Design of multipurpose wheelchair operated by six-bar linkage

Rudra Ramu[1], Rudra Lakshman [2]
[1]*Department of Mechanical Engineering, JNTUH College of Engineering Manthani, Peddapally, Telangana, India*
[2]*Department of Mechanical Engineering, Malla Reddy Engineering College, Hyderabad, Telangana, India*

Abstract **- The elder people or the patients who were hospitalized or physically challenged suffers problems while they interchange from wheelchair to stretcher or bed or vice-versa. Not only the person who is in the chair suffers. But the attendee or nurse who is taking care of them also suffers problems. Many different solutions are proposed to avoid such sufferings. The multipurpose wheelchair is one of the solutions. Though there are many multipurpose wheelchairs, there are some difficulties with them. Most often, the difficulty is in operating the multipurpose wheelchair. So, to make the operation condition of multipurpose wheelchair easy, the mechanism is being used in this design of multipurpose wheelchair. Six-bar linkage is used in this design. This six-bar linkage makes the operation of converting the wheelchair into a stretcher or bed very easy. This design can be operated manually so no external power source is required for the operation of converting wheelchair to stretcher or bed. This makes the fabrication of this design less expensive.**

Index Terms **- Multipurpose wheelchair, Wheelchair, six-bar linkage, worm and pinion gears.**

I.INTRODUCTION

Rigid bodies are used in transferring mechanical energy. Mechanical energy includes force, torque, etc. Rigid bodies are attached together by means of joints. These attached rigid bodies are used in transferring mechanical energy. Such rigid bodies are attached together by means of joints used for transferring mechanical energy forms mechanisms. Such a mechanism is used in this design of a multipurpose wheelchair.

Two four-bar linkages are coupled to a common crank which forms a six-bar linkage, which is used in this multipurpose wheelchair design. The fixed link is the bottom rest which is ground to the frame. Crank is attached to the frame or base of the chair. the Backrest and footrest are the two followers. Two couplers are used to couple the backrest and the footrest to the crank. Six links namely bottom rest, footrest, backrest, crank, and two couplers form the six-bar mechanism.

II. OBJECTIVES

The main objective of this multipurpose wheelchair design is to make the operation of converting the wheelchair into a stretcher or bed easy. To be able to make the design for the fabrication very easily. To achieve the design such that the two different purposes that are wheelchair and stretcher or bed in a piece o single equipment. Finally, to get the optimum design that will be less expensive after fabrication.

III. MULTIPURPOSE WHEEL CHAIR

Working:

The chair design in this paper is developed in such a way that it can be converted into a stretcher or bed from a chair position or vice versa by using the mechanism. The mechanism gives the predetermined position of the chair when the crank is rotated. For this design developed in this paper, a 90^0 rotation of crank is required for the conversion of wheelchair position into stretcher or bed or vice versa. This rotation of 90^0 to the crank is given by using the worm and pinion gears. Worm and pinion gears are arranged as shown in the figure. The worm is rotated until the pinion gear rotates 90^0. When pinion gear rotates 90^0 simultaneously the crank to which pinion gear is rigidly attached also rotates. This results in the conversion of the wheelchair into the stretcher or bed

or vice versa. This is the working of the multipurpose wheelchair design developed in this paper.

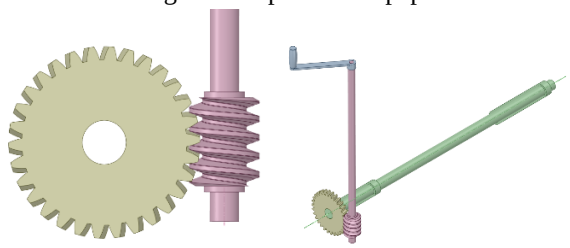

Figure 1: Worm and Pinion gears used in the design and arranged to the crank

Design:

In this design, a six-bar linkage is used to convert the chair model into a stretcher or bed or vice versa. The design of the 3D model of a multipurpose wheelchair is developed in the ANSYS 2020 R2 SpaceClaim. This design of multipurpose wheelchair consists of a backrest, leg rest which are attached to the bottom rest (which is the fixed frame) via revolute joints, two coupler links, crank, worm and pinion gears set, two bigger wheels, and two caster wheels. Worm and pinion gears are attached rigidly to the crank. All the individual parts are connected as shown in the figure to get the final design of the multipurpose wheelchair.

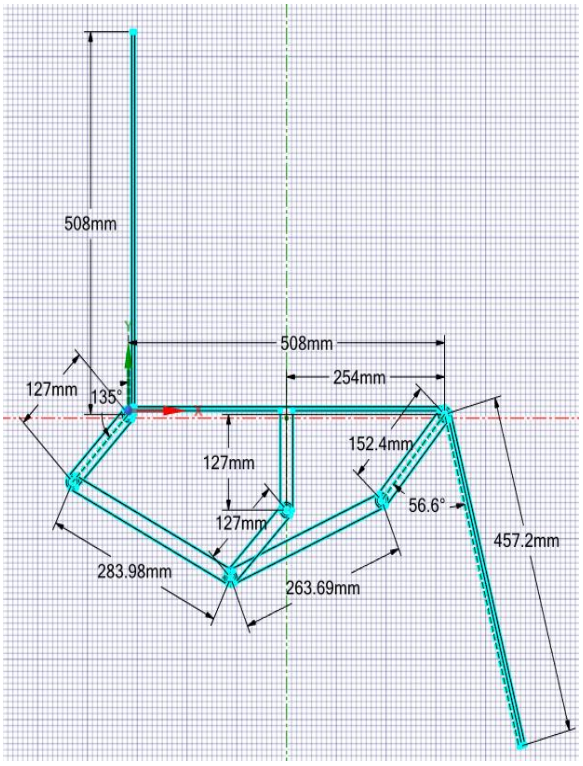

Figure 2: Sketch showing different dimensions

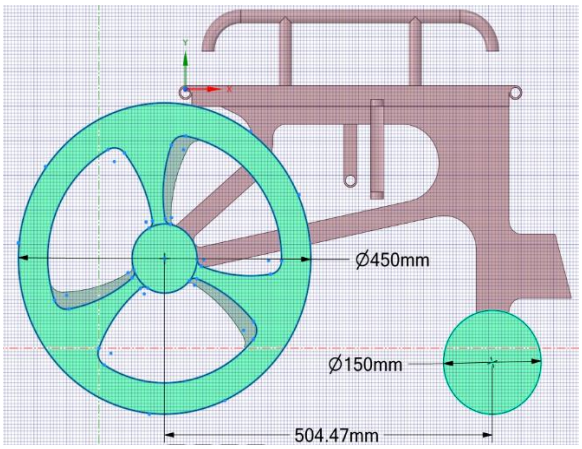

Figure 3: Dimensions of wheels used in the design

Table 1: List of links

Link	Role	Part
1	Fixed	Bottom rest(frame)
2	Crank	Crank
3	Follower 1	Back rest
4	Follower 2	Leg rest
5	Coupler 1	Back coupler
6	Coupler 2	Front coupler

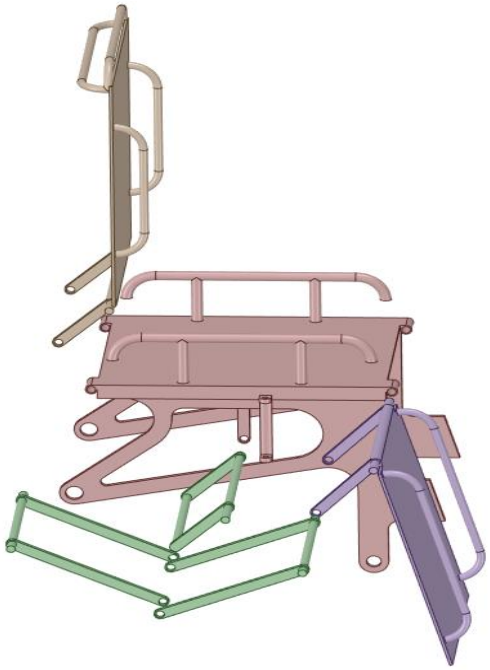

Figure 4: Exploded view of different parts of the wheelchair

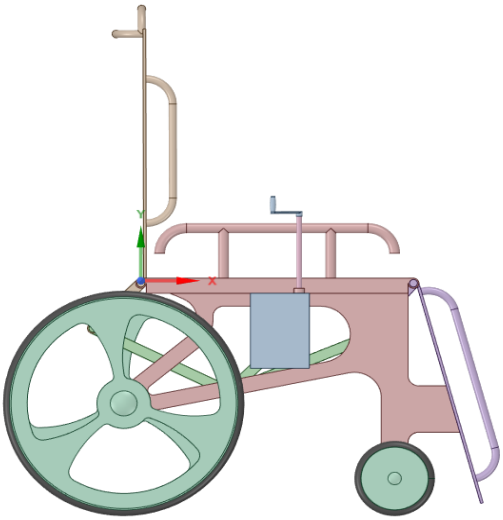

Figure 5: 2D View of wheelchair

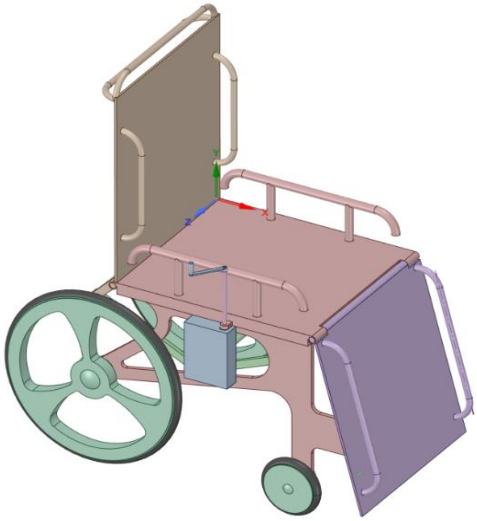

Figure 6: 3D View in sitting posit

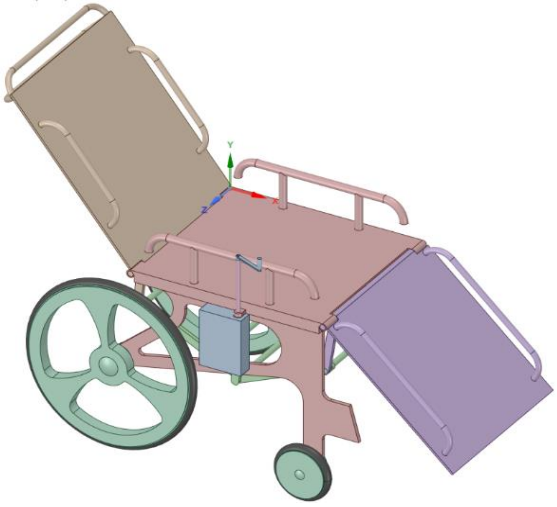

Figure 7: 3D View of intermediate position

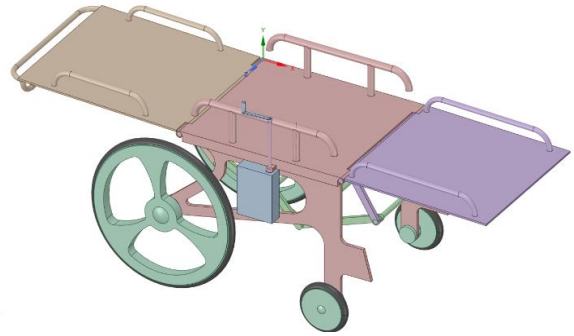

Figure 8: 3D View of sleeping position

IV. ANALYSIS

The maximum deformations in any system or parts will take place where the loads acting on them are high. In this design of a multipurpose wheelchair, the bottom rest which is a fixed link takes the maximum amount of load which is distributed over the wheelchair. The load on the chair is the weight of the human body resting on the chair. The weight of the different parts of the human body contributes to the total weight of the body. This total weight of the human body is distributed over the chair. The percentage of the weight distribution by the different parts of the human body is as shown in the table [4].

Table 2: Human body weight distribution

Part of human body	Weight (%)	Weight of human body parts (kg)
Trunk	48.3	38.64
Head and neck	7.1	5.68
Thigh	10.5	8.4
Shank	4.5	3.6
Foot	1.5	1.2
Upper arm	3.3	2.64
Forearm	1.9	1.54
Hand	0.6	0.48

Results:

As the major load is taken by the bottom rest which is a fixed link, finite element analysis is done by using ANSYS 2020 R2 for the total deformation and stresses developed. These are the results obtained just by considering the ideal design which illustrates the basic idea of designing a multipurpose wheelchair in this paper.

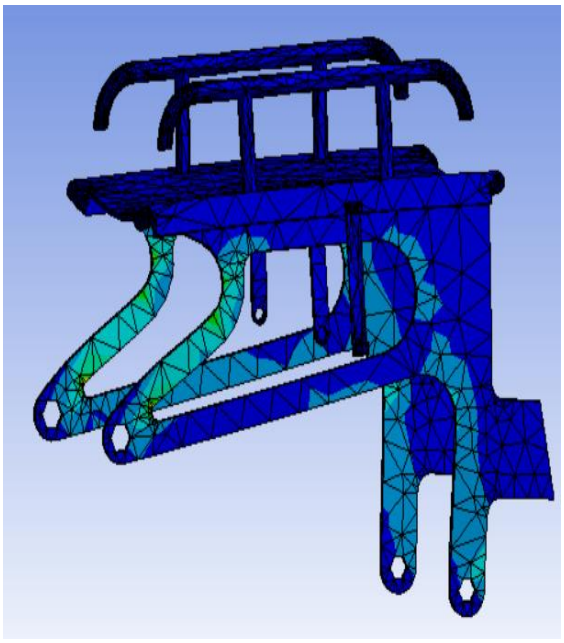

Figure 9: Equivalent (von-Mises) Stress

Equivalent (von-Mises) Stresses are more in the part of the frame where the cross-section area is much less compared to the other part of the frame. This maximum stressed part which we can visualize in figure 9 is the main support to the whole chair. One should take care while selecting the proper material and cross-section area of that supporting part of the frame

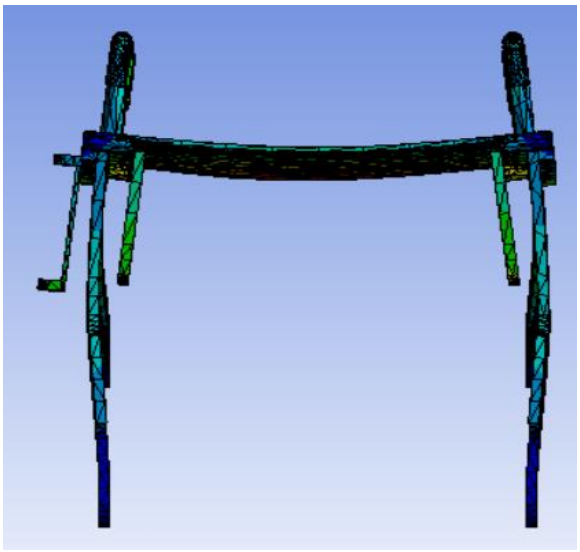

Figure 10: Total deformation (front view)

From figures 10 and 11 we can visualize the deformation of the base of the frame when load i.e., a person sits on it. This deformation also can be reduced by choosing the better design and proper materials for the supporting part.

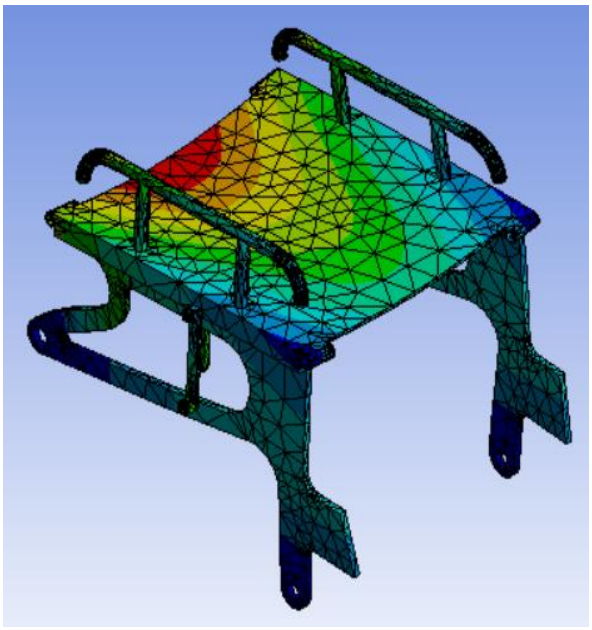

Figure 11: Total deformation (3D view)

The stresses and the deformations obtained are due to less cross-sectional area. This paper is primarily focused on introducing the idea of the design of a multipurpose wheelchair. The cross-section area is not taking as much importance, this resulted in such unexpected results. This kind of deformations and stress can be eliminated by giving the appropriate cross-section which should be evaluated by taking the proper design conditions. Generally, it is better to take the fabrication materials as same as the materials that are being used in making wheelchairs. Arranging the links to the chair is the only extra part that is different from regular wheelchairs.

V. FUTURE SCOPE

The design developed in this paper can be further modified. But further modifications can make the design more costly.

1. Electric motor or other systems can be attached to drive the worm which eliminates the manual operation of rotating the worm.
2. Special attachments can be attached to the chair which makes easy to carry the things and also to hold the saline bottle.
3. Design can be further developed to get the different movements of the backrest and the footrest by developing the mechanism.
4. Electronics can be used for the completely automatic operation of the wheelchair.

VI. CONCLUSION

Operation i.e., converting the wheelchair position to the bed position or any intermediate position will be easy. Worm and pinion gear are self-locking systems. Thus, that setup ensures that there will be no slip at any position due to loads. The six-linkage mechanism used in this design makes the operation free from jerks during the conversion of design from one position to other. Thus, the design will be very comfortable for the users. Meanwhile to the attendee or the nurse whoever takes care of the one in the wheelchair also becomes very easy in handling. A similar wheelchair can be designed for larger sizes or capacities using the appropriate scale which can be obtained from the dimensions mentioned. A multipurpose wheelchair is developed which can be fabricated with less cost and with the material which is available easily. Multipurpose wheelchair with this design can be used in hospitals or in houses which serves the deserved one easily.

ACKNOWLEDGEMENT

We express our sincere thanks to Dr. Ch. Sridhar Reddy, Professor and Head of the Department of Mechanical Engineering, JNTU College of Engineering, Manthani, Dr. K. Prasanna Lakshmi Associate professor, Mechanical Department, JNTUCE Manthani and Mr. S. Shiva Rama Krishna, Asst. Prof (C), Mechanical Department, JNTUCE Manthani, Dr. A. Raveendra, Principal, Malla Reddy Engineering College, Hyderabad, Dr. N Rishi Kanth, Head of the Department of Mechanical Engineering, Malla Reddy Engineering College, Hyderabad for their valuable suggestions and guidance.

We would like to express our sincere gratitude to Dr. R. Markandeya, Professor and Principal, JNTUCE Manthani, Dr. B. Vishnu Vardhan, Professor and Vice Principal, JNTUCE Manthani for their support.

We would also like to thank all the faculty members of the Department of Mechanical Engineering, all the staff members JNTUCE Manthani, Malla Reddy Engineering College, Hyderabad for their kind cooperation

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