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Design and Analysis of Automated Wheelchair cum Bed with Sanitizer Mechanism

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Abstract: **India accounts 2.1% of its population for the paraplegic individuals and the count is increasing. Now in case of an emergency, these individuals face a lot of problem while transferring them from their wheelchairs onto a stretcher. Hence to avoid this issue, a dual-purpose wheelchair is proposed in order to solve this major issue. A dual-purpose wheelchair facilitates a wheelchair [sitting mode] and a stretcher [sleeping mode] which helps the individuals to sit or sleep with much ease. Also in case of an emergency, they won't be required to shift from a wheelchair onto a stretcher, avoiding further risks. The design of wheelchair is done keeping in mind the ergonomics and the cost of production, which makes it more comfortable and affordable for everyone. These dual-purpose wheelchairs can be can be used in schools, colleges, offices, industries and hospitals in case of an emergency. We have also fixed sanitizing mechanism onto the wheelchair so as to keep preventive measures of current COVID-19 pandemic and other viruses away from the individuals/patients.**

Keywords- Design, wheelchair, analysis, sanitization, bed.

I. INTRODUCTION

The purpose of a wheelchair is to ease the life of the people having either difficulties in walking or impossible to walk owing to an injury, illness or disabilities. They improve the locomotion and provide functional independence to the paraplegics. These paraplegic individuals are living normal and independent lives due to the evolution of the wheelchair from manual to automated ones. But there are still some problems encountered by these individuals which need to be rectified for making their lives better. Wheelchairs are not very comfortable and can cause fatigue by being on it all day long. Also, in case of an emergency, it is very risky to transfer a patient from a wheelchair onto a stretcher. To overcome this, we have designed a dual-purpose wheelchair which is basically a wheelchair which can be converted into a stretcher/bed.

We have achieved the motion to convert a wheelchair into a stretcher using some mechanical linkages and some mechanisms. Ergonomics play a very vital role in any product as it should be easy and comfortable for anyone to use. Anthropometry is the study of human body measurements. In today's era, to optimize products according to the human body dimensions, Anthropometry plays an important role in designing products such as industrial designs, clothing designs, ergonomics and architecture.

Currently, the world is facing a global pandemic of COVID-19, and in this situation, the physically challenged are being neglected or forgotten as their incapability is being taken for granted. They are not given proper treatment or attention. Proper sanitization is the basic need and hence we have designed a sanitizer bottle holder and an automated spraying system built into the dual-purpose wheelchair. Sanitizers are used to maintain the personal hygiene of oneself. This system will help the paraplegics in maintaining their personal hygiene in these tough times of global pandemic.

- *Wheelchair:*

A Wheelchair is a device used for mobility of an individual with disability or injury. It is simply a chair with wheels. There are some specialized wheelchairs based on the seating arrangement, individualized controls or to perform some specific to particular activities. Earlier there were manually operated wheelchairs, but now there are even automated wheelchairs operating on batteries or electric motors. But most of them lacked the comfort factor and the overall weight of the wheelchair. We have designed the wheelchair keeping in mind all the design parameters and ergonomics. After designing, we have analyzed the model for making it feasible to use.

- *Dual-Purpose Wheelchair:*

A Dual-Purpose Wheelchair, as the name suggests, is a wheelchair which can be doubled as a stretcher/bed. This idea was proposed in order to fulfill the needs of the paraplegics. These individuals can sleep on their wheelchair itself by converting it into a bed using an automated system. In case of an emergency, the same wheelchair can be used as a stretcher, further avoiding any risk for the patient. Various construction features were used to create a dual-purpose wheelchair. Dimensioning and analyzing components, material selection, and ergonomics considerations are all part of the design and development process. Also, during this COVID-19 pandemic, the use of sanitizers has been mandatory. In Hospitals, the wheelchairs and other equipment must be sanitized before use. Therefore, we have introduced a sanitizer bottle holder, which is pneumatically operated. The sanitizer will be automatically sprayed over the entire length of the stretcher/bed. This will help the patients and the paraplegics to stay away from the viruses and other infections.

II. METHODOLGY

- The preparation process of our work entails preliminary analysis, a literature review, and a background investigation.
- The idea generation process then follows, which involves reviewing existing wheel chairs, consumer needs, and concept designs.
- The conversion of a wheelchair into a bed is accomplished using a rack and pinion system as well as some linkage.
- Creating a light-weight wheelchair that can support a weight of up to 100-120 kg.
- Implementation and connections of all equipment, such as motors, links, and other components.
- Implementation of a rack and pinion system to turn the wheelchair into a bed and adapt it to the patient's comfort level through a switch given.

III. DESIGN OBJECTIVE

The objectives of this project are:

- To develop a Model of Automated Wheelchair cum Bed.
- To design and analysis of Automated Wheelchair cum Bed.
- To keep the patients safe from current pandemic, a Sanitizer Spray is being integrated into the wheelchair.

IV. WORKING AND DESIGN MODEL

- When a wheelchair is converted to a bed, the switch is turned on, and the wiper motor receives a 48V electric supply from the batteries.
- As shown in Fig. 1, the motor with pinion is in contact with the rack, which is inserted into the rack slot. And, in the design diagram, the rack is connected to the back rest and leg rest through links.
- When the motor is turned on, the rotation is converted to linear motion by the rack connection, resulting in angular displacement of the backrest in the downward direction, which is synchronous with the angular displacement of the leg rest in the upward direction. The wheelchair will be converted to a bed using this method.
- As the polarities of the batteries are reversed by the reverse switch to convert the position of the bed to wheelchair, the rack returns to its original position.

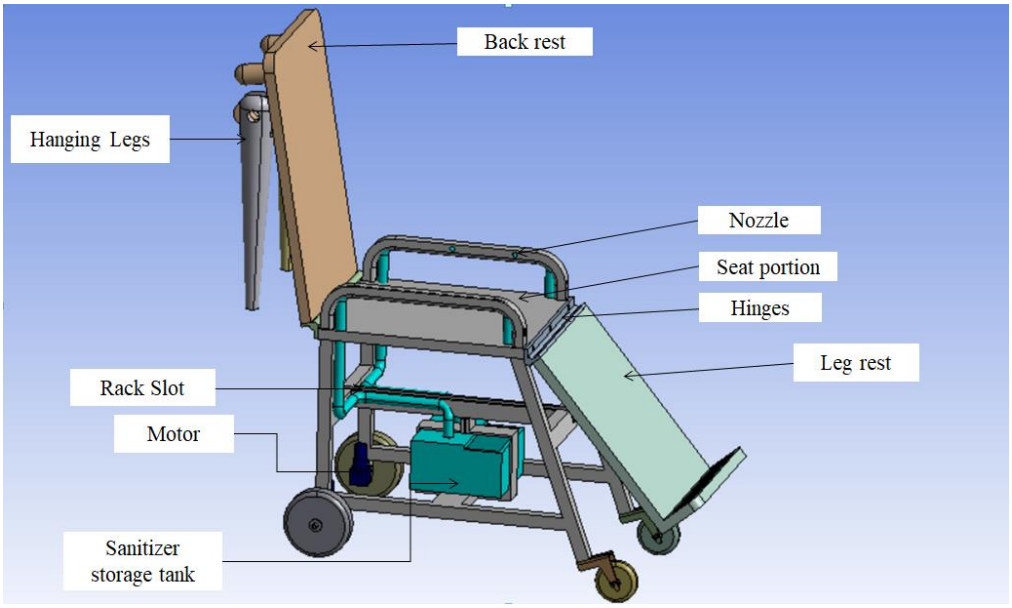

Fig. 1 Labeled Wheelchair

Dimensions:

Weight of the wheelchair: 24.25 kg.

Height of the wheelchair: 480 mm.

Width of the wheelchair: 450 mm.

Length of the wheelchair: 1680 mm.

Back rest: 650*450*25 mm^3.

Leg rest: 480*450*25 mm^3.

Seat portion: 550*450*25 mm^3.

Design Model of Wheelchair & Stretcher:

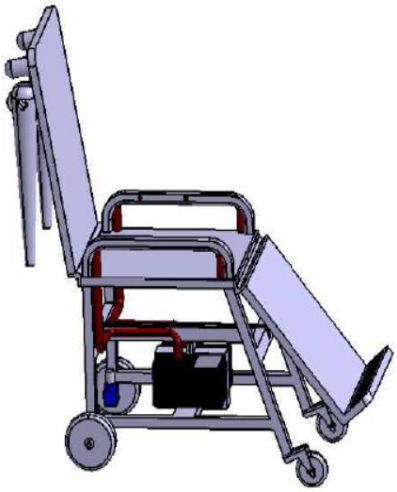

Fig. 2 Design of Wheelchair

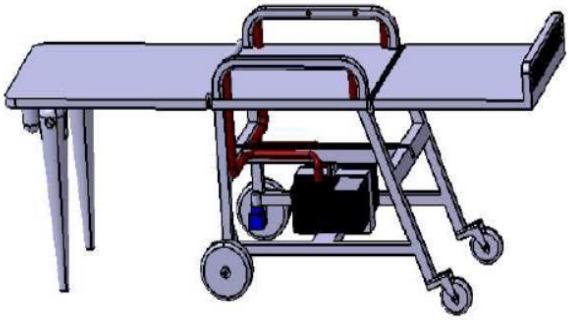

Fig. 3 Design of Wheelchair converted to Bed

V. ANALYSIS

A. Wheelchair Analysis:

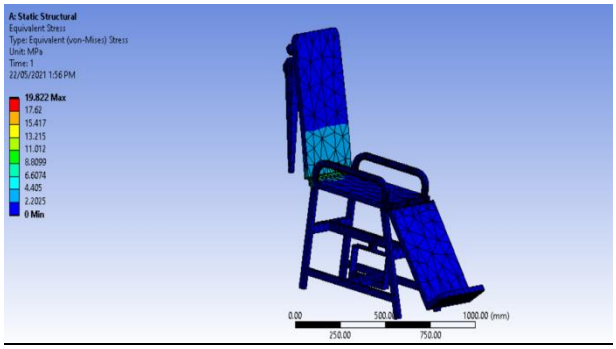

Fig. 4 Stress Analysis

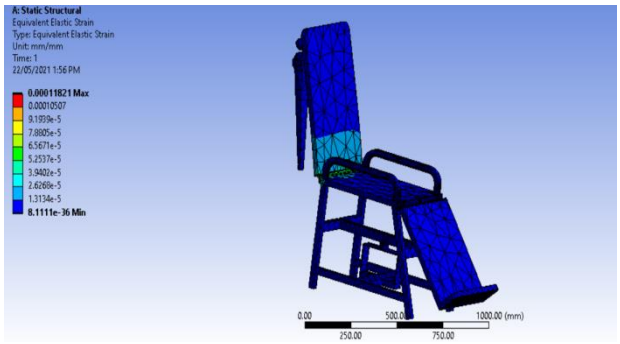

Fig. 5 Strain Analysis

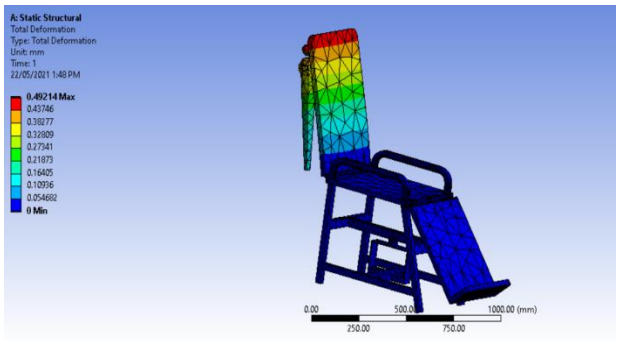

Fig. 6 Total deformation Analysis

B. Wheelchair cum Bed Analysis:

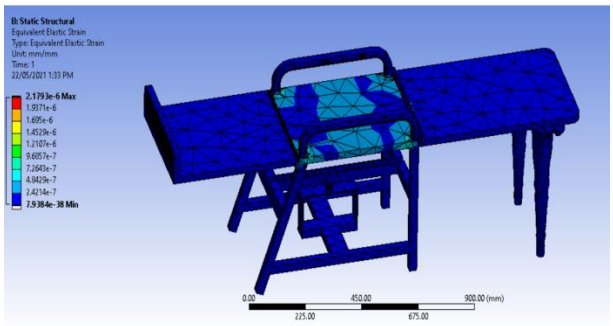

Fig. 7 Strain Analysis

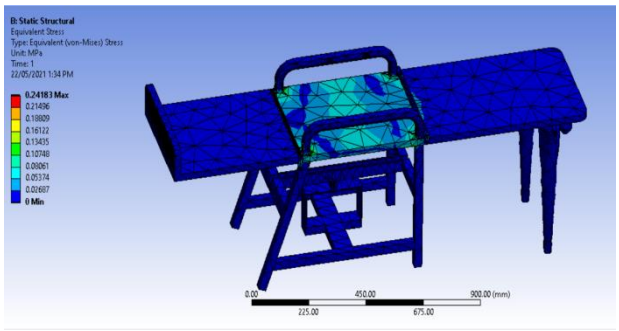

Fig. 8 Stress Analysis

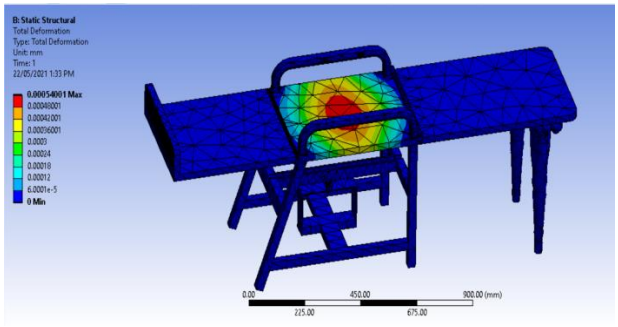

Fig. 9 Total Deformation Analysis

VI. CALCULATIONS

❖ LOAD CALCULATIONS :

- ✓ Load on Front Caster :
  - Weight of Wheelchair, m_W= 24.25 kg
  - Weight of Human Body, m_H= 120 kg (maximum carrying capacity of human body)
  - Inclination Angle for Front Leg, $\Theta_l = 20^o$

$F_{f(vertical)} = (m_W + m_H) * g$

$= \underline{1415.1}$ N

$F_{f(inclined)} = [F_{f(vertical)} * \cos \Theta_l]$

$= \underline{1329.8}$ N

∴ Force on each Front Caster, $F_{C1} = \frac{Ff(inclined)}{2}$

$= \underline{665}$ N

- ✓ Load on Rear Caster :
  - Weight of Wheelchair, m_W = 24.25 kg
  - Weight of Human Body, m_H = 120 kg
  - Weight of Screw Motor, m_S = (2*1.25) = 2.5 kg

$F_{f(vertical)} = (m_W + m_H + m_S) * g$

$= \underline{1437.2}$ N

∴ Force on each Front Caster, $F_{C2} = \frac{Ff(vertical)}{2}$

$= \underline{718.6}$ N

- ✓ Load on Back Rest portion :
  - Angle of Inclination for back rest, $\alpha = 10^o$
  - Average weight of human back, m_B = 66.12 kg
  - Weight of Back Frame, m_{BF} = 6.5 kg

Total Force, $F_B = (m_B + m_{BF}) * g$

$= \underline{712.40}$ N

Actual Force, $F_{AB} = F_B * \text{Sin } \alpha$

$= \underline{123.7}$ N

- ✓ Load on Rear Caster :
  - Weight of Wheelchair, m_W = 24.25 kg
  - Weight of Human Body, m_H = 120 kg
  - Weight of Screw Motor, m_S = (2*1.25) = 2.5 kg

$F_{f(vertical)} = (m_W + m_H + m_S) * g$

$= \underline{1437.2}$ N

∴ Force on each Front Caster, $F_{C2} = \frac{Ff(vertical)}{2}$

$= \underline{718.6}$ N

- ✓ Load on Back Rest portion :
  - Angle of Inclination for back rest, $\alpha = 10^o$
  - Average weight of human back, m_B = 66.12 kg
  - Weight of Back Frame, m_{BF} = 6.5 kg

Total Force, $F_B = (m_B + m_{BF}) * g$

$= \underline{712.40}$ N

Actual Force, $F_{AB} = F_B * \text{Sin } \alpha$

$= \underline{\underline{123.7}}$ N

VI. Conclusions

- CAD software was used to create and analyze the dual-purpose wheelchair.
- Based on the results of our survey, we believe that our wheelchair cum bed design is simple to use for elderly people as well as people with leg impairments.
- The motion of the wheelchair has also been automated.
- Finally, due to the ongoing COVID-19 pandemic, we have installed an automatic sanitization function over the bed.

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