# DEVELOPMENT OF A PROTOTYPE FOR MOTORIZED WHEELCHAIR WITH ADAPTATION MECHANISMS OF SIMPLE AND EASY HANDLING AUTOMATION

**Samuel Franco do Nascimento, samuduff@hotmail.com**
**Keyll Carlos Ribeiro Martins, kmartins@ifma.edu.br**
Department of Mechanical and Materials, Federal Institute of Education, Science and Technology of Maranhão, Avenue Getúlio Vargas, 4, Monte Castelo – CEP 65000-000, Sao Luis, MA, Brazil.
**Lídia Santos Pereira Martins; lidiamsp@gmail.com**
Department of Chemistry and Biology, State University of Maranhão, University City Paulo VI - Tirirical Avenue S/N, Tirirical -CEP 65055-970 - Sao Luis, MA – Brazil.
**Jean Robert Pereira Rodrigues; jrobert@ifma.edu.br**
Department of Mechanical , State University of Maranhão, University City Paulo VI - Tirirical Avenue S/N, Tirirical -CEP 65055-970 - Sao Luis, MA – Brazil.
**Rubens Soeiro Gonçalves, rsoeirog@hotmail.com**
Department of Mechanical and Materials, Federal Institute of Education, Science of Technology of Maranhão, Avenue Getúlio Vargas, 4, Monte Castelo – CEP 65000-000, São Luis, MA, Brazil.
**Hellen Cristina Silva Pires, hellen_pires@hotmail.com**
**Vitor RenatoPereira Santos; victor_renatu@hotmail.com**
**Nirral Morais de Abreu; nirral@hotmail.com**
Department of Mechanical and Materials, Federal Institute of Education, Science of Technology of Maranhão, Avenue Getúlio Vargas, 4, Monte Castelo – CEP 65000-000, São Luis, MA, Brazil.

***Abstract***. This work deals with the modification of a mechanic and manual wheelchair by adapting a system of automatic engine, electric motor powered by batteries connected to it, without wheelchair ergonomics changes. The drivability of the engine locomotive control device is accomplished through the easy handling joystick. The wheelchair is included in the class of products of medium technological complexity, for this reason it is not only the designer's responsibility to develop techniques or mastering such technology because it involves the participation of professionals from various fields to solve the problems arising from the project. Moreover, for the wheelchair prototype construction, cheap materials were used in order to make the final price more accessible to disabled people from all social classes. Another important aspect is the automated vehicle maintenance, which is relatively simple, what makes the project feasible and effective, because it meets the expectations of users in terms of technological innovations.

***Keywords****: Ergonomics, Wheelchair, Electric Motoring.*

## 1. INTRODUCTION

Formerly the physically disabled people, with the upper body parts working, had to spend their life on a rough and ugly tricycle. The necessary requirements to physical rehabilitation advances have resulted in the technical improvement design, construction and also the wheelchairs materials (LIANZA, 1994).

In an attempt to help a the disabled person, technology has created objects that they can use to overcome their difficulties. Also, technology itself has enabled considerable progress to the wheelchairs models, as we see all kinds serving the diverse needs.

The wheelchair is a resource used to meet the limited mobility of disabled people, contributing as a tool for independence, socialization and continuity of life, as it is stated by the Information System of the National Coordination for the Integration of Persons with disability, see Brazil (2009).

According to Pierson (2001) the need to use a wheelchair as the primary means to move, requires that the equipment fits the individual properly aiming to promote maximum functionality, stability, comfort, safety and protection of body structures.

According to Masters (2003) the wheelchair must indirectly encourage functional independence, but relevant aspects should be considered, such as: size and weight, safety, method of propulsion, diagnosis, prognosis and cost, to ensure perfect adaptation of the patient on his wheelchair, making it essentially functional.

The existing models of wheelchair can be divided by a differentiation based on the level of technology present in each product. Barroso Neto (1982) states that the products are classified as low, medium and high technological complexity.

The wheelchair can be pulled manually or motorized. The manual low technological complexity wheelchairs can still be classified as mechanic manual wheelchairs , which require human power to drive and can be propelled either by an assistant or the user. This type of chair has large rear wheels, 20 to 26 inches in diameter that resemble bicycle

wheels. Along with these rims wheels are coupled with the slightly smaller diameter wheels that allow propulsion of the wheelchair by the occupant's upper limbs.

The technological medium grade wheelchairs are called electromechanical; the motorized wheelchairs belong to this group, which typically use DC motors with outputs close to 1cv.

According to Alvarenga (2002) the choice of this type of motorized chair must take into account both the sensory and motor skills of the user, also his desire to move independently. The wheelchair can compensate the deficiencies of the user related to propel the vehicle; however the user must have a spatial sense and cognitive factor that allows the use of the vehicle.

This research aims to develop a motorized wheelchair for easy handling, with no complex technology and especially low cost, which has its cost estimated in 30% compared to the current commercialized motorized chair. The motorized wheelchairs sold in local market are unaffordable to people with disabilities and they have sophisticated technological resources, sometimes unnecessary to the wheelchair.


(a) (b)

Figure 1. (a) Mechanic manual wheelchair. (b) Motorized wheelchair.

## 2. DISABILITY

Disability is defined as the absence or dysfunction of a psychic, physiological or anatomical structure. It concerns the biology of the person. This concept was defined by the World Health Organization. The term person with disabilities may be applied referring to anyone with a disability. However, it should be noted that in legal contexts it is used in a more restricted way and refers to people who are under the protection of specific legislation.

People with disabilities often need specialized care, whether for therapeutic purposes, such as physiotherapy or motor stimulation, or to learn to deal with disability and develop their own potential. Special Education has been one of the areas that have developed scientific studies to better meet these people needs, however, the regular education has also assumed the responsibility to assist these people what includes the ones with disabilities in addition to the behavioral needs.

## 3. WHEELCHAIR

### 3.1. Classification of Wheelchairs

Lianza established in 1994, a division into four major groups:

- Wheelchairs-rigid: for indoor use only in exceptional cases, today, they are very little used.
- Wheelchairs-fold: to use internal and external manual propulsion. -Motorized wheelchairs, to be used by quadriplegics with extensive paralysis of the arms.
- Wheelchairs to be used in sports made of lightweight material and subjected to aerodynamic design.

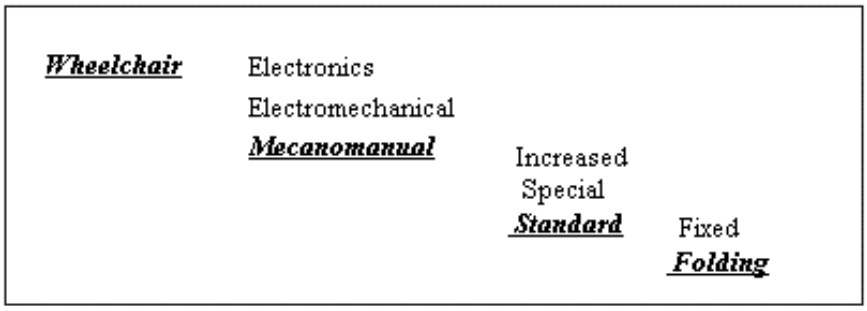


Figure 2.Classification of the wheelchair.
Source: http://www.scielo.br/scielo.php?pid=S0103-65132002000100007&script=sci_arttext

### 3.2 Materials and Methods

For the transportation prototype development of the disabled it was used a mechanic manual wheelchair for its simple adjustment and easy automation. The wheelchair with a capacity of 150 kg, used in the research, was donated by the Federal Institute of Education, Science and Technology of Maranhão - IFMA, as shown in Figure 3.

Figure 3. Mechanic manual wheelchair.

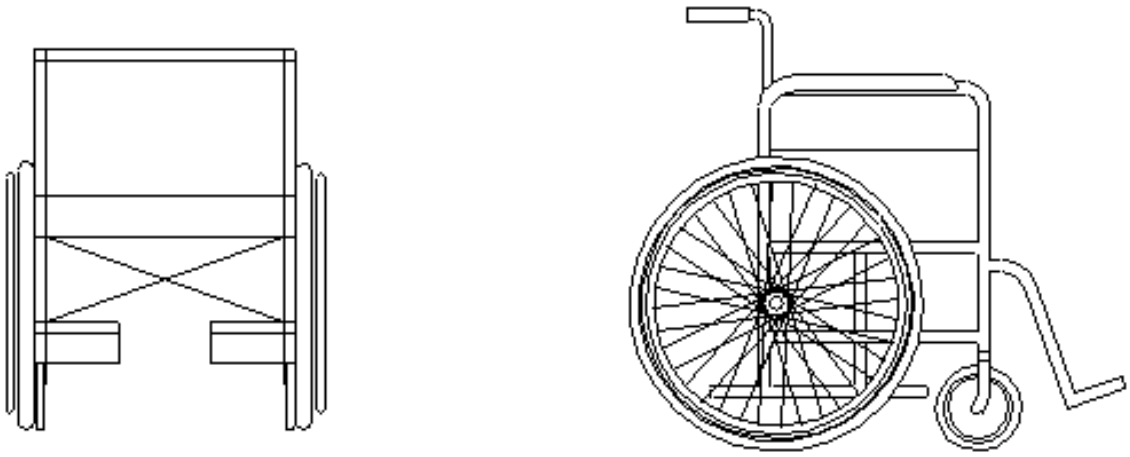

Figure 4. Technical drawings of the mechanic manual wheelchair

After the purchase of a wheelchair technical drawings were carried out in AutoCAD to illustrate the dimensions and technical details of the chair for easy viewing of future changes in the structure of the chair, indicating mechanical components, drive mechanisms, types of materials used in its construction with their dimensions and spacing adjustments and tolerance, as illustrated in Figure 4.

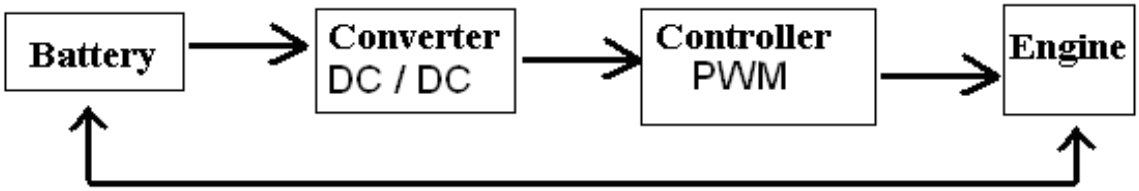


Figure 5. Flowchart of inverter voltages.

The figure 5 illustrates the flow diagram mounted on the support of the chair which consists of the battery that powers the entire system and provides the energy needed to run the engine in terms of 12volts, 36A. Another element is the DC / DC converter when receiving the battery voltage rises to a 12v voltage as the 40v engine can work. the PWM controller is connected to the potentiometer track and has a form of variable width square wave whose width will determine the engine speed. This width varies proportionally to the resistance of the pot placed in the chair mat. An electric motor 4HP direct current power was installed for the independent movement of the chair. The arrangement of the components used in the wiring diagram is shown in Figure 6.

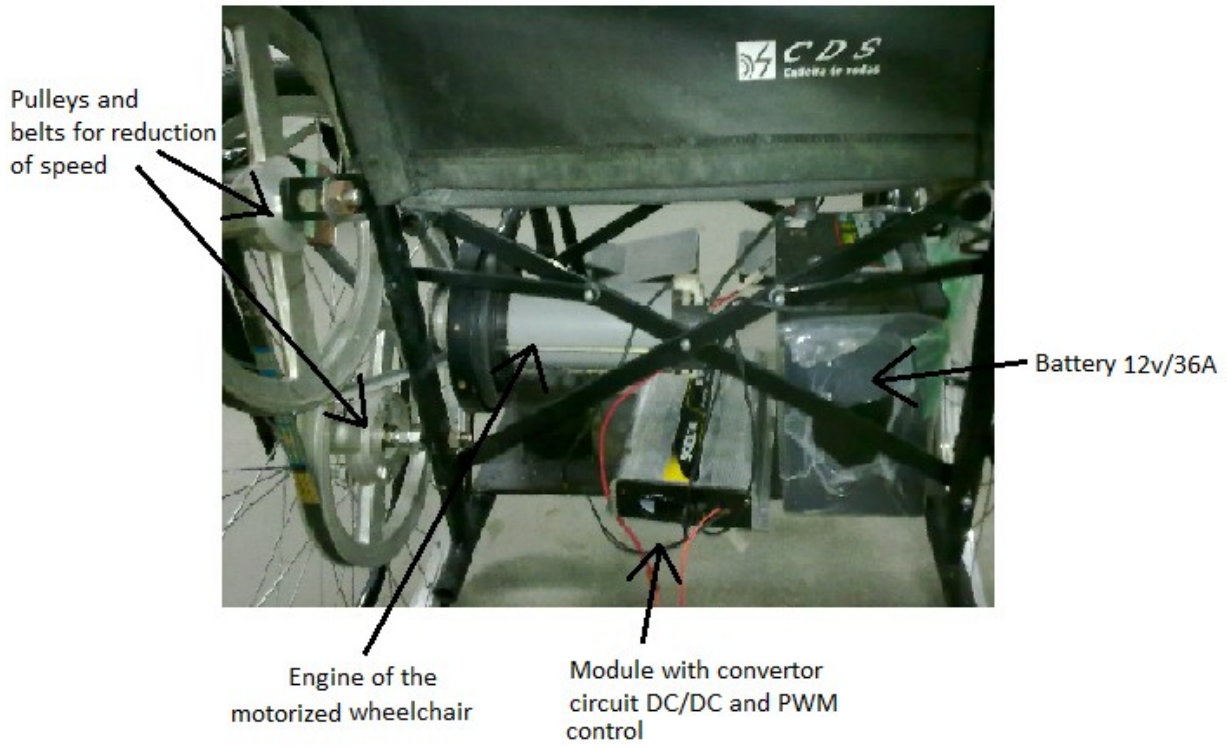


Figure 6. Arrangement of components used in the wiring diagram of the wheelchair.

Then it was welded an iron plate between the bases of the wheelchair making the chair to be permanently open and close the base was welded to another plate of iron, but of smaller size, U-shaped, it was inverted and placed with two mounting holes for the engine, as shown in Figure 6.

The electric motor was installed to apply force only on the left wheel of the wheelchair getting another free wheel facilitating its turns movement, as the motor applying force on the two wheels that would not be a wheel to spin more than the other to facilitate the turn.

Figure 7. Support the base of steel SAE 1020.

The Figure 7 indicates the adaptation of transmission mechanism through belts and pulleys, which allow you to get speed reduction and acquire power in the rear wheel axle to the mechanic manual wheelchair displacement.

Initially a pulley with 3.8 cm diameter has been put in the engine and beside the rear wheel other two steel pulleys were coupled, with 11.2 cm and 6 cm in diameter each, and it was placed in the left rear wheel a 10 cm diameter pulley all connected through belts to reduce speed and increase the torque, as shown in Figure 8.

Figure 8. Belt system adapted to speed reduction.

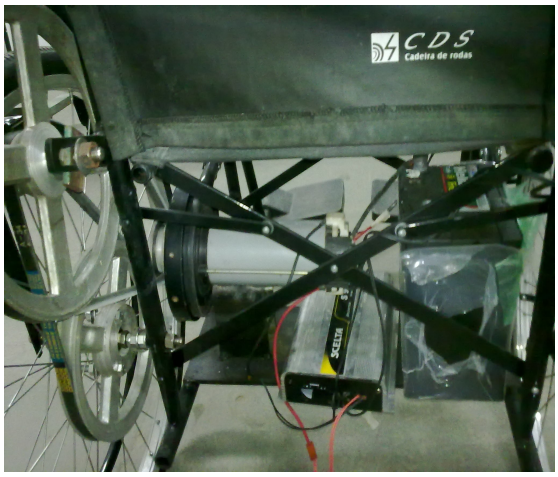


Figure 9. Back view of the speed reducer and control system of the wheelchair.

In addition to these materials a welded tube to a cable were added to the project , both of then made of iron, to control the direction of the wheelchair in their front wheels.

Aiming to achieve a good engine adjustment, as shown in Figure 9, an iron plate was welded between the bases of the wheelchair in order to make it permanently open and on this basis another iron plate was welded, but of a smaller size, U-shaped, but in an inverted position and placed with two holes to adjust the engine.

The engine was placed to apply force only in the left wheel of the wheelchair getting a free wheel to facilitate the curved movement of the engine prototype, because if the force were applied on the two wheels there would be a wheel that would spin more than the other to facilitate when in need of turning.

Having set the engine four pulleys have been placed forming a speed reducer set with one pulley in the motor, two pulleys in the structure on the left side of the wheelchair and one pulley attached to the left wheel of the wheelchair for speed reduction and torque increase. To figure out The transmission relation and the estimated speed of the wheelchair is given below.

$$i = \frac{(d_1 . d_3)}{(d_2 . d_4)} \tag{1}$$

In that,

d1 = 3.8 cm (diameter of the pulley placed on the motor);
d2 = 11.2 cm (diameter of the pulley connected to the motor);
d3 = 6cm (diameter of pulley linked the D2 pulley);
d4 = 10cm (Diameter of pulley of the left wheel).

Thus, $i = \frac{(3{,}8\, x6)}{(1{,}2\, x10)} = \frac{22{,}8}{112}$

$$i = 0{,}2036$$

Where d1 is the diameter of the drive pulley placed on the engine, d2 is the diameter of the driven pulley placed in the structure of the wheelchair, d3 is the diameter of the drive pulley placed on the same structure on the left side of the wheelchair as shown in Figure 7 and d4 is the diameter of the pulley attached to the left wheel of the wheelchair.

Thus, i is approximately 1 / 5 that brings a good reduction for the engine 4hp, because in this relationship while the motor turns five times the wheel chair will turn just once.

Table 1 - DC electric motor data and calculation of speed Wheelchair

| Wheelchair Parameters | Values |
|---|---|
| Voltage | 110 volts |
| Frequency | 50/60Hz = 3000/3600 rpm |
| Transmission ratio | 5: 1 |
| Turns pulley electric motor | 720 rpm |
| Rotations of the chair | 3600 rpm |
| Speed treadmill | 1 a 12km/h |
| Estimated speed of the wheelchair | 2,4km/h |
| Average Value Weight operator | 75kg |
| Nominal amount of battery weight | 11,7Kg |
| Approximate value of the weight of the chair | 30kg |

## 4. CONCLUSION

This present study was designed to adapt automated analog circuit in a mechanic manual wheelchair in order to control and move the wheelchair circuit based on a PWM (Pulse Width Modulator). The generated signal is modulated by means of a potentiometer that regulates the voltage supplied to the electric motor, varying in this way, the speed of the prototype motor.

The application of this control system in the structure of the mechanic manual wheelchair became possible through the application and adaptation of iron plates, in the wheelchair structure to support the engine and battery power of the prototype engine, manual guidance system and support for adjustment and setting of pulleys and belts used in the system to reduce speed and increase torque.

The speed control circuit is inexpensive and easy to reproduce in the local market and it can be improved for the convenience of motor-impaired users.

## 5. REFERENCES

Alvarenga, Bonilha Flávia Alvarenga. Engine Systems Development Alternatives to Conventional wheel chair. Campinas-SP, 2002.

BRAZIL. Ministry of Justice. Sicorde. Media and Disability. 3.ed. New York: CORD, 1996. Available at: <http://www.mj.gov.br/corde/midia.asp>. Accessed: 10/maio/2009.

Lianza, Sérgio, tens, Edison L. Orthotics. In: LIANZA, Sérgio. Rehabilitation: locomotion in patients with spinal cord injury. In: Medical rehabilitation. 2. ed. Rio de Janeiro: Guanabara Koogan, 1995.

Pierson, F.M. Principles and techniques of patient care. 2.ed. Rio de Janeiro: Guanabara - Koogan, 2001.

## 6. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.