VOL. 14, NO. 15, AUGUST 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DESIGN AND IMPLEMENTATION A SMART SEAT FOR HANDICAP PEOPLE

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ABSTRACT

Wheelchairs are seen as an important means of rehabilitation as they enable the disabled to move and exit from the isolation that can be imposed by his inability to move because of his paralysis or loss of legs or other disabilities as well as with the use of Illnesses and the elderly. The use of wheelchairs depends on the degree and the type of disability. The more the disability affects the movement of the individual whenever the need for chairs is necessary. The current smart wheelchairs move strongly with electric motors without the need for someone else to push the chair or mechanical motor causing pollution to the environment with high noise and higher maintenance than its electric counterpart. The current research, the electric seat is powered using 220 ACV electric source to charge two batteries (12 VDC, 18-35 A/hr.) to supply 24 VDC input voltage for the electronic chopper (DC to DC voltage converter) as a source to DC motor type DG-168A1 which has a good and suitable specification: 24 VDC, 125watt, max drawn current 4.5 Ampere with maximum rotation speed 140 rpm. The classical mechanical energy by using his self-hands of the disabled is to move the wheel chair. In addition, two additional kinds of electronic devices are used for developing the control process. The second control device is electric battery charger which is used to adjust the two DC motors speed. Third control device is to regulate the sound signals to run the two DC motors. The wheel chair was tested in the University of Diyala/ Baaquba / Iraq on flat and tilted land steady state linear speed reached more than 0.9 m/s with a maximum weight was more than 100 kg. The design is subject to real electrical and mechanical engineering tests alongside using decades of applied equations on wheel chair to validate the experimental tests.

Keywords: design, smart seats, handicap.

1. INTRODUCTION

The, design of the disabled chair is not easy process. It takes a lot of considerations, in addition to the cost and efficiency of the application and the overall weight. The choice of metal is appropriate for each part of the chassis according to the degree of stress which is exposed to. The electrical components of the chair are divided into two parts: the first relates to the power system of the chair and includes the electric motors with the system of the gear-box each and this is called the electric traction. The electric traction system in the chair needs electric energy that may be continuous or alternating depending on the type of motor used whether it is running with a continuous feeding system such as DC motors or if the motor operates with alternating feed system, as in the motors of single and three phases. The chair is equipped with a battery system with an electric battery truck. In order to operate the electric motors in the chair, the inverter is used to transfer and control the voltage fitted to the used motors, whether continuous or alternating [1].

The most important features of electric traction machines used in moving machines, elevators and belts, including the chair of the electric impedance is the torque and speed of the motor, which must take into account the weight of the driver with batteries, two motors, gears and the metal chassis. The determination of stillness still starting and stability motion of the motor play a vital role in estimating the electric power of the motor, weight of the chair and thus the cost [2]. The electrical design equations for the traction motors will be used in the current search of the real designed chair and factory.

The following researchers have developed models for smart seat for handicap system. The first formulation was made by Richard Miller (2004) [3] and [4]. He designed the Smart Wheelchair Component System (SWCS). He did interface with wheel-chair from many different manufactures. This design criteria on wheelchairs with motor controllers and guide the directions of wheel configuration with both a traditional joystick and a switch joystick.

The results from this design was tested that the SWCS can hold - up of ways of obstacles, wall following and door passage. The results also proof that different behavior of configuration of the control. The SWCS uses in school, help nursing home and living facilities.

Mr. D. Satish Kumar and E. Dhinakaran. V. Gohul, P. Harisankar [5] presented in 2017 a simple wheelchair system for isolated words to control the motion of an electric motorized wheelchair for handicap people. They design a wheelchair used in the hospital etc.., the design reduced the cost to perform the required by taking minimum time. They used their wheelchair for old age people, handicap people. In proposed design focuses the wheelchair into advanced wheelchair system.

Jesse Leaman, and Hung M. La in 2017 [6] designed a smart wheelchair (SW) to become available on a mass scale that was a advanced from the manual wheelchair. They developed several prototypes; the system can be used for many people who need PWs. The manufactures of electric chair are in position to produce a stand-alone SW. They developed a model may take into account sensor feedback, as from Emotive sensors and various sensing sensors such as laser scanners, cameras

ARPN Journal of Engineering and Applied Sciences

and global position system and they ensured that SW will be used for million people who they are handicap.

Youcef Touati and Ali Cherif in 2012 [7] developed a new system uses for disable people based on technologies with reference to user's needs. They designed a control architecture for smart wheelchair SW monitoring according to gain mobility and independency. The control based on external force –feedback joystick to translate the distance between the wheelchairs and obstacles. They allow to connect a reliable remote with obstacle in a constrained taking into account systems interactive. They proved in their result that the increasing of perceived efforts, from sample 3000, to 1000 corresponding to displacement and these efforts tend to oscillate between 1200 and 25 according to X and Y- axis.

Jolle, Robert, Amin, Julien and Francois in 2011 [8] developed an intelligent wheelchair that minimizes the physical and recognize load required in steering it. It is main to have check the wheelchairs of performance and safety. They suggested a paradigm that permits to use this test to the quality of intelligent wheelchairs and is relative to clinical practice in rehabilitation on situations occurring in the daily lives of wheelchair users. In this sense, a rigid valuation is decisive step for both establishing and gauging of intelligent wheelchair.

Robit Mittal and Dinesh Hoyal in 2014 [9] designed a smart chair based on computer system with infrared sensors and RGB-D Kinect camera to develop of obstacle avoidance, automatic wall following and door passage. They designed for different operating levels ranging from simple obstacle to fully autonomous navigation. The chair had a little of sensors on its side and does not have sensors on its back.

Takashi Gomi and Ann Griffith in 1995 [10]. They presented and designed a series of intelligent wheelchairs based on readily available power chairs which have been well-engineered over years. The approach was to be found sufficient on-board autonomy at low cost. The system has been designed and tried on two common power wheelchair models. One of the chairs is now able of roving to its indoor using land-mark navigation.

Mohammed Asgar, Mirza Badra, Khan Irshad and Shaikh Aftab in 2013 [11]. They designed a smart wheelchair in sensors, ultrasound and radar has proved for electronics traveling aids (ETAs). These devices are used by blind and physical peoples and they used belt and binaural sonic, NAV guide cane, electric wheelchair control by joystick, voice and eyes movement. They proposed an automated innovative wheelchair controlled by moving of neck position of person. The user can give just four orders signals to the wheelchair and that are start, stop, right and left with rotation by360^o. They designed a wheelchair to help poor people who they can buy them.

Deepak Kumar Lodhi, Prakshi Vats, and Addala Varun in 2016 [12]. They designed a smart, motorized, voice-controlled wheelchair by using established system. They represented the voice-controlled wheelchair for handicap by voice command is transferred and converted to string by voice control and the voice instruction is given through a cellular device having Bluetooth is connected to Arduino board for the control of the wheelchair. The system was designed to save time, cost and energy of the patient. As the person switches for the circuit to be moving, the obstacle which is predictable to lie within of 4 meters by the Ultrasonic sensor to help and older and handicap people.

Prof. Vishal V. Pande, Nikita S. Ubale, and Darshana P in 2014 [13]. They developed a wheelchair control is useful for handicap people with moving hands or hand gesture recognition using acceleration technology. The wheelchair can be controlled by simple hand gestures. When it changes the directions, the sensor register is changed and are giving to microcontroller, the microcontroller controls the direction of the chair as Right, Left, Back and Front.

2. DESIGN OF HANDICAP

The handicapped chair consists of three engineering components: mechanical, electrical and control. Mechanical components [14]. The structure of an ordinary metal chair is a four-pointed cube with a stretch from the front legs of the chair so that the disabled person can place both feet on the armrest, providing stability to the back of the chair. The back rest of the chair is covered with leather and sponge that allows the user to turn back side rests of the chair to the right and left of the chair also covered with compressed sponge with the skin and may contain extensions to carry the catches and keys. The dimensions of the chair are determined according to the size and weight of the user. There are several types, including a small chair suitable for children, a chair suitable for young people of medium size, a chair suitable for adults with sizes and weights.

Steering wheelchairs by voice commands is the latest in the world of manufacturing devices for the disabled. The dumb also can 'hum' to move their chairs: Some victims of paralysis have to spend the rest of their lives in a wheelchair, and common wheelchairs are nothing more than a prison to be added to the prison. But disability research centers have developed wheelchairs to provide greater embarrassment to the victims.

Backbone injuries are one of the most important causes of paralysis, which leads to sever nerve link between the brain and muscles in the limbs, so that the muscles are unable to move, and confirmed injuries to the backbone caused by car accidents, leading to paralysis in many cases. Paralysis is due to damage to the spinal cord caused by a backbone injury. The spinal cord is the part of the nervous system located within the cavity of the vertebrae, which is the backbone, which is the connecting link between the brain and the limbs. On the other hand, the spinal cord was cut off between the brain and one or more limbs.

The person sitting on the chair will apply force distributed downwards depending on the total weight mounted on four tires. There are many opposite forces such as friction between the four tires and the ground, wind resistance and inclination [14] and [15]. In order to overcome this friction, a starting force must be available to

ARPN Journal of Engineering and Applied Sciences

move the standstill overall mass to the steady state speed which is called the force of inertia. As is known, force is the determination of that torque, the starting torque for moving the chair must be at least 1.5 times as much as the rated torque required to move the chair at its steady state rated speed. The horizontal starting torque in the linear motion and the rated steady state torque of the chair are originally run by using two Direct Current Motors (DCM) associated with the gear box at each rear left and right sides of the chair.

These two left and right gear boxes are attached to the right and left rear tires. The electric calculations to find the right motor ratings to generate the appropriate starting and rated torques and will determine the efficiency of the linear speed and the appropriate acceleration to start from the standstill with the person as the vertical load.

From this short introduction we note that the connection between the speed / electric torque of the DC motor will be shifted by the gear box to the two rear tires of the chair to starting torques towards forward or backward or twist to the right or left of the chair i.e. achieve the four movements required. These facts represent the principles of the chair design. There are many forces opposite to the main force of movement of tires, one of them is called the friction force which is constructed between the four tires and the earth with the presence of the user as a vertical load. The contact zone between each tire and the earth will distort the area between them until it becomes flat, generating a force equal to the total weights of the person, chair metal frame, batteries and accessories.

A. Analysis and study of flowchart design

The person seated on the chair will generate force downwards which is being concentrated regularly on the chair seat. The seat is mounted on four vertical pillars are connected with four tires. The four tires are subjected to the weighted force that is distributed on them and oriented down. The force downward effect on each tire will lead to the creation of a contact flat layer between each tire and ground. The frame is made of flexible elastic material that can be stretched and changed according to the pressure on which it is designed. Therefore, the starting movement of the tire from the static will opposite the friction force between the tires and the ground. This force depends on the surface area and the coefficient of friction between the earth and the material of the tires. If the moving force of the tire overcomes the force of the opposite friction, the tire will gain acceleration that will accelerate its movement to the required stable speed.

The full engineering design of the chair is clarified in real flowchart is as shown in Figure-1 The design starts first with an initial knowledge of the weight of the seat with the addition of weights such as batteries and the chassis with the two DC motors and their gear-boxes. The starting torque of the chair from the static as well as the stable speed of the virtual chair are also important information required in the construction of design in the performance calculations of the two DC motors in the chair with the gear boxes each.

The mathematical equations for each of the performance of the two DC motors with the total weight lies in the field of engineering electric machinery traction so it must be familiar with the choice of suitable motor, taking into account the issue of cost for the success of the design.

In contrast, the design equations in the analysis of the mechanical stresses that are affected on the metal structure beams are classified to five basic mechanical stresses such as pressure, tensile, bending, shear and torsion.

As shown in the flowchart, the two electrical engineering and mechanical designs have two possibilities: failure or success. The failure of mathematical tests means restoring the assumptions, whether electric, such as the ability and torque and speed of the motor or mechanical, such as the type of material and dimensions of the metal used in the construction of the chair structure to match with the basic stresses.

The next stage after the success of the mathematical design is to move to the stage of building the metal structure of the chair by choosing the metallic beams with mathematical dimensions. The welding, fixing of the four tires, the seat, the back and the installation of the two DC motors were carried out as well as the batteries.

Finally, electronic devices such as the joystick, the sound recognition device and the Arduino controllers are installed in a location away from direct dust and heat and not affected by vibration shocks. All these articles relating to the stages of design and construction of the chair on the ground have been represented in the scheme of the flowchart below.

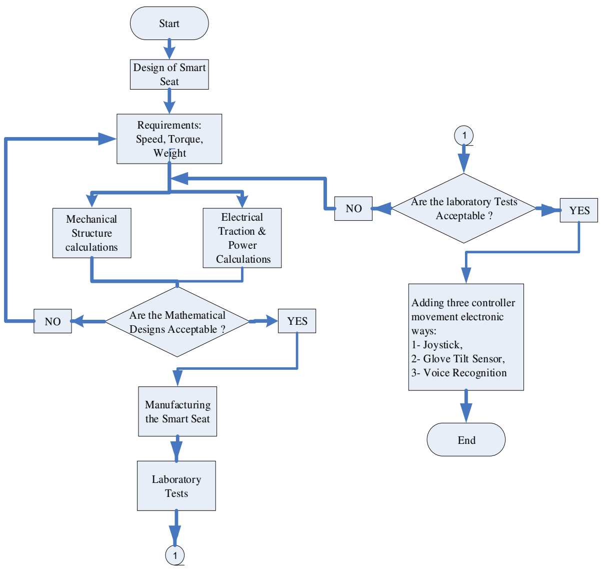

Figure-1. Flowchart of the handicap design.

3. THEORITICAL MODEL

The necessary traction force on the wheel [16] is given by (1).

$$F_t=F_a+F_r \quad (1)$$

The slope of the road is determined by (2).

$$F_t=F_a+F_r+F_g \quad (2)$$

VOL. 14, NO. 15, AUGUST 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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A. Acceleration force

The acceleration force required for moving the chair is given by (3).

$F_a = m_w * a$ (3)

Using mass factor can be substituted for additional mass is determined by (4).

$F_a = me. a = (We / g) a$ (4)

B. Resistance force of handicap

The resistance force [17] to the chair is calculated by (5).

Fr = m(kg) * r (Newton / kg) = m*r (5)

C. Force of gravity

The force of gravity is expressed by (6).

$F_g = W \sin\Theta = m. g. \mathrm{Sin}\Theta$ (6)

The road slop is expressed by (7). The force of gravity cab be identified again by (8)

$C\% = (Y / X). 100 = 100 \sin\Theta$ (7)

$F_g = m. g. C$ (8)

D. Force per tire

The total force which are applied on the four tires can be determined by (9) and (10).

$F_t = F_a + F_r + F_g$ (9)

$F_t = m_e. a + m. r + m. C$ (10)

E. Power per tire

The power needed for moving the tires is given by (11).

$P_o = F_t. V$ (11)

The power of the electric motor is calculated by (12).

$P_m = P_o / \eta = F_t. V / \eta$ (12)

F. Mechanical chair movement

All the relation among the torque of the electric motor, total force and gear box ratio are calculated by (13) to (16).

$T_m = F_1 * (d_1/2)$ (13)

$T = F_t * (D/2) = \eta\ F_t\ (d_2/2)$ (14)

$F_t = F_1 * \eta * (d_2/D)$ (15)

$F_t = \eta * F_1 * (d_2/D) = \eta * 2T_m/d_1 * (d_2/D) = 2\ \eta\ \sigma$ (16)

total traction force (10) can be modified by (17).

$F_t = \mu\ m_e. a + m. r + m. C$ (17)

4. ELECTRICAL TESTS AND CALCULATIONS

A. Electrical motor and loading

Traction force (F_t) is dependent on the mass (*m*) of the chair and its acceleration (*a*) for moving it from zero to max speed during limited time. The required traction force needed to drag the chair can be determined using (18). The DC motor used is shown in Figure -2.

F_t=m (Kg*) **a** **(**Km1000/hr*3600/sec.) (18)

Figure-2. DC motor for handicap traction and its name plate.

From the experimental tests, it is found the mass of present vehicle with the driver equal 125 Kg, the acceleration (a) is tested to be less than 2 Km/hr/sec.
Then, the calculated traction force using (18).

F_t=125Kg*2(1000/3600) =69.44 N

The power required to drag the chair (P_t) can be identified using (19) where the power is dependent on the traction force (F_t) and steady state speed of the chair (v).

$P_t = F_t(N) * v(m/sec.)$ (19)

The required traction power of the motor can be calculated using (2).

P_t= 69.44N* 40km/hr(1000/3600) =771.55 Watt

B. DC/AC Inverter

The electric DC/AC inverter used is open loop that means the control of the output AC voltage is proportionally with the required motor speeds as highlighted in the practical tests on the chair.

C. Batteries

The inverter DC/DC needs 48 VDC in its input terminals so that four batteries each 12VDC, 14Ahr are connected in series. There are two batteries are connected in series to deliver the DC-DC inverter by 48VDC. The capacity of each battery used is a round 14A.hr which is considered balance in terms of energy, cost and weight.

VOL. 14, NO. 15, AUGUST 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

D. Mechanical gear box

The linear velocity and angular rotational speed of the gear box shaft can be represented by (20) and (21).

$V_t=2\pi r.\ \omega_t$ (20)

$\omega_t\ D=\omega_2\ d_2$ (21)

5. MECHANICAL TESTS AND CALCULATIONS

A. Bending stress calculations

The force which is measured at the centre of the beams is calculated by (23).

$F_w=m_w*a_g$ (23)

$F_w= 125\ *9.8=1225$ Newton

The bending stress is estimated by (24).

$\tau_b=F_b/A_b$ (24)

B. Shear stress calculations

The axial total force F_s causes axial shear stresses on the shafts of four tires (25).

$\tau_s=F_s/A_s$ (25)

Figure-3 shows the overall dimensions of the designed chair according to the mathematical calculations. Figure-4 shows the final real handicap during the manufacturing processes.

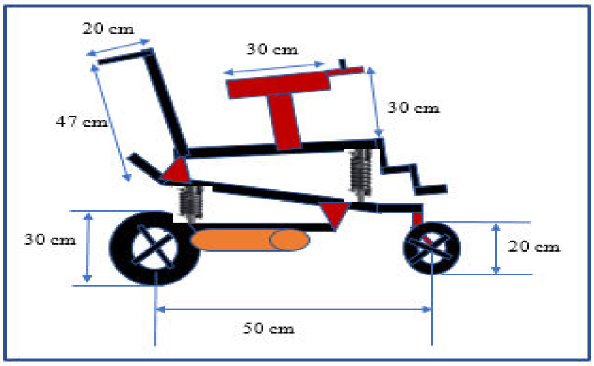

Figure-3. Layout of handicap design.

Figure-4. Manufactured handicap.

6. RESULTS AND DISCUSSIONS

The practical results are shown in Table-1. The power drawn is given by (26) and output power by (27

$P_{in}=V_L\ I_L$ (26)

$P_{mo}=T_{sh}\ \omega=\eta_m\ P_{in}$ (27)

From Table -1, by (26), [5] and [7].

P_{in}=23*4.5=103.5 Watt

Corresponding to test9, P_{in}=363.6 Watt.

P_{in}= 456.72 W for test 3. Then, efficiency of the DCM can be assumed 90%.

By return to (27), and using (20) and (21), the torque produced is

$0.9*456.72=2\pi*1500/60\ *T_{sh}$

T_{sh}=2.6 N.m

Table-1. Practical values.

Test No.	DC Volt	Chair Speed (km/hr.)
1	1	5
2	2.5	11
3	4	17
4	8	38.5
5	10	53.1
6	13	71.4
7	17	90
8	20	108.6
9	21	119.8
10	23	120.6

7. CONCLUSIONS

The smart seat of handicap, which was designed according to the applied engineering equations and manufactured in private workshops for researchers, is an excellent step in keeping up with the global technologies in the field of smart seats. Electric design using electric traction machines is a type of DC motors with a small rating of 144 watts per DC motor and using only two small batteries of energy 18 A.hr each is a suitable design in terms of weight, cost and efficiency. So that the electronic devices used by the type of PIC controller only three devices with suitable price and appropriate weight as well as acceptable efficiency can be developed in the future. Especially special electronic recognition sound device can be developed in future by adding a band pass filter to the voice stage to be more efficient, which will increase the speed of access of the signal to the DC motors at a lower time and a signal pure noise-free voice signals surroundings the smart seat.

ACKNOWLEDGEMENTS

This work was supported by University of Diyala/ College of Engineering /Electrical Power and Machine Department.

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