Modeling, analysis, and fabrication of load carrying equipment for elderly people

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ABSTRACT

Load carrying assistance is essential for elderly people at different places such as domiciles, hospitals, book shops, library etc. This paper aims to model, analyse, and fabricate load carrying equipment for elderly people with staircase climbing mechanism. Modeling of the equipment is completed using CATIA V5 R20. Maximum von Mises stress obtained for beam and frame is 35.6 MPa and 4.55 MPa respectively based on the analysis using CATIA V5 R20. Fabrication process involved several operations such as cutting, bending, drilling, grinding, welding etc. Machines used for these operations are laser cutting, drilling, grinding and welding. Total cost for completing the equipment is Rs. 13000. Post working analysis of equipment is satisfactory. In future, composite materials can be adopted in order to reduce overall weight of the equipment and rubber wheels can be employed to reduce vibration and to enhance smooth operation.

Key words*: Modeling, analysis, fabrication, load carrying equipment, elderly, CATIA*

1. INTRODUCTION

Carrying and moving various objects from one place to the other is always a difficult task within industry as well as in domicile (WSHC 2014; OHD 2007). Conversely, carrying weight usually cause injuries to humans (WSHC 2014). Injuries are caused not only by the increased weight but also due to the way of handling it and duration of use (OHD 2007). One way to reduce the risk is to practice ergonomic way of handling the weight (CDIR 2007; KellerOnline 2012). On the other hand, devices can be developed which reduce human effort (CDIR 2007; KellerOnline 2012). Aim of this paper is to design, analysis, and fabricate load carrying equipment for elderly people.

Hossain et al. (2010) modified the existing type of stair climbing wheels to a curved type wheel and found that it working efficiently if the stair angle is at 44^0 and the project was in view of developing a vehicle, which can climb staircase. Additionally, Gaikwad and Kadam (2013) constructed a hand-truck with stair wheel mechanism, which can be used for different sizes of stairs by altering the frame and also reported that mechanism will work efficiently when inclination of the stair is 44^0 and beyond this value, climbing was found impossible. Design and manufacturing of stair climbing hand truck with four wheels was demonstrated by Rathod et al. (2013) for a load of 1962 N and found that labour cost can be reduced considerably by employing this vehicle in library, book shop, hospitals etc.

Apart from this, Gangadia et al. (2015) modelled a stair climbing trolley for a load of 491 N and found some disadvantages such as high power consumption and working is noisier. Additionally, a stair climbing hand trolley was fabricated by a team of researchers for carrying heavy load near to 630 N using tri-star wheels (Praveen Raj et al. 2016). Focusing further, Gondole et al. (2016) designed and fabricated a hand trolley with stair climbing mechanism to carry a load of 539 N and found it can carry the load effortlessly through stairs. Furthermore, a light-weight trolley was developed for lifting load over staircase using tri-star wheel using Nylon 66 with a wheel diameter of 370 mm (Ajay et al. 2017).

Additionally, a domestic load carrier trolley was manufactured using tri-star wheel for climbing stair case and designed to withstand a load of 1962 N (Kumar et al. 2018). In addition to this, a trolley for carrying heavy loads equipped with tri-star stair climbing wheel was engineered for industrial and domestic purposes, which is designed to carry a load of 539 N (Kaviyarasu et al. 2018). Rajkumar et al. (2018) designed a universal trolley carrier for a load of 785 N with a stair climbing mechanism and found safe based on analysis using Workbench 14.5. Ravindar et al. (2018) fabricated a stair climbing trolley and analysis was carried out for a load of 9800 N using ANSYS 14.0. Based on the analysis, paper also reported that design found safe and trolley can carry heavy load with less effort.

Tri-star wheel is employed in most of the staircase climbing devices and maximum design load was found as 1962 N. Design load varies from 491 N to 1962 N. Paper reveals that further advancements are required in the field of stair climbing devices for different purposes both in industry and domestic. Here aim is to develop load carrying equipment for elderly people, which can also climb the staircase.

2. METHODOLOGY

2.1. Modeling

Conceptual Model of the load carrying equipment was completed using CATIA V5 R20. Figure 1 shows the conceptual model of load carrying equipment. Main components of equipment are frame, bearings, DC motor, battery, wheels, lead screw/screw rod, handle, hook, and spur gear.

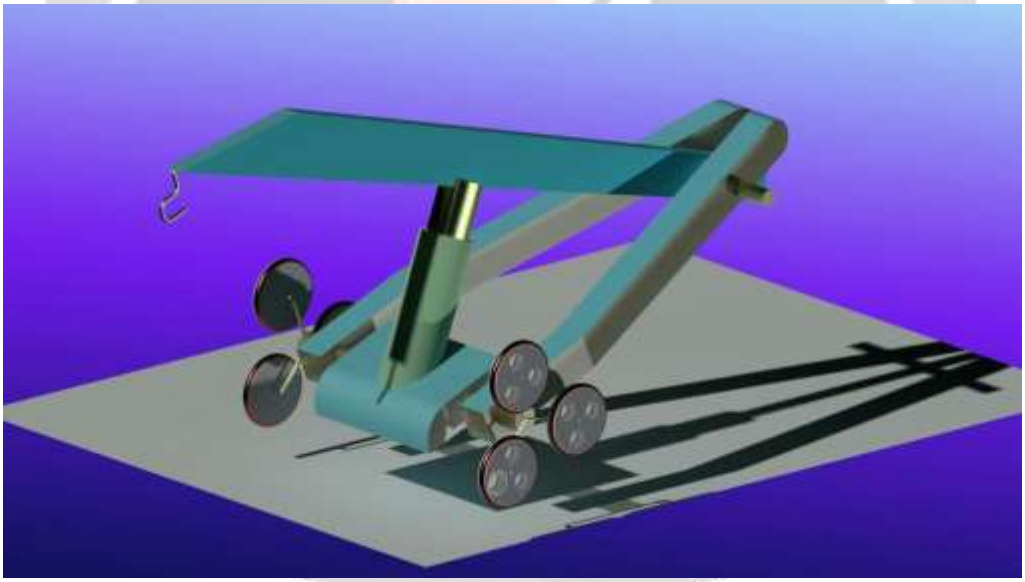

Figure 1 CAD Model of the equipment

2.2. Analysis

Analysis is carried out using CATIA V5 R20. Beam and frame is selected for analysis as the effect of load is highest on these two parts. Mild steel is used for fabricating both beam and frame. Von Mises stresses for beam and frame is shown in figure 2 and figure 3 respectively.

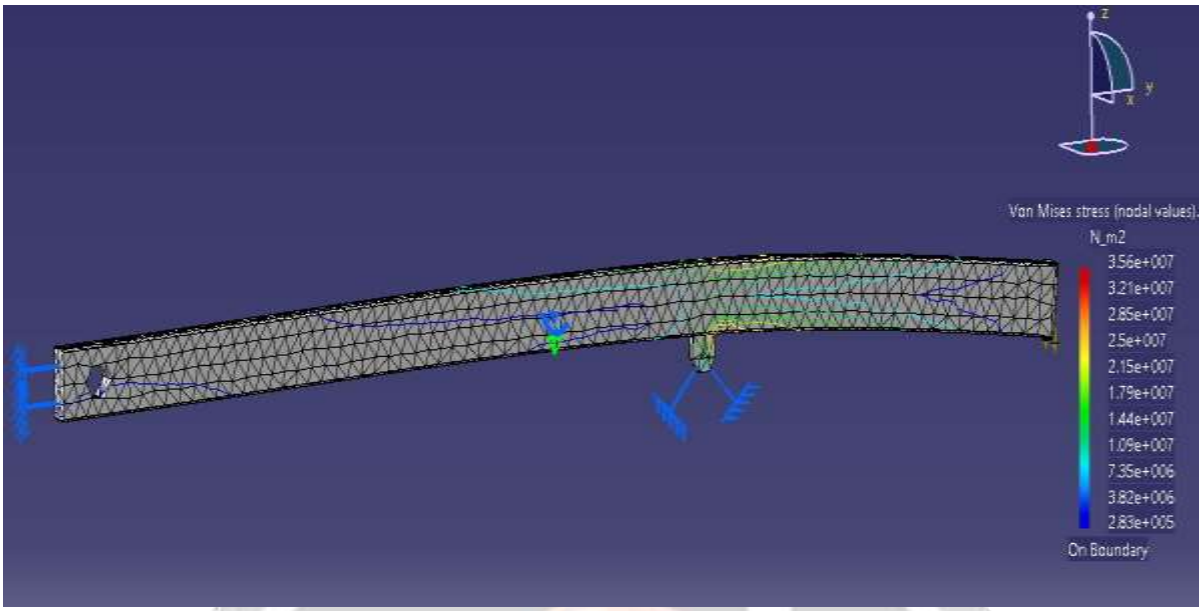

Figure 2 von Mises Stress in beam

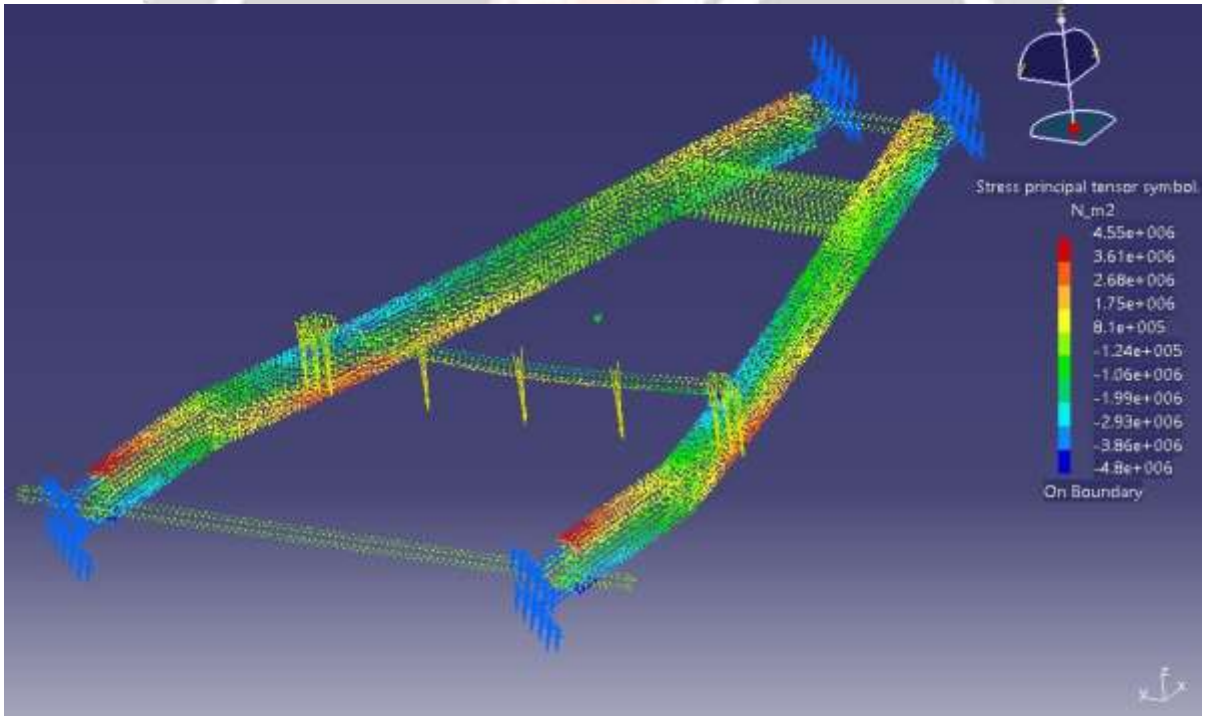

Figure 3 von Mises Stress in frame

Von Mises stress for both beam and frame were found safe based on the von Mises stress criteria. Von Mises stress criterion of failure in ductile materials is used for validating the results obtained from stress analysis of modified laparoscopic forceps handle, which states that the von Mises stress obtained from analysis should be less than the yield stress of the material (Chandrupatla and Belegundu, 2002).

Comparison of maximum von Mises stress for beam and frame with yield strength of mild steel is tabulated in table 1. It is evident from the table that maximum von Mises stress is well within the limit and members are found safe. Maximum von Mises stress obtained for beam and frame is 35.6 MPa and 4.55 MPa respectively.

Table 1 Maximum von Mises stress for beam and frame

SL No.	Component	Maximum Von Mises Stress (MPa)	Yield Strength of Mild Steel (MPa)
1	Beam	35.6	247
2	Frame	4.55	247

2.3. Fabrication

Fabrication process involved several operations such as cutting, bending, drilling, grinding, welding etc. Machines used for these operations are laser cutting, drilling, grinding and welding. Fabricated model of the load carrying equipment for elderly people is shown in figure 4. Equipment works satisfactorily and it is fabricated as a semi-automatic type.

Figure 4 Fabricated model of load carrying equipment

Total cost of load carrying equipment is detailed in table 2. Rs. 13000 is the total cost for completing the equipment. Highest cost is spent for developing frame. Purchasing spur gear cost less.

Table 2 Total cost of load carrying equipment

SL.NO	PART NAME	QUANTITY	AMOUNT (Rs)
1	Frame (MS)	1	3500
2	Lead screw (MS)	1	1000
3	Wheels (Polymer)	6	1500

4	Dc motor	1	2000
5	Battery (12Volt)	1	2000
6	Spur gear (MS)	1	1000
7	Bearings (Steel)	10	2000
Total Cost			**13000**

3. Conclusions

Modeling, analysis, and fabrication of load carrying equipment for elderly people is completed successfully. A tri-wheel staircase climbing mechanism is attached to the equipment to aid old age people to operate the equipment easily. Modeling of the equipment is completed using CATIA V5 R20. Computer aided analysis confirmed that the design is safe. Maximum von Mises stress obtained for beam and frame is 35.6 MPa and 4.55 MPa respectively. Total cost of the project is Rs. 13000.

In future, composite materials can be adopted in order to reduce overall weight of the equipment and provide more strength. Additionally, equipment can be further automated by using hydraulic cylinders and actuators. Furthermore, rubber wheels can be employed to reduce vibration and to enhance smooth operation. This equipment can be used by elderly people at domiciles, book shops, library, hospitals etc for carrying various types of load.

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