International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 9 Issue 6 ǁ 2021 ǁ PP. 58-71

Design and Manufacturing of Multipurpose Wheelchair

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Abstract
The purpose of this project was to manufacture the multipurpose wheelchair in low cost which promote mobility and enhance the quality of life for the people who have difficulties in walking. This product make the users to lift the patient directly from the bed which help to reduce the pressure injuries. Along with the reducing the cost of product, we also aim to minimizing the pressure injuries and fall. Other specialty of the multipurpose wheelchair is, we can use it on indoor as well outdoor. Then after the completion of project we have successfully achieved what we set out to bring in wheelchair. We made a better multipurpose wheel chair with all safety measures, low cost and high quality. It provide a safe transferring of patients from one place to another place. The procedure that is used for transferring patients is very simple and unique.

Keywords: *Patient, Multipurpose, Wheelchair*

Date of Submission: 03-06-2021 Date of acceptance: 17-06-2021

I. INTRODUCTION

Disability has affected thousands of families in the world. As of today approximately 650 million people, are suffering from disability [3]. In developing country like India there are almost 21.9 million people with some or the other disability [3]. Regardless of their disabilities, these people still need to get up each morning and live life. For most, this can only be possible with the help of a wheelchair. Wheelchair is a device which can empower and enable a person with a disability to live a normal and independent life. Over the years wheelchairs have evolved rapidly from the manual wheelchairs to the powered wheelchairs. But still these wheelchairs have not been able to satisfy the needs of the disabled people. It is therefore critical that the problems of disabled be understood and accordingly wheelchairs are developed fulfilling their needs.

1.1 PROBLEM DEFINITION

Nowadays the numbers of patients are increasing day by day due to our lifestyle. Hospitals are being crowded by the patients but they cannot provide better care for their patients due to lack of technologies or due to expensiveness of the available technology which cannot be afforded by the common peoples and hospital management. Among them paralyzed patient are more suffering [5]. The main problem faced by the patients is during the time of shifting from bed to stretcher and vice versa. Pressure injuries and falls are the main problem faced by the paralyzed patient. The main aim of our project is to manufacture a multipurpose wheelchair with low cost that is affordable in our country without compromising any services which is done by the conventional method. Multipurpose wheelchair is a medical aid equipment which enables transfer of patients from bed to stretcher and vice versa. There is no existing technology as such even though there are electrically controlled equipment which are expensive.

1.2 OBJECTIVES OF THE PROJECT

In this project we modify this into a system which can be more suitable and affordable for all the citizens. The manufacturing of this product is cheap compared to the conventional method. Moreover, this product can be used in the hospitals, homes, old age homes and is easily portable. Patients may feel disturbed while shifting manually from one place to another. In this project we claim that no such issues will be faced by the patients during their shifting, as there is no direct contact by the patients. Multipurpose can use in a single wheelchair like commode chair, walker for waking therapy etc. Objectives of multipurpose wheelchair are given below:

- Promote mobility and enhance quality of life for people who have difficulties in walking.
- To produce low cost multipurpose wheelchair.
- Aiming to lift the patient directly from the bed.
- To provide Height adjustable wheelchair.
- To minimize pressure injuries and fall.
- To make the use of multipurpose wheelchair in both indoors and outdoors.

I.3 SCOPE OF THE PROJECT

- The multipurpose wheelchair must be available and affordable and be maintainable and sustainable in the country of use. This is not always easy, because wheelchair users are a diverse group with different requirements and environmental and socioeconomic [2].
- Multipurpose wheelchair is more than an assistive device for many people with disabilities; it is the means by which they can exercise their human rights and achieve inclusion and equal participation
- A wheelchair provides mobility, ensures better health and quality of life, and assists people with disabilities to live full and active lives in their communities.
- There are various moving and handling devices available in the market. But these devices have their own limitations which restrict their use and they need to be purchased separately, increasing the cost of wheelchair. Hence there arises a need for exploring new concepts. The manufacturing of this product is cheap compared to the conventional method

I.4 LIMITATIONS OF THE PROJECT

- Wheelchair with a lifting function is designed to assist a caregiver when transferring a wheelchair user only in indoors but not in outdoors.
- Using of GI iron for the fabrication of frame work of multipurpose wheelchair increased the total weight of multipurpose wheelchair.
- Screw thread of lower pitch had resulted in increased number of rotation given on the handle as input

II. WORKING PRINCIPLE

Screw nut mechanism is the working principle of the multipurpose wheelchair. A screw nut mechanism is mechanism which convert rotational motion to linear motion combining a screw and a nut where the screw thread is in direct contact with the nut thread. In the case of roller screws, the rollers rather than the nut are in direct contact with the screw thread offering greater efficiency [7]. There are three types of manufacturing process for a screw, either rolled, ground or machined using a whirling process. Power Jacks employs all methods in the manufacture of our lead screws.

Lead screws are used in a very broad range of applications, sold as individual products or incorporated into screw jacks and electro-mechanical actuators. As with screw jacks, Industrial Automation, Medical, Defense and Transport applications are particularly popular lead screws. In this mechanism patient are lifted by rotating the thread rod with the help of handle.

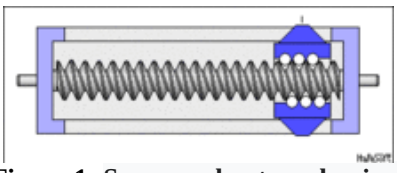

Figure 1: Screw and nut mechanism

In this mechanism patient are lifted by rotating the thread rod with the help of handle.

2.1 PARTS OF MULTIPURPOSE WHEELCHAIR

The major parts of multipurpose wheelchair are:

- Frame
- Caster wheel
- Seat
- Tie down belt
- Back rest
- Handle

2.1.1 FRAME

The whole frame of multipurpose wheel chair is made of GI square and round pipe. The structure of frame is C shaped when viewed from the side which has great advantage over conventional wheelchair that help to make too close to the lying on the bed.

Figure 2: Frame

2.1.2 CASTER WHEEL

A caster is an undriven wheel that is designed to be attached to the bottom of the equipment to enable that object to be moved. Casters are used in numerous applications, including shopping carts, office chairs, hospital beds, and material handling equipment. They are commonly made of rubber, plastic, nylon, aluminum and stainless steel.

Figure 3: Caster wheel

2.1.3 SEAT

Seat is made up of rexine, which is made of cloth surfaced with a mixture of cellulose nitrate (a low explosive also used as the propellant in firearms rounds), camphor oil, pigment and alcohol, embossed to look like leather. Used as a bookbinding material and upholstery covering, Rexine was also widely used in trimming and upholstering the interiors of motor vehicles. The size of the seat is 15 × 20 inch.

Figure 4: Seat

2.1.4 TIE DOWN BELT

A seat belt is a vehicle safety device designed to secure the driver or a passenger. So, inspiration from the material used in the seat belt in vehicle lead us to use webbing and buckle for holding the seat in multipurpose wheel chair. Seat belt webbing is made of polyester, most safety belt webbing is made from polyester because it is a high quality material that has high strength tenacity (almost 10g/den).

2.1.5 BACKREST

Back rest is a support for the persons back when they are seated and additional safety belt is provided to prevent the falling of the patient.

Figure 5: Backrest with safety belt.

2.1.6 HANDLE

Handle is used for lifting the patient by rotating. When handle is rotated in clockwise it move in upward direction and in anti-clockwise it move in downward direction. Handle reduces the effort required to rotate the screw rod on lifting operation.

Figure 6: Handle

2.2 MATERIAL

Galvanized iron pipes are used for making the frame. Galvanized iron is among the most popular iron types because of its extended durability, having the strength and formability of steel plus the corrosion protection of the zinc-iron coating. Galvanized iron is the same as standard iron, the only difference is that it features a layer of zinc. The added layer of zinc helps to protect the iron from rust and corrosion. Without it, the iron will be exposed to moisture and oxygen from its surrounding environment. If left unchecked, this will trigger a chemical reaction with the iron known as oxidation. Oxidation will cause the iron to rust and corrode.
The material used for making multipurpose wheel chair are:

- Round pipe 1 ¼'', 1 ½''
- Square pipe 1 ½''
- Bearing
- Thread rod 1''
- Nut

Figure 7: Bearing

Figure 8: Thread rod

Figure 9: Nut

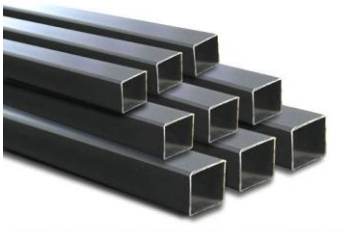

Figure 10: Square Pipe

Figure 11: Round Pipe

III. DESIGN AND ANALYSIS

The structural design is basically a modification of a conventional wheel chair. It consists of three main parts:

1. Upper frame
2. Pair of Thread rod
3. Lower frame
4. Seat

The upper frame and lower frame is made of Galvanized iron. Thread rod is of normal iron and seat is made of rexin material.

The upper frame can be lifted or droped to a certain distance (20 mm) .The upper frame carries sling seat which is hung with 2 seat belts on each side of seat . The upper frame also carries the back rest.

Screw rod enables the linear motion. It is enabled when screw rod is rotated ,this rotational motion is converted by a screw nut mechanism to a linear motion.

Lower frame bear the maximum load. Lower frame supports the upper body to actuate its funtion.

Figure 12: Multipurpose Wheelchair

3.1 DIMENSION

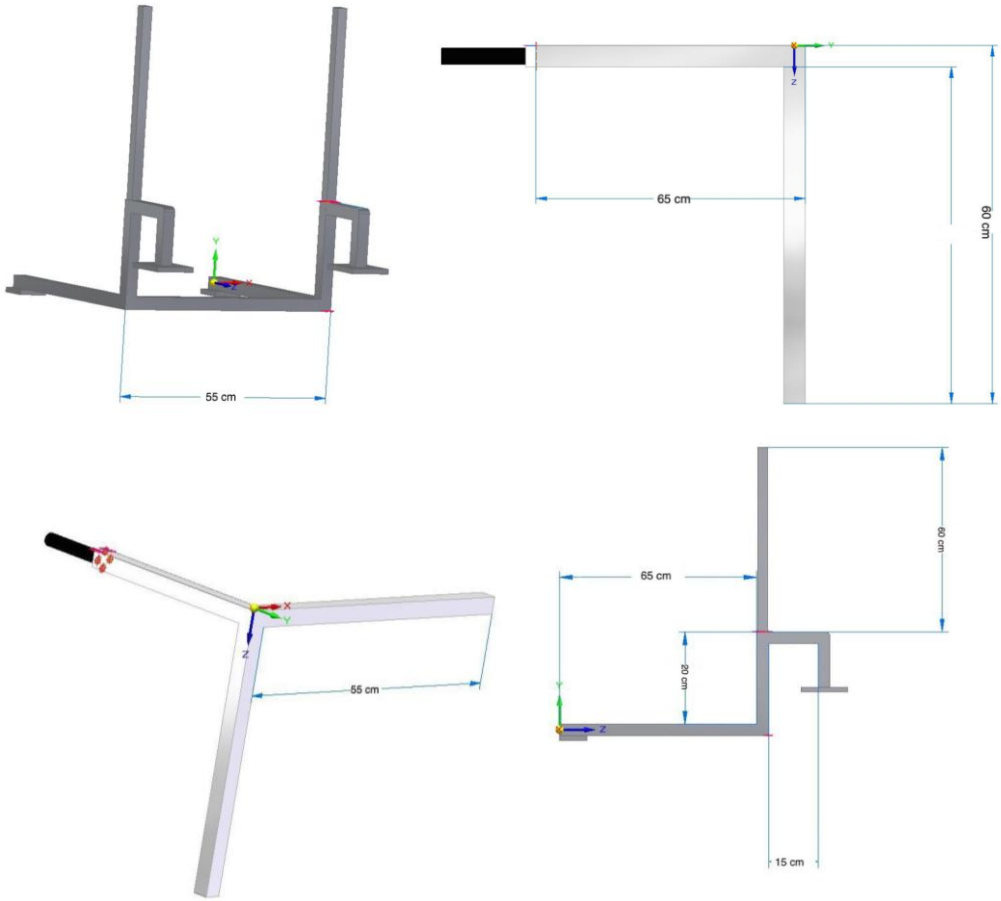

Figure 13: Dimension of the frame

3.2 STRESS ANALYSIS

The analysis of the frame was done by using ANSYS 20.0. A load of 100 Kg was applied on the upper surface of the upper frame which can be cosidered as weight of patient. The safety factor for static loading were found good enough to sustain the load. The safety factor which is equal to ratio of Ultimate stress to the maximum allowable stress is found to be 4.9. Maximum deformation was found at the rear end of arm rest on which the seat is being hanged. The stress analysis was done by using the maximum principal stress theory . The maximum allowable stress were found as 71.385 Mpa and the ultimate strength of the material used is 350 Mpa which shows the design is safe [2,7].

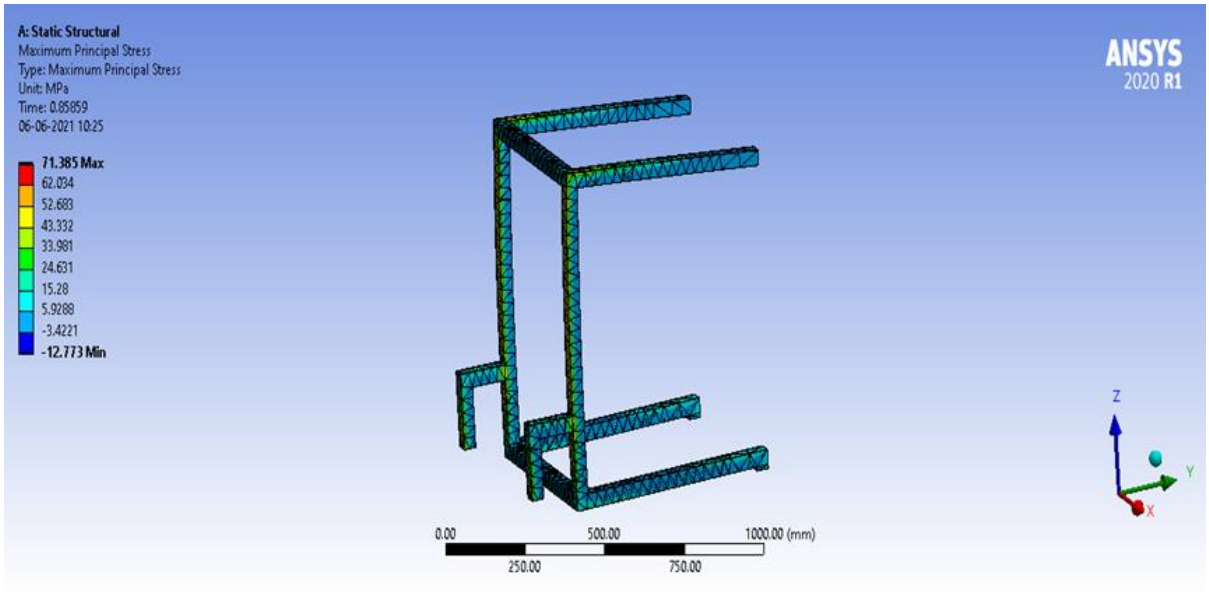

Figure 14: Maximum principle stress

3.4 TOTAL DEFORMATION

The force applied on arm rests of 1000N and it has rotary displacement respectively. It was obtained that maximum deformation of 10.526 mm are found at red area as shown in figure. Since the deformation is less we can ensure a strong frame.

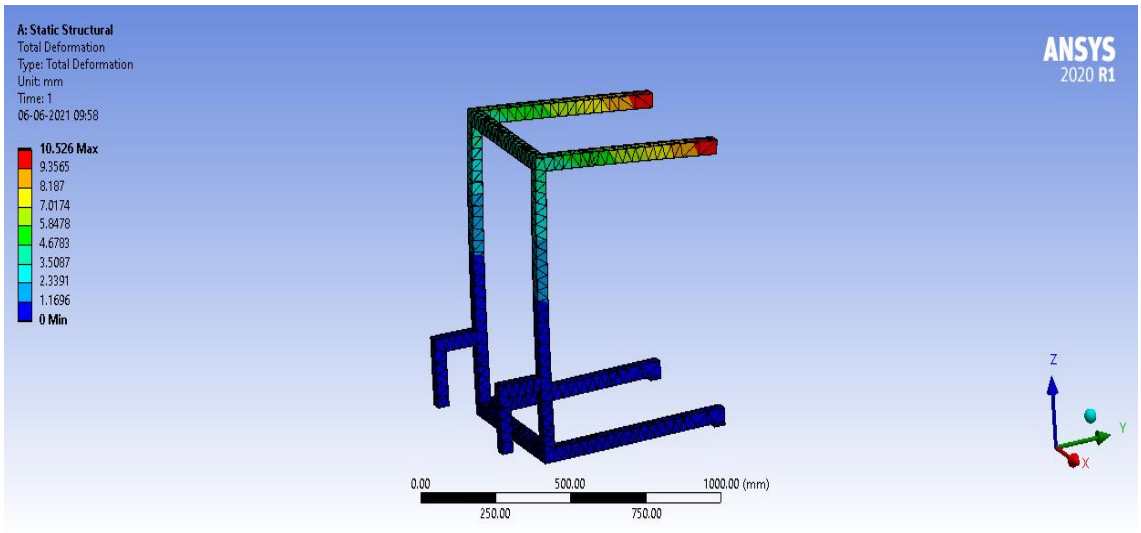

Figure 15: Total deformation

3.5 SHEAR STRESS

According to this theory, failure occurs whenever maximum shear stress induced in the component becomes equal to maximum shear stress in a tension of test specimen when the specimen begins to yeild. The maximum shear stress in the material is found with the equation stated below

$$\tau = \frac{\sigma}{2 * FOS}$$

$\tau = Shear\ stress\ at\ yield\ point$

$\sigma = stress\ at\ yield\ point$

FOS = 4.9 , σ = 350 Mpa So, Shear stress at yield point = 35.714 Mpa

As the Maximum Shear Stress is analyzed on vertical square pipe , the result obtained was that the maximum shear stress is experienced rear area of vertical square pipe with a value of 33.733 Mpa and minimum shear stress at blue area with a value of 0.023652 MPa . From the calculated value it iclear that the maximum shear stress induced in the component is less than that of maximum shear stress in the material at its yeild point.

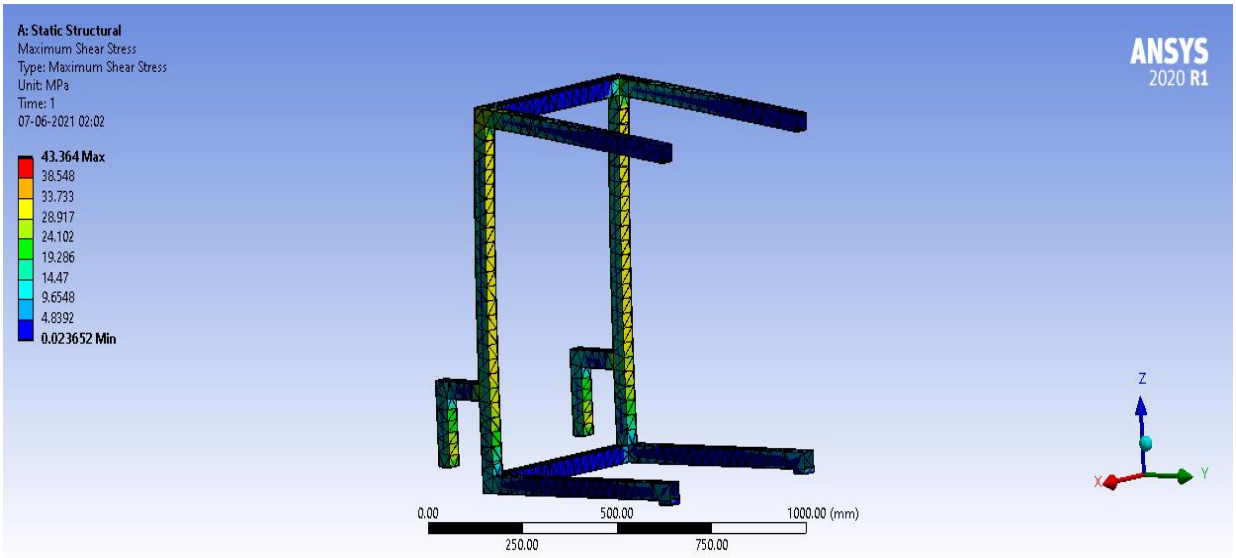

Figure 16: Maximum shear stress

3.6 COST ANALYSIS

Table 1: Cost analysis of multipurpose wheelchair

MATERIAL	AMOUNT
Thread rod and nut	Rs.600
1 ½ GI square pipe = 210 inch 1 ½ GI round pipe = 50 inch 1 ¼ GI round pipe = 50 inch	Rs.1500
Caster wheel	Rs.300
Thrust bearing	Rs.300
Seat work	Rs.500
Fabrication	Rs.1000
TOTAL	**Rs. 4200**

Total production cost of the project is RS 4200 only .As comparing the other products in the market like Electric patient lift, Entros Manual Patient Lifting Machine, has a cost of more than RS 25000 .so comparing the other products in the market multipurpose wheelchair have been low production cost [11,12].

IV. FABRICATION PROCESS

Metal fabrication is the process of building machines and structures from raw metal materials. The process includes grinding, cutting, burning, welding, machining, forming, and assembly to create the final product. Mainly three metal fabrication process are done throughout the manufacturing of multipurpose wheel chair.

- Grinding
- Cutting
- Welding
- Painting
- Stitching

4.1 GRINDING

Grinding is the process of removing metal by the application of abrasives which are bonded to form a rotating wheel. When the moving abrasive particles contact the work piece, they act as tiny cutting tools, each particle cutting a tiny chip from the work piece. Grinding is a subset of cutting, as grinding is a true metal-cutting process. Grinding is very common in mineral processing plants and the cement industry.

Figure 17: Frame after grinding operation.

4.2 CUTTING

Cutting is a common fabrication process used to the metal pipes into two or more pieces or smaller sections. In a lot of applications, the metal being cut is freshly made, and has yet to be shaped into anything in particular. In other applications, pre shaped metals like bars and measured panels are submitted for cutting. Cuts are performed on a range of machinery, from lasers and plasma torches to more elaborate, high tech piece pieces of machinery.

Figure 18: Cutting

4.3 WELDING

Along with cutting, welding is one of the most popular metal fabrication process among craft enthusiasts. The process of welding involves the joining of two separate metal parts. The parts used in a welding application could be sheets, panels, bars or shapes as long as the part are made of metal, it really doesn't matter. Welding is achievable through numerous methods and tools types. Often, a weld is achieved through the application of heat along the point where the two pieces are meant to be joined. A lot of metal workers first pursue the area of metal fabrication with welding projects in mind.

Figure 19: welding

4.4 PAINTING

Paint is the most commonly used material to protect steel. Paint systems for steel structures have developed over the years to comply with industrial environmental legislation and in response to demands from bridge and building owners for improved durability performance. Previous five and six coat systems have been replaced by typically three coat alternatives, and the latest formulations have focused on application in even fewer numbers of coats, but with increasing individual film thickness.

Figure 20: Frame after painting

4.5 STITCHING

Stitching is the process whereby fabric is fashioned into a finished product by means of different sewing techniques. The stitching stage holds extreme significance to ensure that the product takes its shape according to requirements. In itself a highly specialized field, stitching requires care and precision. Seat of multipurpose wheelchair is rexine stitched.

Figure 21: Stitched seat

V. LIFTING OPERATION

Figure 22: Paralyzed patient

Figure 23: Patient leaned to a side

Figure 24: Seat under patient position

Figure 25: patient back is raised

Figure 26: Wheelchair brought towards bed

Figure 27: Seat is attached to frame

Figure 28: Patient on wheelchair

Figure 29: Turning handle

Figure 30: Patient is lifted from bed

Figure 31: Moving patient away from bed

The patient lying on bed is made to lean to either one of side as shown in [figure 22]. The seat is moved towards the patient and the patient made to lie over the seat [figure 23]. The patient is made sit on the seat and faced towards the wheelchair [figure 24] and the wheel chair is brought near to the patient for attaching the seat to the frame [figure 25] .To prevent falling the patient is provided with a backrest and safety belt [figure 26] .The seat is connected to frame by buckling the four buckles of the seat to the wheelchair frame [figure 27]. [Figure 28] shows the patient on the wheelchair. By rotating the two handles are provided sufficient lift from the bed surface [figure 29] .Now after being lifted from the bed [figure 30]. The patient is moved easily [figure 31].

5.1 MULTIPURPOSE WHEELCHAIR

Since the wheel chair can be lifted and it can serve for more than one purpose. Some of the purposes are listed below:

5.1.1 INDOOR WHEELCHAIR

After a client is raised, patient allocation equipment works as indoor wheelchair or as sofa on wheels. The product is also a wheelchair that serve other purposes. A manually operated wheelchair an additional safety belt is also provided to prevent the falling of patients.

Figure 32: Indoor wheelchair

5.1.2 COMMODE CHAIR

This wheelchair can be used as commode chair. The patient is brought down so as to get seated on the toilet. This will be a great advantage for the patients as they face difficulties dealing with toilet use as caretakers too .for this both seat height and height of the upper frame can be adjusted until the specified height is met.

Figure 33: Commode chair

5.1.3 WALKER

Our product is well fitted for therapies especially for walking therapy. The wheelchair frame is in such a design that it provides support for patients who find difficulties when walking.

Figure 34: walker

VI. RESULT AND DISCUSSION

From this project, we designed and fabricated a better multipurpose wheelchair for the shifting of patients from bed to stretcher and vice versa with an affordable amount that will be more suitable in the Indian scenario. Analysis were done on wheelchair through both theoretically and practically.

The theoretical analysis as done on ANSYS 2020 .Maximum principal stress and maximum shear stress were obtained from ANSYS report .The maximum stress was found to be 71.385 Mpa and minimum of –12.733 Mpa .The factor of safety was obtained as 4.9 .According to maximum shear stress analysis it was found that a maximum shear stress of 43.364 Mpa and minimum of 0.0236 Mpa .When the deformation was analyzed a distance of 10.526 mm displacement were found. During practical analysis 110 kg weight were loaded and lifted by multipurpose wheelchair. The cost of multipurpose wheelchair is 4200, it is very low camparing to the electrical and manual wheelchair available in the international market.

The design was validated with the help of theories of failure in material .Since there are five of them here we took two of them .Which were maximum shear stress theory and maximum principal stress theory the maximum allowable stress should always be less than ultimate strength of the material for design to be safe .since we have used galvanized iron. It has ultimate strength of 350 Mpa .According to shear stress theory maximum shear stress induced in structure should be less than that of the material at yield point for deign to be safe .Through calculation the shear stress at yield point of material was found to be 35.0714 Mpa. The maximum shear stress induced in the structure is 33.733 Mpa which is less than the maximum shear stress of material in tension.

VII. CONCLUSION

The allocation of patients from bed to wheelchair is an exhausting job for caretakers. As of paralyzed patients may get obese, we are handling them will become a life threatening challenge for a person. As reports points out the number of injuries occurred to the caretakers while shifting patients, is very high. Even if there is highly advanced equipments, it is highly expensive beyond common patients can't afford. So we have come up with a budgeted advanced three in one wheelchair, with screw and nut mechanism. Which is quite cheap to build and easy maintenance. The total cost of the multipurpose wheelchair is very low comparing to the electrical and manual wheelchair available in the international market. The wheelchair will make shifting of patients to a far better way. One care taker can easily carry out the patient with no time and reduced complexity. As there is no direct contact with the patience during the shifting, disturbance caused is reduced up to an extent. Though our project is less expensive, it does not compromise with the service provided by the conventional equipment. This equipment can be easily portable and can be used in the hospitals, old age homes as well as in houses.

The upper frame of wheelchair can be raised to a distance of 20cm .This function is utilized effectively for transmitting of patient from bed to the wheelchair. Additional seat height can also be adjusted with the help of seatbelt . The linear upward motion is achieved through screw nut mechanism .For this the input rotational motional is given through the two handles provided at the top .It has additional daily life usages like commode chair, walking therapy etc.

There several modification that can be done on the wheelchair one of which is the using a screw thread of higher pitch which could help reduce number of rotation given on the handle as input .Material selected with some good material properties than iron which is used here result in reducing the weight of the equipment

.Replacing the screw nut mechanism with ball screw nut mechanism can greatly reduce the effort required to turn the handle .Hence the product have yet still more modification to be done which significantly helps the patients .

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