinKanojiya, Deepak Yadav, Jayant Patil; "DESIGN AND FABRICATION OF ATTACHABLE WHEELCHAIR AUTOMATOR"; International Research Journal of Engineering and Technology (IRJET); Volume: 09 Issue: 04, April 2022.

2] PrafulRandive, Arvind Chaudhari, Biswajit Das, DevanandKatre, PramodPardhi; "DESIGN AND FABRICATION OF TRI-WHEEL MULTI–OPERATIONAL STRETCHER – CUM – WHEELCHAIR"; International Research Journal of Modernization in Engineering Technology and Science; Volume:04/Issue:06/June-2022.

3]Aslam S. Shaikh, Sachin N. Gaikwad, Mahesh R. Patil, Ragunath T. Bandgar; "HANDCYCLE ATTACHMENT FOR WHEELCHAIR- A EVALUATION"; International Research Journal of Modernization in Engineering Technology and Science;Volume:03/Issue:02/February-2021.

4]Ivan Arango , Carlos Lopez and Alejandro Ceren; "IMPROVING THE AUTONOMY OF A MID-DRIVE MOTOR ELECTRIC BICYCLE BASED ON SYSTEM EFFICIENCY MAPS AND ITS PERFORMANCE"; World Electric Vehicle Journal; Volume:12, Issue:59, Year:2021.

5]M. Srilatha, K. Saketh, V.Sampath Kumar. B. Naveen Kumar;"MODERN ELECTRIC WHEELCHAIR WITH HEALTH MONITORING SYSTEM USING LABVIEW"; International Journal of Advanced Science and Technology; Volume:29, Issue:05, Year: 2020.

6] K. Prahlad Rao, Bader DakhilallahSamranAlrashdi and Naif D. Alotaibi; "SMART NAVIGATION AND CONTROL SYSTEM FOR ELECTRIC WHEELCHAIR"; American Journal of Engineering Research (AJER); Volume-8, Issue-4, 2019.

7]Sania Sheikh, Alfiya Sheikh, Abhishek Waghmare, Ankit Yadav,ShubhamBhoyar, Chetanadolase; "DESIGN AND CONSTRUCTION OF ELECTRIC DRIVE -A SMART SYSTEM FOR DISABLED PERSON WITH THERAPY FACILITIES"; International Research Journal of Engineering and Technology (IRJET); Volume: 05 Issue: 03 | Mar-2018.

8]Yashwant Sharma, Praveen Banker, YogeshRaikwar, Yogita Chauhan, Madhvi Sharma; "R&D ON ELECTRIC BIKE"; International Research Journal of Engineering and Technology (IRJET); Volume: 05 Issue: 02 | Feb-2018.

9] Deep R Prajapati, KunjanShinde, Abhishek Mhaske, AniketPrabhu; "DESIGN AND FABRICATION OF ELECTRIC BIKE"; International Journal of Mechanical Engineering and Technology (IJMET); Volume 8, Issue 3, March 2017.

10]Emiliano Galvan, Guillermo Gonzalez, Guillermo Hernandez, Santiago Manon, Hiram Ponce; "ELECTRIC WHEELCHAIR MODULE: CONVERTING A MECHANICAL TO AN ELECTRIC WHEELCHAIR"; IEEE Mexican Humanitarian Technology Conference (MHTC); 2017.

11]N. Pavan Kumar Reddy, K.V.S.S Vishnu Prasanth; "NEXT GENERATION ELECTRIC BIKE"; IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI); 2017.

12]C. Abagnale, M. Cardoneb, P. Iodicea, R. Marialtoc, S. Stranoa, M. Terzoa, G. Vorraro, "DESIGN AND DEVELOPMENT OF AN INNOVATIVE E-BIKE", Energy Procedia 101 (2016).