

Introducing Asymmetry to Wheelchair Design

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Abstract:

This paper reports the use of asymmetry in designing the chassis of a power wheelchair. The innovative design uses and tests two kinds of power wheels and a new suspension structure. This design carefully considers features which satisfying the special needs of the aging population. Basic electromechanical models and stress analysis of the key parts of the new features have been performed. Prototypes were fabricated in the shop. Performance analysis will be done, and a comparison test to current wheelchair technology completed, when the fully manufactured wheelchair is available.

Keywords: mobility, wheelchair, symmetry (symmetric), asymmetry (asymmetric), nursing home, working load

Design Background:

When designing a new wheelchair, the engineer is seldom conscious of previous wheelchair design symmetry. Instead, wheelchair designers try to balance the two sides of the wheelchair, when locating functional modules. For example, when people draw a wheelchair on paper, they always draw a square to represent the chassis, and two beams. One beam represents the right side, the other represents the left side. This mindset comes from consideration of the dynamic motion of the wheelchair. Actually, the symmetric arrangement of parts that has dominated the past 25 years of wheelchair design is not necessary.

Recently, we analyzed the wheelchair design based upon the consideration of the human and machine interaction. We realized not only does the symmetry of the wheelchair design have no specific reason, but also the design does not provide a convenient level of access. This is especially evident when the wheelchair is used by the aging population. The design question “Where and how should a disabled person or elder access the seat of a wheelchair?” should not logically yield the answer “by the narrow space between the two footrests.” Observation shows that this is not a convenient design. Our design suggests that the seat of the wheelchair should be accessed from the right or left side of the wheelchair, similar to the manner that people access seats in a cinema.

Solution and result:

Figure 1 shows three models that were designed in ProE. Each model is shown in several views. These wheelchair models integrate the motor and brake system into the design of the wheels themselves.

The first kind of power wheel incorporates the motor and transition gears. It has a 13 inch diameter and 5 inch thickness. The outside of the wheel is a solid composite rubber which has been designed for desired elasticity. The power and torque of the design are very stable, with the following specifications: torque: ~ 1.4 – 1.8 rpm/Nm., power consumption: 0.5kwh/100km, loaded current: 3 ~ 4 Amperes. Given the power specifications the wheelchair can move 40km using 2, 12Ah batteries. The wheel weighs 10 lbs.

The second kind of power wheel does not use transition gears, but relies on the motor design to provide low speed and high torque output using a small number of coils and low resistance. This wheel uses an air tire, and was tested in 16 and 18 inch diameters, which are the second and third models, respectively.

From the pictures of the three models shown in Figure 1, we can see the following design features:

- (1) the footrest design allows the disable person or elder to transfer from one side of the wheelchair
- (2) In every design, there is a platform to carry an attendant.
- (3) The design of the suspension is simpler than those on the market.
- (4) The angle of foot rest is adjustable for comfort. This is detailed in Figure 2

Figure 1 goes here

Figure 2 goes here

The stress distribution on the beam was analyzed by using the simple mechanical model shown in the Figure 3. The shop prototype was also tested for comparison with the model's stress analysis. Both tests showed that, for an aluminum tube diameter of 2 inches and a thickness of 1/8 inch, the beam could support 1000 lbs. This conclusion is valid for the both square and round tube materials. For robustness, in design 2in x 1/8in round tube aluminum material is chosen. Fatigue test will be also done based on the vibrations the beam experiences. For the other parts welded with the main beam of the chassis, 1in x 1/8in tube aluminum material is chosen in the design.

Figure 3 goes here

Discussion:

During the design process, we have already considered the manufacturing techniques. They should be as simple as possible. Otherwise manufacturing cost will certainly be high. Figure 1 shows that the chassis and whole body of the wheelchair are easy to make by bending aluminum tube material in simple shop environment. Complex techniques

and costly machine time are not required. The design allows nursing homes and hospital to use power wheelchairs to reduce the working load of nurses, by simplifying transfers and not requiring the attendant to propel the wheelchair.

Once the prototyped wheelchairs are fully fabricated, various tests and comparisons will be performed to gain the clinic perspective. This design tests the feasibility of the new idea of an 'asymmetric' wheelchair. It does not consider portability, transportability, adjustability and seating in the wheelchair.

Reference: [1] <http://www.assistive-technology.ca/compartest.htm>

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Figures:

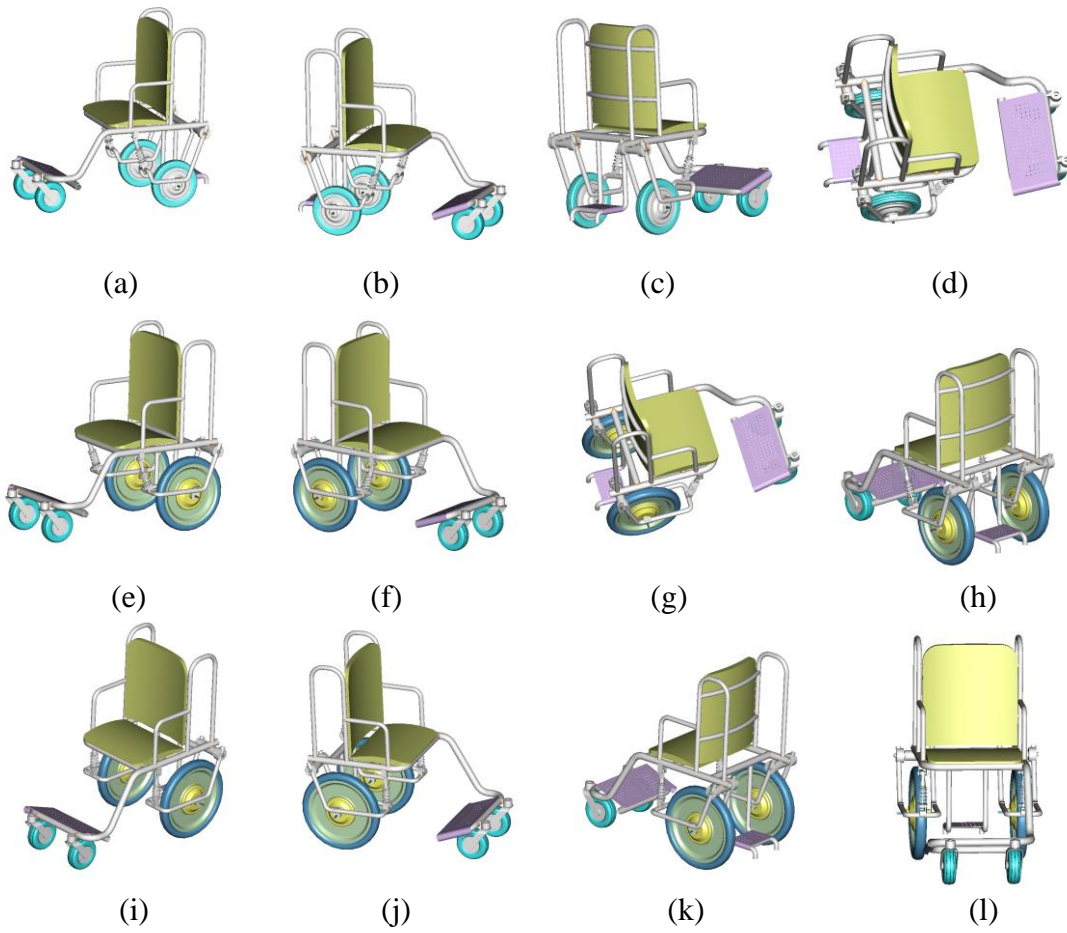


Figure 1: Three asymmetric wheelchair designs using different power wheels. Model 1 shown by (a) – (d) uses first kind of wheel. Model 2 and 3 shown by (e) - (h) and (i) – (l) use second kind of wheel, but different diameter.

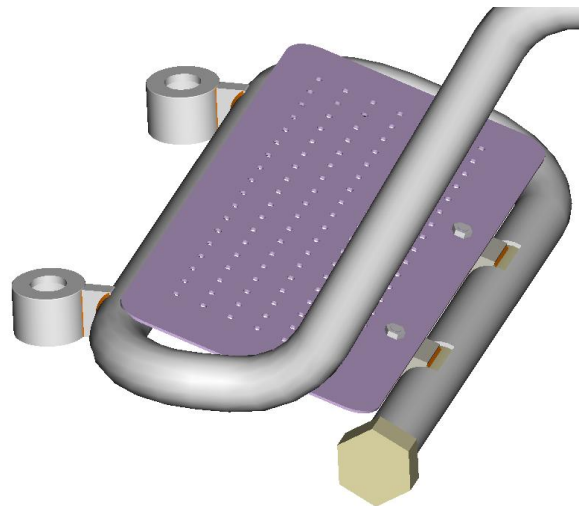


Figure 2: Detail of the footrest design. The hexagon handle can adjust the angle of the footrest relative to ground.

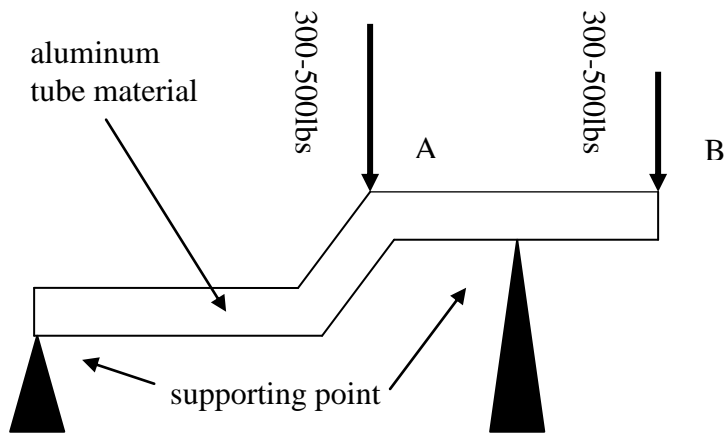


Figure 3. Model for stress analysis and experiment. During calculation and experiment, two forces that varies from 300 lbs to 500lbs are applied to the points A and B.