VIMAL JYOTHI ENGINEERING COLLEGE

APPROVED BY AICTE AND AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

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PROJECT WORK

DEPARTMENT OF MECHANICAL ENGINEERING

Contents

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DEPARTMENT OF MECHANICAL ENGINEERING
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DESIGN AND FABRICATION OF STAIRCASE CLIMBING MINI-FORKLIFT

A PROJECT REPORT

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Under the supervision of

Dr. SREEKANTH M P

(Associate Professor)

To

The APJ Abdul Kalam Technological University
In partial fulfillment of the requirements for the award of the Degree

Of

Bachelor of Technology In

Mechanical Engineering

Department of Mechanical Engineering

Vimal Jyothi Engineering College, Chemperi

MAY 2023

DECLARATION

We undersigned hereby declare that the project report **"DESIGN AND FABRICATION OF STAIRCASE CLIMBING MINI-FORKLIFT"**, submitted for partial fulfillment of the requirement for the award of degree of Bachelor of Technology of the Kerala Technical University, Kerala is a bonafide work done by us under the supervision of **Dr. SREEKANTH M P**. The submission represents our ideas in our own words and where the ideas or words of others have been included; we have adequately and accurately cited and referenced the original sources. We also declare and we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other university.

Place: Chemperi

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CERTIFICATE

This is to certify that the report entitled **"Design and Fabrication of Biomass Stove with Forced Jet of Air"** submitted by **AJITH JOHNY, JYOTHIS PRAKASH K, PRANAV PV,** and **ASRITH P** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the project work carried out by them under my guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

31/05/2023	31/5/23	02/06/2023
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To begin with we are submitting this Project in the divine feet of God Almighty "the satisfaction and euphoria that accompany the successful completion of any task will be incomplete without the mention of people who made it possible". We take this humble opportunity to thank all those who have inspired and motivated us to make the project a success.

We are grateful to our principal **Dr. Benny Joseph,** the leading light of our institution. We express our sincere thanks to the Head of the Department **Cdr. (Retd.) Raju K Kuriakose** for his consent and appropriate guidance throughout the project.

We take this opportunity to express our profound thanks and deep sense of gratitude to our project guide **Dr. Sreekanth M P**, Associate Professor in the Department of Mechanical Engineering for his kind advice and knowledgeable suggestions, which helped us to take our project to great heights of success. We also thank our project coordinators **Dr. Jithin E V**, Associate professor and **Mr. Mejo Francis**, Assistant professor in the department of Mechanical Engineering and **Management Executives** of college for the successful completion of this course.

Now we take our time to thank all the teachers of the college and our entire batch mates for their support and encouragement. We truly admire our parents for the success of our ventures.

ABSTRACT

Designing and fabrication of staircase climbing fork-lift is a unique model which will be the machine-front of the forklift industry and in turn will serve as a great helpful for domestic application. The design of the device is simple enough for all kinds of people to operate and also it is safer as compared to other machines. This is the most suitable machine for carrying loads up to 200 kg in any terrain. The machine consists of a frame where all the necessary components are attached. A simple winch is used for lifting the loads and wheels are attached to the frame for movement. A staircase climbing attachment is used for staircase climbing.

Keywords: Frame, Wheels, winch, staircase climbing attachment

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CHAPTER 1

INTRODUCTION

Forklifts are used to lift heavy loads. Forklift is a small industrial vehicle, having a power operated forked platform attached at the front that can be raised and lowered for insertion under a cargo to lift or move it. Forklifts serve the needs of various industries including warehouses and other large storage facilities. Stair climbing forklift is an extension of general forklift. These are used to transport loads on stair and uneven surfaces. It is used to transport loads with less effort. There need not be a heavy mechanism for stair climbing forklifts. This makes it ideal for use in homes and other buildings with multiple levels. Stair-climbing mini forklifts are typically smaller and lighter than traditional forklifts, making them easier to maneuver in tight spaces. There are a number of benefits to using a stair-climbing mini forklift for domestic applications. First, they can help to save time and effort when moving heavy objects around the home. Second, they can help to reduce the risk of injury, as they can be used to safely lift and transport objects that would otherwise be difficult or dangerous to move. Third, they can be used to transport objects that are too large or heavy to be moved by hand, such as furniture or appliances.

CHAPTER 2

LITERATURE SURVEY

N. Yuviler-Gavish et al. (2023) conducted research and developed a dynamic mimicking system that mounts a user's wheelchair onto a carrier platform capable of performing required maneuvers using the wheelchair's own controls. Two wheelchair user studies were performed to evaluate users' perception of their own wheelchair and the proposed system. The first user study included ten wheelchair users who were interviewed in order to map their current perceptions toward their wheelchair and their views about its shortcomings when traversing rough terrains. In the second study, the system was explained to 33 participants who were then exposed to three simulations of its main features. Participants were interviewed and the experimenter wrote down their answers, which were analyzed using IBM SPSS Statistics 27 software. The conclusions are that special consideration should be given to motorized wheelchair users, and that the designers of the system should include a user interface that explains and demonstrates the system to users.

Saurav Patil et al. (2022) carried out research and fabricated a Battery-Operated fork lift that is an improved version of regular forklift lifting and carrying the load which needs to be transferred from one place to another. This advanced technology has brought a new revolution in the mechanical industries and is most commonly used in heavy Engineering companies. These forklift vehicles had revolutionized ware-housing practices used in the middle of the 20th century. For a long time, semi- automatic types of material handling systems were used. In semi-automatic material handling, the system was manually controlled. These well maintained and safely operated forklifts have made lifting and transporting cargo items very easy. The main purpose of this paper is to design and fabricate a forklift machine which is new and different from existing designs. This designed forklift uses a rechargeable battery which means it is powered completely by electricity.

Z. Ahmad Bhat, J. Ashraf, S. Gupta et al. (2021) found that, nowadays, a number of mechanisms are available to carry heavy objects on the staircase for normal working operations. However, these mechanisms are facing a common problem of slippage while moving onto the staircase. This research work proposes a design of stair climbing trolley with an automatic anti-slippage mechanism to overcome the aforementioned problem. In this design, a four-arm wheel mechanism with braking pins was proposed that restricted the individual movement of wheels while climbing the stairs. These braking pins are attached with rack and pinion arrangement and operated by a motor installed in the control unit. Two proximity sensors were also installed on the control unit, which generally detect the staircase in the path and turn on the DC motor to apply brakes to all the wheels. Through this mechanism, while carrying the heavy objects on the stairs/staircase, slippage chances can be avoided. During the normal shifting, this braking system is released and one can transfer the material on the normal surface, like a normal operational trolley.

H. Ikeda, T. Toyama, D. Maki et al. (2021) developed an automatic control system that allows an assistive robot pushing a wheelchair to climb steps. The robot is equipped with a wheeled mechanism and dual manipulators. The wheelchair is a commercially available model that has been equipped with sensors, circuits, and batteries. The robot and wheelchair are connected when the vehicles climb a step. In that operation, the front wheels of the wheelchair are lifted and placed on the step using the velocity differences between the wheelchair and the robot. Next, when the rear wheels of the wheelchair ascend the step, the robot imitates the upper arm motions of a human pushing against his/her chest that commonly occurs when maneuvering a wheelchair up a step. Similarly, the front wheels of the robot are lifted and placed on the step using the velocity differences between the vehicles and the robot's front wheels. After that,with the assistance of the wheelchair, the other wheels of the robot climb onto the step. In an effort to ensure safety, we also performed a theoretical analysis to determine the most suitable distance for lifting the front wheels of the robot when approaching and climbing a step. The newly developed cooperative step-climbing system makes it possible to eliminate the complicated operations that were required by previous methods and can also prevent collisions between the wheelchair's front wheels and the step, thus drastically improving the convenience of the operation. The test subject riding the wheelchair was an able-bodied male, and the experiment conducted to evaluate our system was performed on a 120 mm step height that had a friction coefficient of 0.72. This setup was sufficient for demonstrating the overall effectiveness of our system.

Sulguti Sai Phani Kumar Reddy et al. (2021) identified that there is no great change in the availability of sophisticated wheelchairs to the common people. The economic or below economic classes of India are suffering with the exorbitant prices for sophisticated or reliable models of wheelchairs. The basic issue, which is found these days is the inability of the wheelchairs to pass through different terrains. Furthermore, the common wheelchairs are not manufactured with the purpose of climbing the stairs. The evolution of the wheelchair has been governed by a notion of comforting diversified users and their accessibility. To solve this problem a deep study of pre-existing models and their disadvantages have been studied and developed.

Manish Prajapat et al. (2020) developed an add-on device for staircase climbing wheelchairs. Motorized designs of stair-climbing wheelchairs available in western countries are heavy and expensive, and hence, unsuitable for developing countries. Manually operated solutions for stair-climbing wheelchairs also tend to be bulky and complex. As stair-climbing is an occasional activity for wheelchair users, having a built-in stair-climbing mechanism result in complexity and redundancy. In this work, an add-on device is envisaged, which requires the wheelchair to be mounted onto the add-on only when stair-climbing is needed. This work developed a Hex-wheel mechanism to address the demerits of the Y-wheel mechanism commonly used in load carriers, as well as to improve usability for stair-climbing. Furthermore, a suitably designed actuation mechanism was applied to the Hex-wheel to enable manual operation. Finally, a prototype of the stair-climbing add-on device was built to validate the developed mechanisms. The force required to operate the device was measured and found to be within 10% of the predicted theoretical value. The novel design provides a solution manually operable by an assistant, which is cost-effective and independent of wheelchair type to improve accessibility in low-resource settings.

Youngsoo K et al. (2019) established a fast staircase climbing wheelchair with an advanced curved spoke tri-wheel mechanism. Stairs are common obstacles in indoor environments and are difficult to overcome for robots. The speed of robot stair-climbing should be similar to that of humans for commercial products, but their speed remains limited. Additionally, the variety of dimensions of stairs is also a significant problem for robust stair-climbing by robots. In this paper, a curved spoke-based tri-wheel mechanism is proposed for fast and robust stair-climbing. The goal speed of stair-climbing is similar to the human speed for variously sized stairs. The proposed wheel system is composed of a tri-wheel mechanism with a curved spoke, wherein the dimensions of the mechanism are determined based on a kinematic analysis. Between the tri-wheels, a stopper mechanism acts to make the initial condition of the sequential stair-climbing the same as the initial starting condition. Static analysis to analyze the minimum friction coefficient is performed to verify the performance of the robot. Experiments based on the prototype are performed to verify the stair-climbing speed for variously sized stairs; the results indicate that fast and robust stair climbing performance is achieved. These findings can be used to design an indoor service robot for various applications.

Snehita Kilari et al. (2019) constructed a tri-wheel staircase climbing hand trolley. Simple mechanical devices like hand trolleys with single and dual wheels are finding their use in a large number of industries as well as for household purposes. But their usage is limited to carry goods along the floors from one location to the other. Out of the formulated designs that are available in the market, no design fulfills the need of support in shifting the load over stairs. To eliminate this difficulty, stair wheels (combination of three wheels) are used as a substitute which will reduce the effort of lifting. The present paper focuses on the design and manufacturing of a tri-wheel stair climbing hand trolley to move along rough surfaces and to transport considerable loads over stairs with the improved wheel arrangement, with comparatively less human effort & manufacturing cost. The design concerns including steepness of the stairs, steadiness and speed of the trolley while climbing the stairs are discussed. Hybrid trolleys such as tri wheeled ones can be adopted to carry several items at various locations where mechanical elevators cannot be installed.

Mr. Pratik H. Rathod et al. (2013) dealt with the designing and manufacturing of a hand truck, which can climb stairs with less effort compared to carrying it manually. The technical issues in designing this vehicle are the stability and speed of the vehicle while climbing stairs. However, the steepness of the stairs is also an important concern of this study. The uses of this special vehicle are in the frequent lift of goods such as books for library, medicines for hospital, regular goods of any technical or non-technical institutes, or transportation of any toxic material for industries and give freedom to the retarded person or paralyzed patients to move anywhere over flat surface as well as stairs. The vehicle has four-wheel arrangements to support its weight when it moves over the flat surface. Each set wheel frame consists of three wheels attached with a nut and bolt. Using this vehicle, the labor cost can be reduced as well as huge loads can be transferred uniformly with less power consumption.

Pravat Kumar Behera et al. (2018) introduced a simple and novel mechanism for wheelchairs that assists in climbing stairs. The design mechanism consists of two 2 degrees of freedom legs. Each leg consists of two four bar linkages joined to each other in a certain manner. Each leg is fitted with two actuators which assist the chair to move the legs as required. The proposed design has statically stable leg motion with adjustable height. Inverse kinematics analysis has been performed and the position values for each leg is determined. The Sitting position remains horizontal on climbing ensuring the comfort of the person. This would assist in resolving the balancing issues while climbing the stairs through a wheelchair.

Giuseppe Quaglia et al. (2017) presented a new version of Wheelchair with stair climbing ability. The wheelchair is able to climb single obstacles or staircases thanks to a hybrid wheel leg locomotion unit with a triple-wheels cluster architecture. The new concept presented in this work represents an improvement with respect to previous versions. Through a different arrangement of functional elements, the wheelchair performances in terms of stability and regularity during movement on stairs have been increased. In particular, attention has been paid to ensure a regular and comfortable motion for the user during stair climbing operation. For this reason, a cam mechanism has been introduced and designed with the aim to compensate for the oscillation generated on the wheelchair frame by the locomotion unit rotation. A design methodology for the cam profile is presented. Moreover, a parametric analysis on the cam profile and mechanism has been conducted with the aim to find a cam profile with suitable dimensions and performances in terms of pressure angle and radius of curvature.

O.J.Oyejide et al. (2020) focused on the development of a flexible and intelligent sensor controlled convertible cart-trolley to support physical distribution of goods. Transporting of homogeneous and heterogeneous commodities is a common trend in laboratories, offices, supermarkets, warehouses and industrial settings. In developing countries, handling and transporting of materials are usually done using manually operated trolleys. Such practice could be time consuming and laborious, thus this research. The unique design consists of three mechanisms, designed such that: when stretched, the system turns to a cart; when tilted it turns to an incline cart with flat plate attached to make payloads stable and when folded it turns to a trolley. Both the steering and the driving of the trolley are controlled by the two wiper motors, which are attached to the two wheels and powered by 12V DC batteries. The circuit board consists of Wireless Module (ESP8266EX), relays, and wires. The wireless module (ESP8266EX) serves as the microcontroller housing the commands to be executed by the cart, while the relay controls the amount of current released by the batteries to the motors and the circuit in general. The Wireless Module (ESP8266EX) serves as a receiver. The car trolley was developed and tested, the result showed that the machine throughput capacity and efficiency were 550.37 kg/hr. and 52.2 % respectively.

Michael Hinderer et al. (2017) developed a new technology which can be utilized in wheelchairs or robots that can overcome stairs independently and safely. It is an autonomous based leg mechanism that consists of two legs with lower and upper leg support. As there are very different stair geometries, the wheelchair must have an adaptable climbing function so that it can automatically adapt to the stair conditions. The stair scanning is based on ultrasonic-distance sensors so that the wheelchair is able to climb different stair geometries. Due to dynamic stabilization, the wheelchair moves on only one axis. Thereby, it has highly agile driving behavior and is compact in size. While climbing a stairway, the legs push the wheelchair on the next higher situated step. Afterwards the legs are pulled successively on to the next step as well. While climbing down, the opposite sequence of movements occurs.

P.Jey Praveen Raj et al. (2016) fabricated a mechanism for easy transportation of heavy loads over stairs. Devices such as hand trolleys are used to relieve the stresses of lifting while on flat ground which is restricted to stairs. Thus, the design of a stair climbing trolley can carry heavy objects up the stairs with less effort compared to carrying them manually. The main objective of the project was to find an efficient and user-friendly method of carrying various objects through stairs using minimum effort from the user and to also provide a smooth movement while climbing the stair. Under the project a stair climber was manufactured with tri lobed wheel frames at both sides of the climber and three wheels on each side are used in the tri lobed frame. The wheel assembly is rotated by a gear- motor mechanism where a DC gear motor is used to provide the necessary power for rotation and a pinion-gear mesh is used for reducing the rotating speed of the wheel. The motor is connected to a lead acid battery of similar ratings and they are in turn connected to the DPDT switch.

Roshan Alaspure et al. (2016) developed a mechanism for effortless transportation of heavy loads over stairs. Using this vehicle, the labor cost can be reduced as well as a large amount of load can be transferred uniformly with less power consumption thus our project introduces a new alternative for transportation of load over the stairs. It was designed in such a way that it can climb a stepped path with its modified wheel structure. In this concept a set of three wheels on either side of the vehicle rather than single or double wheel. The plate which is mounted on the base is movable. The Design is made in such a way that it requires only minimum human effort.

Mr. Pratik H. Rathod et al. (2013) designed and manufactured a hand truck, which can climb stairs with less effort compared to carrying it manually. The uses of this special vehicle are in the frequent lift of goods such as books for library, medicines for hospital, regular goods of any technical or non-technical institutes, or transportation of any toxic material for industries and give freedom to the retarded person or paralyzed patients to move anywhere over flat surface as well as stairs. The vehicle has four-wheel arrangements to support its weight when it moves over the flat surface. Each set wheel frame consists of three wheels attached with a nut and bolt. Using this vehicle, the labor cost can be reduced as well as huge loads can be transferred uniformly with less power consumption.

G. Quaglia et al. (2011) established a Wheelchair with the concept for a stair climbing wheelchair capable of moving in structured and unstructured environments, climbing over obstacles and going up and down stairs. The design of the wheelchair, consisting of a frame, a seat and a four-bar linkage mechanism that connects frame and seat, is presented. The four-bar linkage moves and rotates the chair to prevent the wheelchair from overturning and to guarantee a comfortable posture to the passenger during different operations. The kinematic synthesis of the linkage mechanism is discussed using an algebraic method. When the wheelchair faces an obstacle such as a step or a stair, it can passively change locomotion mode, from rolling on wheels to walking on rotating legs, thanks to its self-adaptive locomotion units. The function of the locomotion unit is described and modeled using kinematic equations. The locomotion unit requires only one motor, for both wheeled and legged locomotion. Tests on a scale prototype were conducted in order to evaluate the effectiveness of this locomotion.

R. Morales et al. (2010) conducted research on mechanical devices, control schemes and the trajectory generation of which a new wheelchair prototype capable of climbing staircases is formed. The key feature of the mechanical design is the use of two decoupled mechanisms in each axle, one to negotiate steps, and the other to position the axle with regard to the chair in order to accommodate the overall slope. This design simplifies the control task substantially. Kinematic models are necessary to describe the behavior of the system and to control the actuated degrees of freedom of the wheelchair in order to ensure the passenger's comfort. The choice of a good control scheme based on a local and a global trajectory planner simplifies control, decreases power consumption, reduces the time invested in traversing the obstacles and maintains passenger comfort throughout all movements. After studying the time outs in the staircase climbing/descent process due to configuration changes, they started to increase the capabilities of the trajectory planner in order to reduce the time invested in traversing obstacles. The optimization algorithm is only used in the period of time in which configuration changes are being produced. More specifically, they have used the special properties of the mechanical configuration, the kinematic model and the trajectory planner to develop an improvement in the trajectory planning based on complex notation. The new optimized algorithm solves a nonlinear problem in order to discover an auxiliary center of mass route which is free of obstacles, through the work environment of the wheelchair prototype. Additional properties of the new optimization algorithm are: (a) the resulting analytical expressions are closed (iterative calculation is not necessary); (b) it is easy to implement in the real prototype and (c) it can be executed in real time. Experimental results are reported which show the behavior of the prototype as it climbs a staircase both when using the original trajectory planner and when using the new obstacle avoidance optimization algorithm explained. The results obtained illustrate a high percentage of time reduction and the maintenance of comfort levels. However, the control prototype becomes more complicated, the power consumption is increased and the comfort level is slightly lower.

2.1 CONCLUSIONS FROM LITERATURE SURVEY

From the various journals that were referred, different models that are used for climbing stairs are studied. The main challenge for developing staircase climbing mechanisms in most of the cases was the stability and reliability. Different types of wheels were used to assist climbing stairs. Design of stair climbing mechanism with an automatic anti-slippage mechanism to overcome the problem faced during climbing of stairs was studied. The main objective of the majority of journals referred to was to find an efficient and user-friendly method of carrying various objects through stairs using minimum effort from the user and to also provide a smooth movement while climbing the stair. The design concerns to be considered while designing the staircase climbing mini forklift were the steepness of the stairs, steadiness and speed at while it climbs the stairs.

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CHAPTER 3
PROBLEM DEFINITION

3.1 PROBLEM DEFINITION

Factories, industries and godown need forklifts and cranes for storage and moving large goods. But there is also a number of goods weighing around 10 – 200 kgs that are comparatively lighter but cannot be moved around easily by human labor and the same lifting and transport of such small weights is there in households, small shops etc.

3.2 SOLUTION

So, this project proposes the idea of a staircase climbing mini forklift which can be used outdoors and indoors. The mini forklift will be able to carry weight up to 200 kg. The staircase climbing feature will be very helpful for easily adapting to indoor situations.

3.3 AIM AND OBJECTIVES

AIM

To design and fabricate a staircase climbing mini forklift for domestic application which can lift a weight of 200 kg.

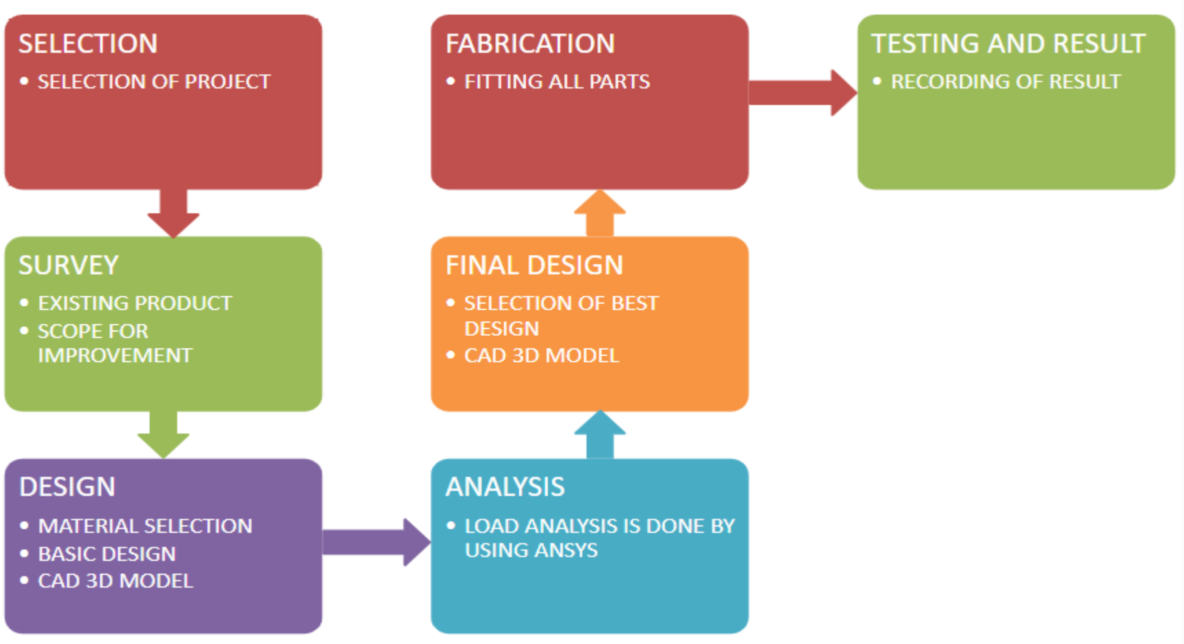
OBJECTIVES

1. To develop possible designs for forklift and select the feasible one.
2. To analyze the platform of the mini forklift and select the material.
3. To fabricate and test the mini forklift.

CHAPTER 4

METHODOLOGY AND WORKPLAN

4.1 METHODOLOGY



The methodology for the project report begins with the selection of the project which includes the selection of the existing product and the scope for improvement. The selection process should include an evaluation of the existing product and the scope for improvement. This helps to identify the areas where the product can be improved and the design criteria which must be met. After the selection of the project is done, a survey is conducted to determine the materials and basic design of the project. This includes the selection of the material based on the expected load and the exact dimensions of the project. The material should be chosen based on the anticipated load and environment in which the project will be used. The survey process should also include the identification of potential weak points and areas of stress concentration.

Once this is done, a CAD 3D model is created to be used in the analysis. The CAD 3D model helps to visualize the structure and also helps to identify potential weak points and areas of stress concentration. The load analysis is then done using ANSYS. This involves the application of the load to the structure in order to determine the deformation and stresses caused by the load. Various types of loads can be used for the analysis such as point loads, distributed loads, and boundary conditions. The results obtained are used to select the best design. The safety factors, yield stress, and other design parameters are calculated to ensure that the structure can withstand the applied load without any issues.

After the best design is selected, the components required for the project are purchased, and all the parts are fitted together. This includes the fitting of the elements together and the adjustment of the load-bearing members. If required, additional components can be added to improve the performance of the structure. The components should be chosen based on their strength, durability, and compatibility with the materials used in the project. Finally, the testing and results are recorded and compared to the design specifications. If required, the parameters are adjusted to ensure that the structure meets the design requirements. The testing process should include both static and dynamic tests to evaluate the performance of the structure under various conditions. The results of the testing should be recorded, and a report summarizing the results should be generated. The report includes the stress distributions and loads, as well as the total deformation values. This provides valuable insight into the performance of the structure, and enables the engineer to make informed decisions regarding the design and construction of the structure.

4.2 WORK PLAN

Table 4.1 Work Plan

WORK PLAN		S7					S8			
Sl. No.	Activities	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	Literature Survey									
2	Designing of system									
3	Modelling									
4	Analysis									
5	Material Selection									
6	Cost Estimation									
7	Purchasing Material									
8	Fabrication									
9	Trial Test & Validation									
10	Product Feedback									
11	Report Writing									

CHAPTER 5

DESIGN PROCESS

5.1 DESCRIPTION ABOUT THE PROPOSED DESIGNS

5.1.1 MODEL 1

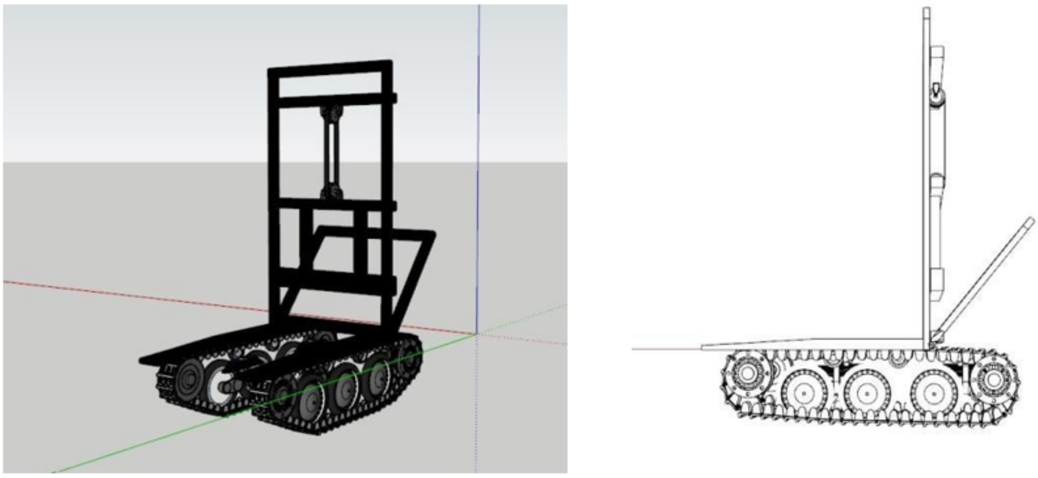


Fig 5.1 Design of model 1

In this model, a belt drive mechanism is used for movement of the mini forklift (Figure 5.1). It can be used in all terrain. It is very suitable for outdoor and indoor applications. When the motor rotates the roller attached to it rotates which causes the belt to move around the roller and hence enabling the mini forklift to move. The problem with this design is its complexity and the increased cost of manufacture.

5.1.2 MODEL 2

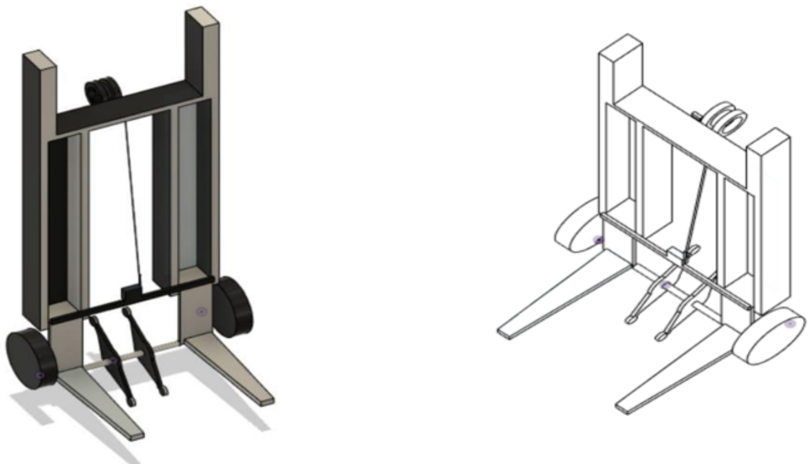


Fig 5.2 Design of model 2

Here, the parallelogram shaped structure which is connected with the shaft is made to rotate by the electric motor (Figure 5.2). The structure pushes the mini forklift to move upward during the climbing of stairs. It uses a simple mechanism. The effort required by the user for movement of mini forklift through the stairs can be reduced significantly by using this design. The main disadvantage of this design is that it lacks stability and there are chances for falling while moving by carrying load.

5.1.3 MODEL 3

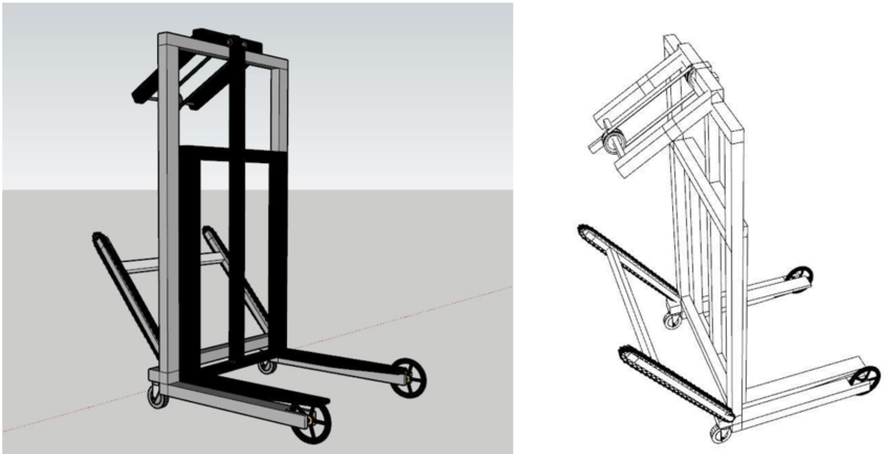


Fig 5.3 Design of model 3

Separate wheels are provided in this design for moving the mini forklift through ordinary terrains and staircase (Figure 5.3). Normal wheels are provided for moving through ordinary terrain and for climbing staircase belt wheel drive are provided. It can move through all terrains. As a separate mechanism is provided for moving through stairs and outdoors, it is not very user friendly.

5.1.4 MODEL 4

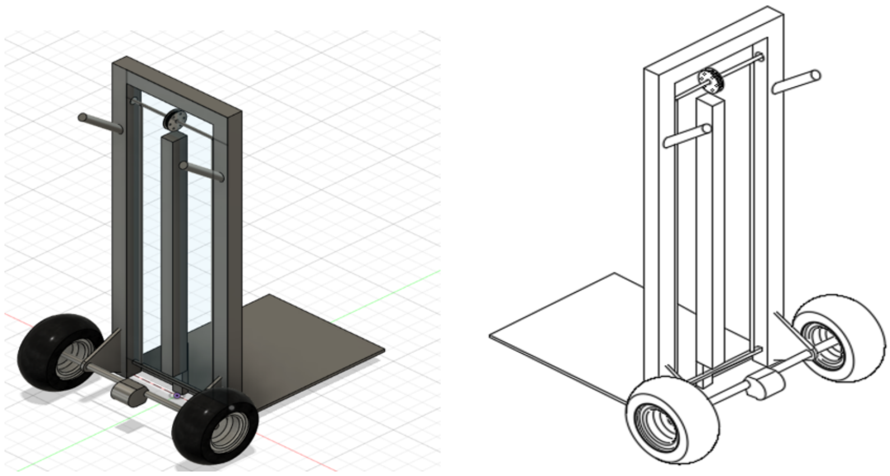


Fig 5.4 Design of model 4

In this design, a special attachment is used to connect wheels and the shaft (Figure 5.4). This attachment can freely rotate with the shaft and enables the user to carry out the movement of the mini forklift effortlessly through any type of terrain. Winch mechanism is used for lifting the plate. The model is very simple and user friendly. It is a cost-efficient model and thus affordable to ordinary people.

5.1.5 MODEL 5

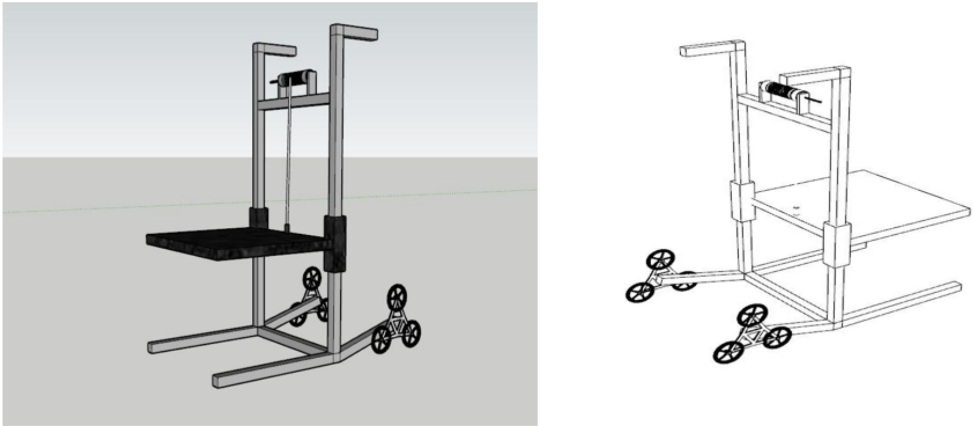


Fig 5.5 Design of model 5

Three wheels are connected in the form of a triangle which helps the mini forklift for movement in this model (Figure 5.5). It is a very simple mechanism that has been used since earlier times. As it is simple it is easy to manufacture hence the cost can be reduced. The main disadvantage of this model is it is not suitable for outdoor applications.

Table 5.1 Comparison of proposed models.

MODEL	ADVANTAGES	DISADVANTAGES
MODEL 1	Can move through all terrain.	Complex mechanism, Costly.
MODEL 2	Simple mechanism.	Lack of stability.
MODEL 3	Can be used in all terrains.	Costly, difficult to operate.
MODEL 4	Simple mechanism.	Not suitable for outdoor application.
MODEL 5	Simple, Economical, Stable.	Effort required.

Table 5.1 tabulated the comparison of proposed models of stair climbing mini forklift. Based on the comparison, model 5 is selected because of the factors such as:

1. safety and reliability
2. economical
3. stability in stair climbing

5.2 FINAL DESIGN

The design of the stair climbing mini forklift is finalized by making some modifications in the model 5. The winch is replaced by lead screw by considering factors like cost and unavailability of small – scale winches. The tri – wheel mechanism is moved slightly forward to frame to increase stability during climbing stairs. The handle is placed behind the frame at hip level parallel and same in length as frame width to reduce effort and increase comfort while handling the mini forklift. The modified design is shown in the figure 5.6. Also, figure 5.7 illustrated the significant dimensions of the final design.

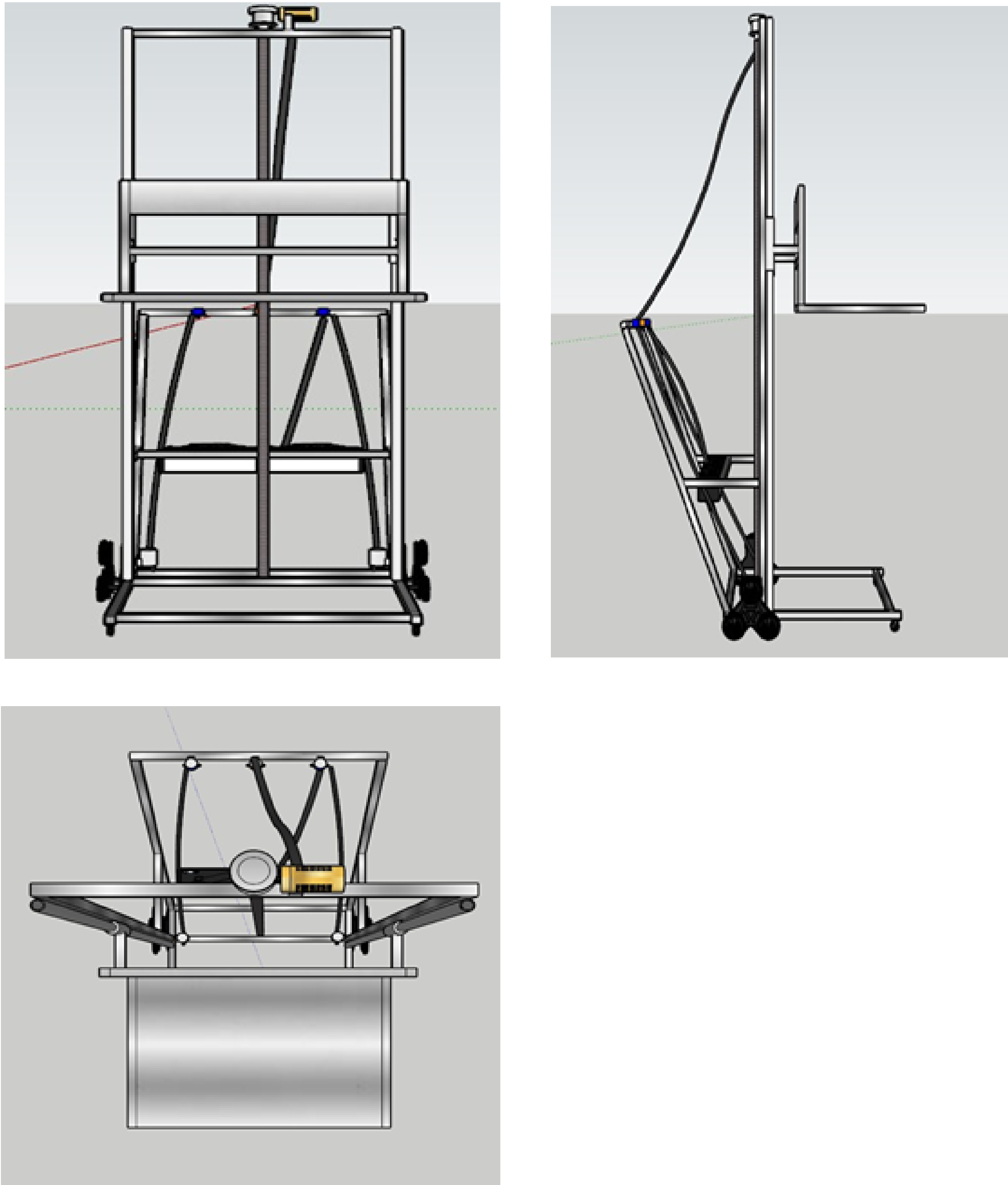


Fig 5.6 Front, Top, and Side Views of Final Design

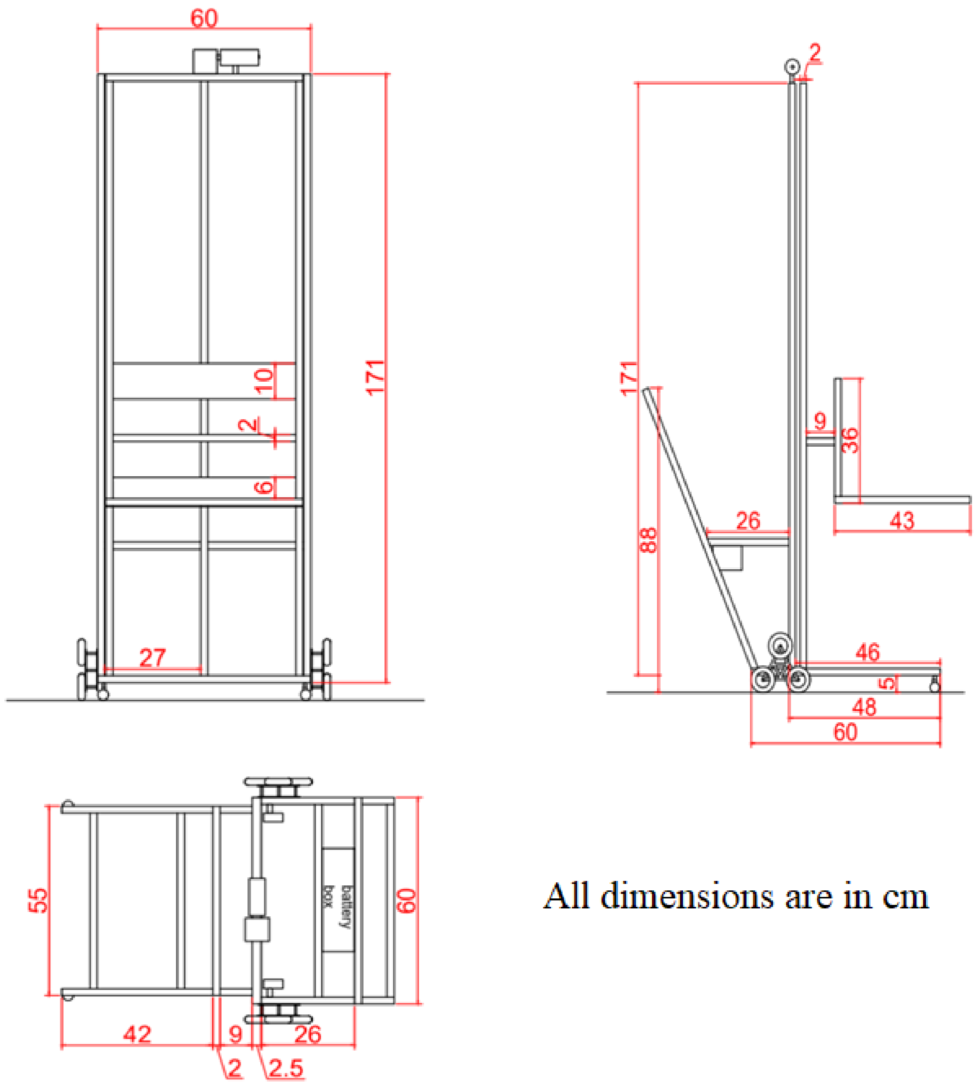


Fig 5.7 Front, Top, and Side Views of Final Design with Dimensions

CHAPTER 6
DESIGN CALCULATIONS

6.1 SELECTION OF MOTOR

Power = Torque x Angular velocity

Angular velocity, w = $2\pi N/60$

= $(2\pi\times75)/60$

= 7.853 rad/sec

Force on forklift, Ff = 30×9.81 = 294N

Maximum load force, Fl = 200×9.81 = 1962N

Force on Wheel = Ff +Fl

= 294+1962=2256N

Load on each wheel = 2256/2=1128N

Torque = F×(D/2)

= 1128 × (12.7×10^-2)/2

= 1128×0.0635

= 71.628 Nm

Power = 71.268×7.853

= 562.4946 W

This is equivalent to 0.75 hp (hence, selected 1 hp motor)

6.2 SELECTION OF BATTERY

Current =Power/Voltage

Voltage = 12v

= 563/12

= 46.91 Amperes

12v, 50 Ahr Battery is select

CHAPTER 7

ANALYSIS

7.1 ANALYSIS OF PLATFORM

In this project, performed an ANSYS Workbench analysis of a rectangular platform, which carries the weight of the forklift with dimension 400*500 mm. Analyzed the plate with various thicknesses of 4 mm, 5 mm, 6 mm, 8 mm and 10 mm by applying a load of 2000 N. The objective of this analysis was to select the thickness of the platform and material. Static structure analysis is conducted here using ANSYS Workbench 2022 R2 Student version and the bottom face of the platform is fixed and load is applied on the top face. Element type is SOLID 186 (quadrilateral) with an element size of 0.4 mm (used the same in all analysis).

The following steps were taken to perform the analysis:

1. Open ANSYS Workbench.
2. In the LaunchPad, select Static Structural.
3. In the Model tree, right-click on Geometry and select Create.
4. In the Create Geometry dialog box, select Rectangle and click OK.
5. In the Geometry dialog box, enter the following dimensions:

   Length: 400 mm

   Width: 500 mm

   Thickness: 4 mm, 5mm, 6mm, 8mm, 10 mm (according to case)

   Click OK.
6. In the Model tree, right-click on the plate and select Assign Material.
7. In the Assign Material dialog box, select Structural Steel and click OK.
8. In the Model tree, right-click on the plate and select Mesh.
9. In the Mesh dialog box, select AutoMesh and click OK.
10. In the Model tree, right-click on the plate and select Loads.
11. In the Loads dialog box, select Uniform Load and click OK.
12. In the Uniform Pressure dialog box, enter the following values:

    Force: 2000 N

    Direction: X

    Click OK.
13. In the Model tree, right-click on the plate and select Solve.

14.	In the Solve dialog box, click OK.

The results will be displayed in the Results window after the analysis. Figures 7.1, 7.2, 7.3, 7.4, and 7.5 illustrate the von Mises stress and deformation of the platform with 10mm, 8 mm, 6 mm, 5 mm, and 4 mm respectively.

Figure 7.1 shows the von Mises stress and deformation of the platform with thickness 10 mm. 43.68 MPa is the maximum von Mises stress and 1.80 mm is the maximum deformation obtained.

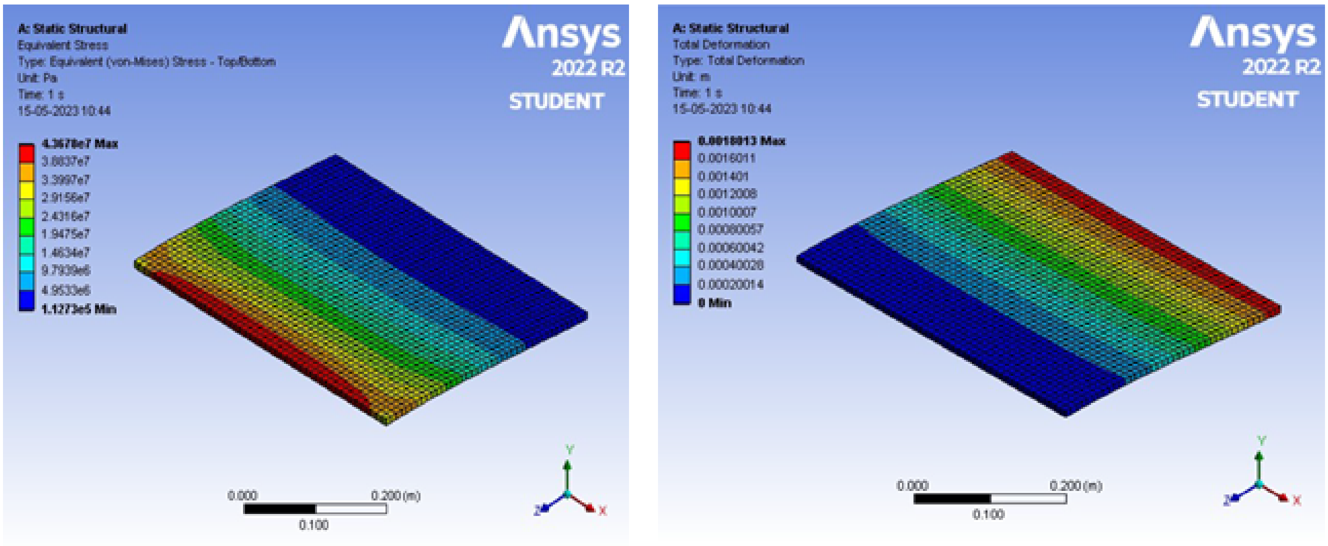


Fig 7.1 Von-mises stress and total deformation (10 mm)

Figure 7.2 shows the von Mises stress and deformation of the platform with thickness 8 mm. 68.22 MPa is the maximum von Mises stress and 3.52 mm is the maximum deformation obtained.

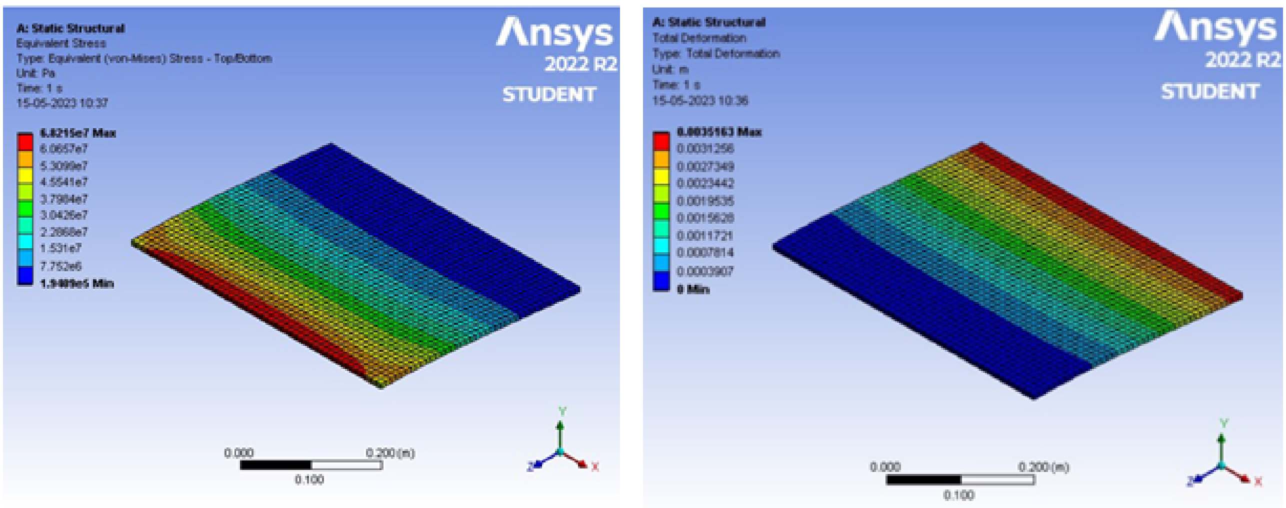


Fig 7.2 Von-mises stress and total deformation (8 mm)

Figure 7.3 shows the von Mises stress and deformation of the platform with thickness 6 mm. 121.22 MPa is the maximum von Mises stress and 8.33 mm is the maximum deformation obtained.

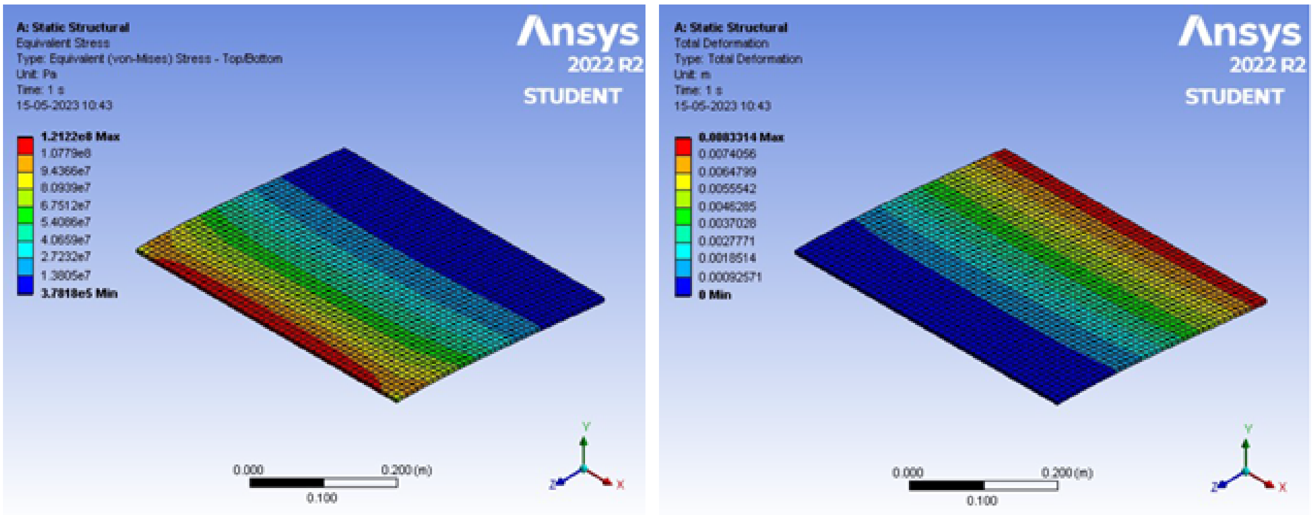


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Fig 7.3 Von-mises stress and total deformation (6 mm)

Figure 7.4 shows the von Mises stress and deformation of the platform with thickness 5 mm. 174.52 MPa is the maximum von Mises stress and 14.39 mm is the maximum deformation obtained.

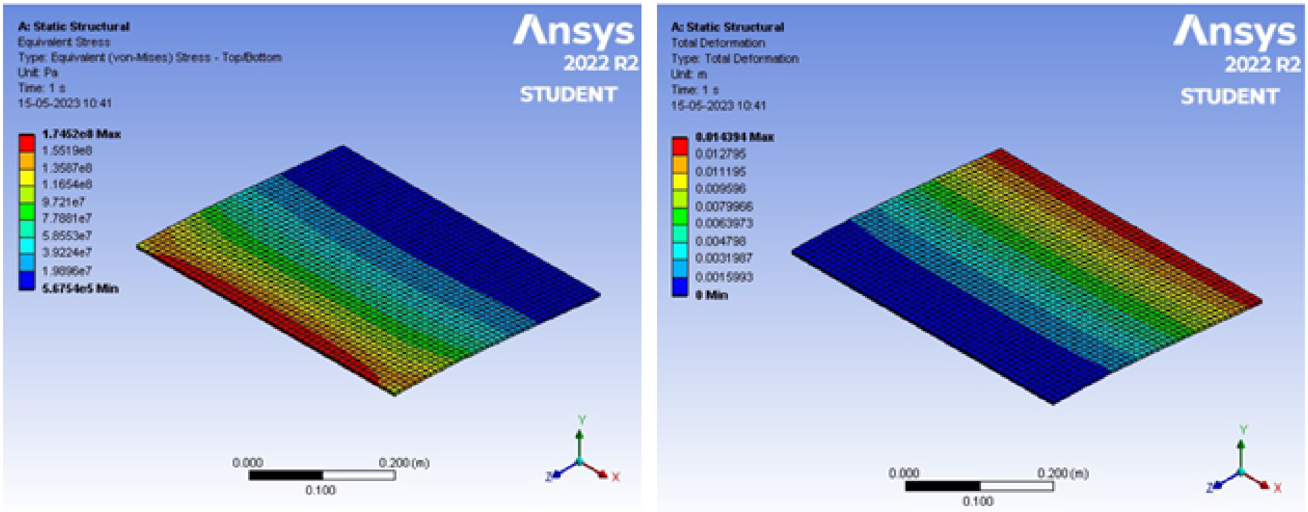

Fig 7.4 Von-mises stress and total deformation (5 mm)

Figure 7.5 shows the von Mises stress and deformation of the platform with thickness 4 mm. 272.65 MPa is the maximum von Mises stress and 28.11 mm is the maximum deformation obtained.

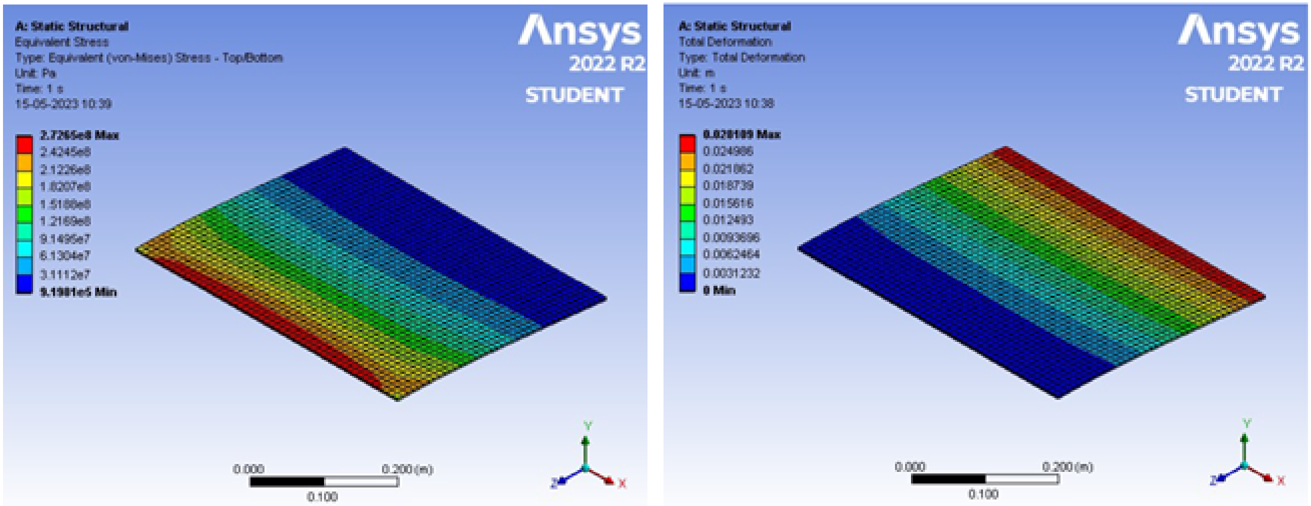

Fig 7.5 Von-mises stress and total deformation (4 mm)

The analysis results are tabulated in table 7.1 for comparison. The deformation is maximum for 4 mm (28.11.mm) thick plate and minimum for 10 mm thick plate (1.80 mm). Deformation for other plates varies between 3.52 mm and 14.39 mm. Von mises stress varies between 43.68 MPa and 272.65 MPa. The minimum value is for 10 mm thick plate and maximum for 4 mm thick plate.

Table 7.1: Element thickness and corresponding von Mises stress and displacement

Sl No	Element Thickness (mm)	Deformation (mm)	Von-Mises Stress (MPa)
1	10.00	1.80	43.68
2	8.00	3.52	68.22
3	6.00	8.33	121.22
4	5.00	14.39	174.52
5	4.00	28.11	272.65

7.2 CONCLUSION FROM PLATFORM ANALYSIS

The results obtained from the analysis will be used to select the thickness and material of the staircase climbing mini forklift. The structure is required to withstand a load of 2000 N and the plate can be made thicker to reduce the deformation and stress. The element type used in the analysis was SOLID186 (Quadrilateral), which is a hexahedral element with 8 nodes and quadratic shape functions. This element is a good choice for structural analysis because it is accurate and efficient.

The following are some of the limitations of the analysis:

- The analysis assumed that the plate was perfectly elastic. In reality, the plate would deform plastically under a large load.
- The analysis did not take into account the effects of friction between the plate and the supports.
- The analysis did not take into account the effects of temperature.

Despite these limitations, the analysis provides valuable insights into the behavior of rectangular plates under load. Results obtained from the analysis showed that the deformation and stress of the platform increases with decreasing thickness. The maximum deformation and stress occurred at the unsupported side of the plate. Based on the results of the analysis, a 10 mm plate is the best choice for the fabrication of the forklift. This is because the 10 mm plate has the lowest deformation and stress (refer table 7.1). This will ensure that the machine will be able to withstand the load with minimum deformation and avoid any possible failure.

From the analysis carried out on ANSYS software for 10 mm plate thickness:

Von Mises Stress = 43.68 MPa

Therefore, Safe working Stress = 43.68 × 2

(Source: https://www.engineeringtoolbox.com/factors-safety-fos-d_1624.html)

Safe working Stress = 87.36 MPa

7.3 ANALYSIS OF FRAME

This analysis is carried out to understand the behavior of the forklift as a whole. Frame as well as platform was analyzed together here and 2000 N is applied (same as the analysis of platform) on the platform with wheels fixed. Static structure analysis is conducted here as well using Autodesk Fusion 360. Parabolic element is used with an element size of 20 % of average size of the frame.

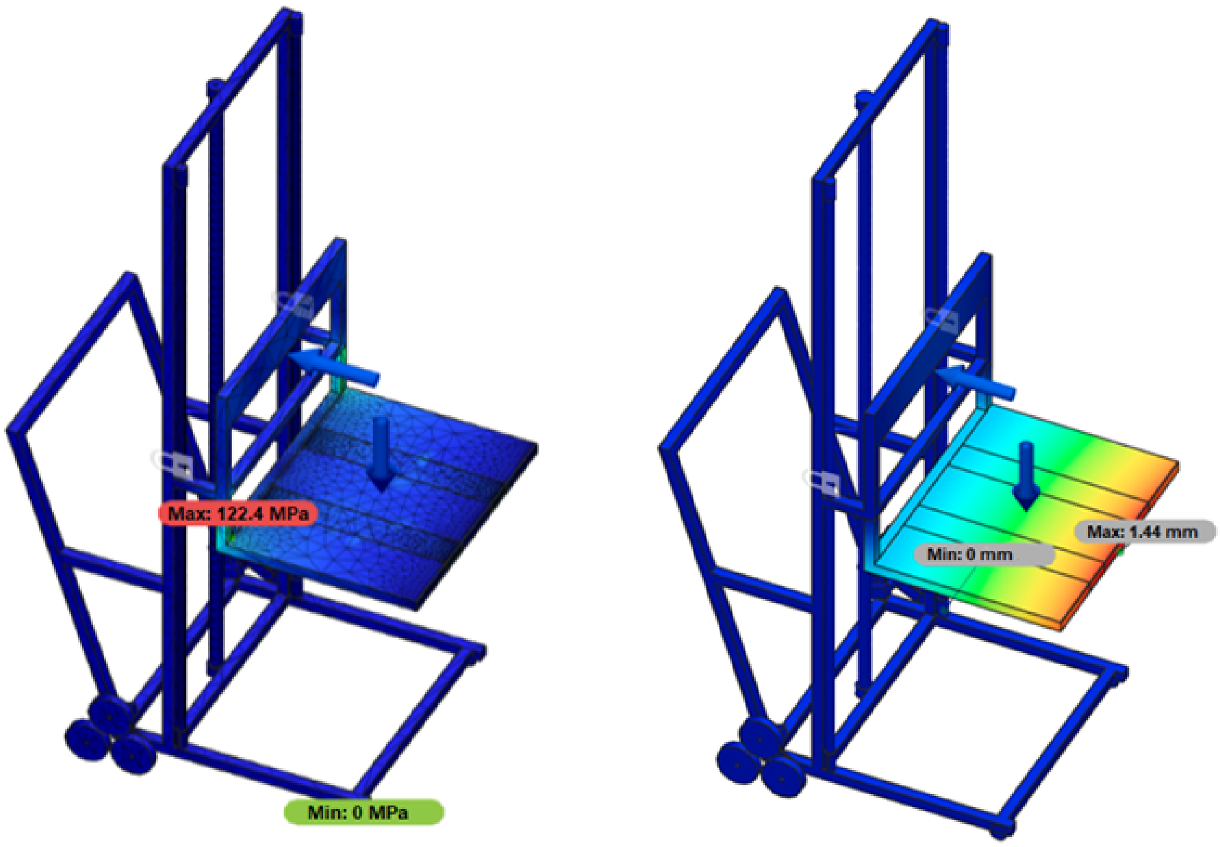

Fig 7.6 Von-mises stress and total deformation of frame

Figure 7.6 illustrates the results of static structure analysis on the frame of mini – forklift. Maximum deformation appears to be 1.44 mm and maximum von Mises stress obtained is 122.4 MPa when a load of 2000 N is applied on the platform, while the wheels are in stationary position.

Based on the results obtained from the structural analysis of the frame under a load of 2000N, it can be concluded that the frame exhibits satisfactory structural integrity and is able to withstand the applied load without fail. The analysis considered various aspects such as stress distribution, deformation, and factor of safety, providing valuable insights into the frame's performance and safety. The stress distribution analysis revealed that the frame experienced localized stress concentrations at specific regions, typically nearer to the connection points and areas with higher load transfer. However, the maximum stress levels remained within acceptable limits, indicating that the frame is adequately designed to handle the applied load.

Furthermore, the analysis of deformation indicated that the frame exhibited minimal displacement and deformation under the applied load. This implies that the frame maintains its structural stability and retains its original shape, ensuring the overall structural integrity of the system.

The factor of safety, which is a crucial parameter in assessing the safety margin of a structure, was also considered during the analysis. The calculations demonstrated that the frame possesses a factor of safety higher than the required minimum, suggesting a satisfactory safety margin. This means that the frame can endure the applied load while still having additional capacity to withstand unforeseen variations or external forces that may occur during its service life. Overall, the structural analysis results indicate that the frame is well-designed and capable of withstanding the specified load of 2000N. In conclusion, the structural analysis has provided confidence in the frame's structural integrity, validating its suitability for the intended application and load requirement. From the analysis the following calculations can be made;

Von Mises Stress = 122.4 MPa

Therefore, Safe working Stress = 122.4 × 2

(Source: https://www.engineeringtoolbox.com/factors-safety-fos-d_1624.html)

Safe working Stress = 244.8 MPa

7.4 MATERIAL SELECTION

Material selection is based on von Mises stress criterion (Source: https://www.simscale.com/docs/simwiki/fea-finite-element-analysis/what-is-von-mises-stress/) and some other factors which will discuss in the subsequent paragraphs. Von Mises stress criteria states that if the von Mises stress of a material under load is equal to or greater than the yield limit of the same material, then the material will yield. In other words, von Mises stress should be less than the yield stress of the material. This can be utilized for ductile materials, mostly metals, to find whether the loading condition is safe or not. Table 7.2 tabulated the properties of various materials, which can be used for fabricating the forklift. The parameters which are crucial for the project are listed in the table.

Referring to table 7.1, table 7.2 and figure 7.6 (analysis of frame), it can be found whether the design is safe. Based on the von Mises stress criteria, Stainless steel and Wrought steel can be excluded as the von Mises stress (with factor of safety) obtained in the analysis of the frame is higher than the yield strength of these materials. Both mild steel and galvanized steel can be considered as yield strength is higher than the von Mises stress obtained both in analysis of platform and analysis of frame (with factor of safety). However, Mild steel is selected for fabricating the mini – forklift by considering other factors which are listed in the subsequent paragraph along with the properties listed in the table 7.2.

Table 7.2: Material selection for the Mini - forklift

Sl No	PROPERTY	MILD STEEL	GALVANIZED IRON	STAINLESS STEEL	WROUGHT STEEL
1	Yield Stress	250 MPa	450MPa	241MPa	220MPa
2	Durability	High	High	High	High
3	Cost (1kg)	40-50	50-55	180-200	100-110
4	Corrosion Resistance	High	High	High	High
5	Availability	More	More	More	More

- **Easily Weldable:** Mild steel can be easily welded, making it a good choice for applications where the material will need to be joined together.
- **Ductile:** Mild steel is ductile, meaning that it can be easily bent or shaped. This makes it a good choice for applications where the material will need to be formed into complex shapes.
- **Light Weight:** Mild steel is lighter than other materials, such as cast iron or stainless steel. This makes it a good choice for applications where weight is a concern, such as in transportation or aerospace.
- **Ideal Mechanical Properties:** Mild steel has ideal mechanical properties for a wide range of applications. It is strong, tough, and ductile, making it a good choice for a variety of uses.
- **Favorable Chemical Properties:** Mild steel has favorable chemical properties, meaning that it is resistant to corrosion and rust. This makes it a good choice for applications where the material will be exposed to the elements.
- **Recyclable:** Mild steel is recyclable, which makes it a sustainable choice for many applications.

Overall, mild steel is a versatile material with a number of advantages that make it a good choice for the fabrication of the mini forklift.

CHAPTER 8

MATERIALS REQUIRED & COST ESTIMATION

8.1 MATERIALS REQUIRED

Based on the design of the mini-forklift and its analysis, the components required for the project and materials are listed in table 8.1. Size / specifications, and quantity / weight of the materials required are also listed. Battery, bearing, motor, screw etc. are selected based on the availability in the market.

Table 8.1: Materials Required

Sl No	Item/Part	Material	Size/Specification	Quantity/Weight
1	Square pipe	Mild Steel	¾, 1 Inch	25kg
2	Square sheet	Mild steel	10 mm	1.5kg
3	Wheel	Hardened Rubber	5 Inch	6 NOs
4	Wheel Frame	Mild Steel	3mm	1kg
5	Electric Motor	Copper	12V, 100W	2NOs
6	Battery	Lithium-ion battery	12V, 22Ah	12NOs
7	Bearing	Steel	19mm, 15mm	4NOs
8	Screw rad	Mild Steel	29mm	6 kg
9	Switch	Plastic	12V dc	3

8.2 COST ESTIMATION

The cost of the components is listed in the table 8.2. Rs. 22114.00 is the estimated cost of the project. The main cost elements are lathe working charges, electric motor, miscellaneous expenses etc.

Table 8.2 Cost estimation

Sl No	Particulars	Quantity	Cost (in Rupees)
1	Rubber wheels	6 Nos.	1800.00
2	Pillow block ball bearing	4 Nos.	1000.00
3	M.S Plate	2 Kg.	200.00
4	M.S Square pipe	14 Kg.	1050.00
5	Switch	3 Nos.	150.00
6	Material for shaft	6 m	800.00
7	Electric motor	3 Nos.	3000.00
8	Wires	6 m	114.00
9	Gear	14 Nos.	2000.00
10	Battery	2 Nos.	2000.00
11	Lathe charges		4000.00
12	Welding and finishing costs		2000.00
13	Other expenses		4000.00
	TOTAL		**22114.00**

CHAPTER 9

MATERIALS USED FOR FABRICATION

9.1 FRAME – MILD STEEL SQUARE BARS

Project used square pipes having cross sections of ¾ inches, 1 inch and 4 inches for the fabrication of frame with a carbon content of 0.05-0.25 % (figure 9.1).

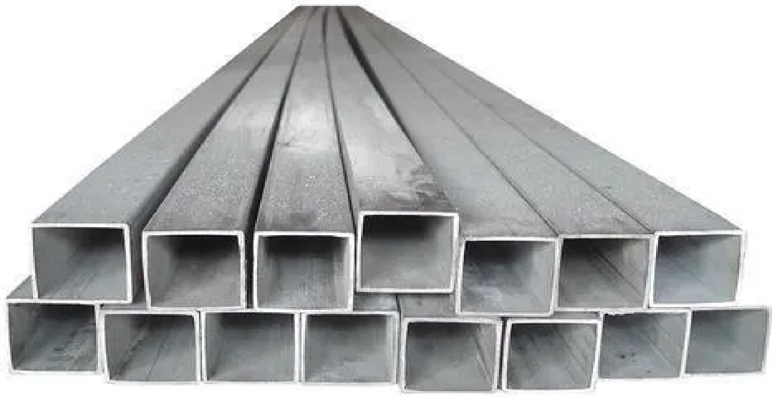

Fig 9.1 Mild steel square bars

9.2 MILD STEEL SHEET

Mild steel sheet is a thin, flat piece of steel with many applications. Project used 10 mm thick sheets for our fabrication of the platform (figure 9.2).

Fig 9.2 Mild steel sheet

9.3 SPUR GEAR

Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radially, and the edge of each tooth is straight and aligned parallel to the axis of rotation (figure 9.3). Table 9.1 tabulated the various dimensions of the spur gear.

Fig 9.3 Spur gear

Table 9.1 Dimension of gears

DIMENSION OF GEARS	DRIVING GEAR	DRIVEN GEAR
NO OF TEETHS	40	22
OUTER DIAMETER	84	48
PITCH DIAMETER	80	44
ROOT DIAMETER	75	39
ADDENDUM	2	2
DEDENDUM	3	3
WORKING DEPTH	4	4
WHOLE DEPTH	5	5
CIRCULAR PITCH	6	6
BASE CIRCLE	75	41

9.4 PILLOW BLOCK BEARING

A pillow block bearing, or a bearing housing or Plummer block, is a pedestal that is used to provide support for a rotating shaft (figure 9.4).

Fig 9.4 Bearings

9.5 BATTERY

The 12-volt batteries usually consist of three cells connected in parallel. Each cell can produce around 4 volts of power, making up a total of 12 volts of electrical power – which is enough to power vehicles, RVs, home energy storage systems, and most household appliances (figure 9.5).

Fig 9.5 Battery

9.6 DC MOTOR

An electric motor is an electrical machine that converts electrical energy into mechanical energy. The reverse conversion of mechanical energy into electrical energy is done by an electric generator (figure 9.6).

Fig 9.6 DC Motor

9.7 RUBBER WHEEL

Rubber wheels provide elasticity and provide good traveling performance on uneven road surfaces. Hard rubber wheels offer a slightly higher weight capacity than that of soft rubber wheels (figure 9.7).

Fig 9.7 Rubber Wheel

9.8 FABRICATION PROCESS FLOW OF MINI-FORKLIFT

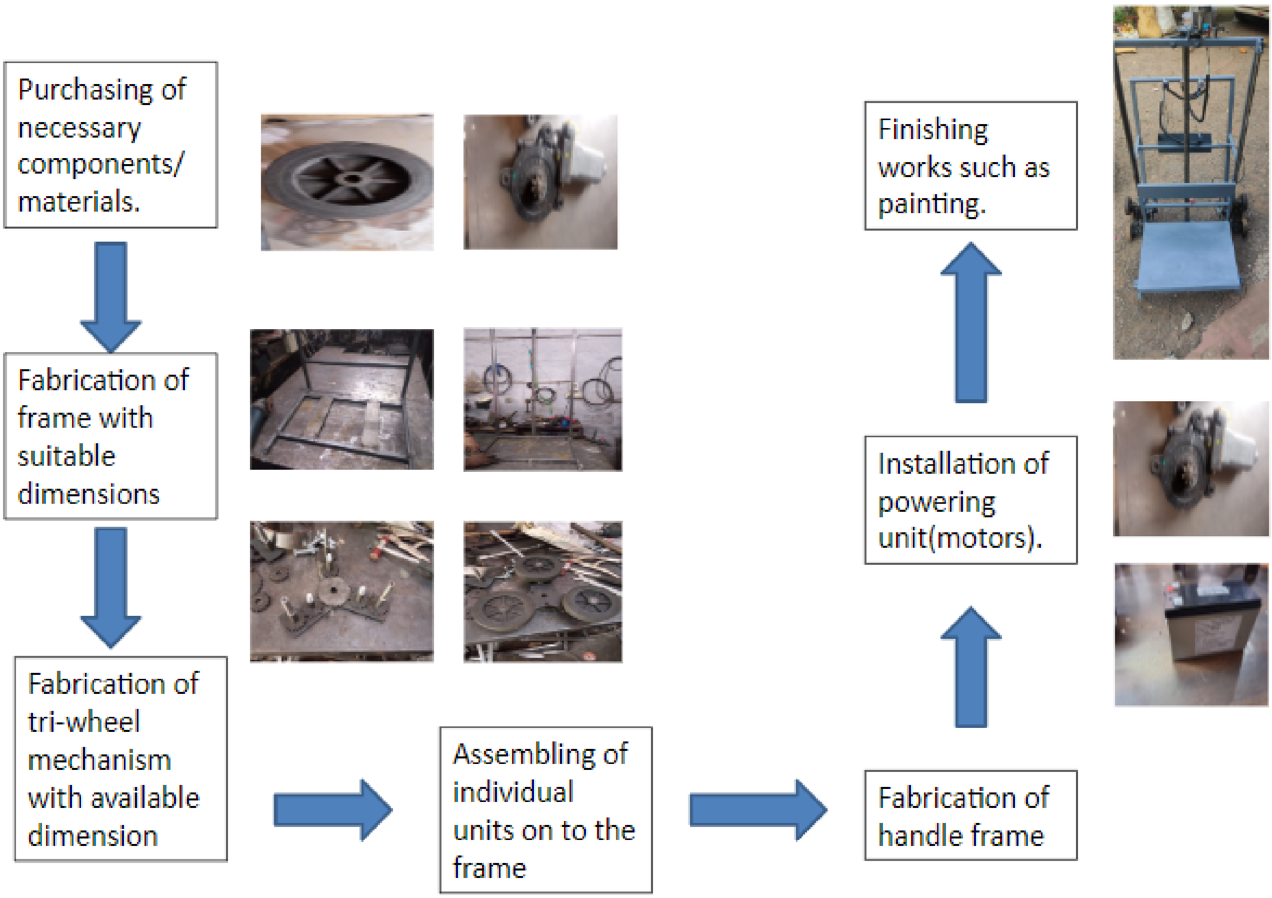

Fig 9.8 Flow of fabrication process

Figure 9.8 demonstrates the flow of the fabrication process of mini-forklift. During the process, acquired various essential components, including a 24V, 250W DC motor, 12V, 100W DC motors, 12V, 7Ahr batteries, rubber wheels, and mild steel. To enable the lifting mechanism, purchased a lead screw and support bearings from a lathe. Additionally, manufactured a Y-shaped structure, which supports the tri-wheel mechanism, using lathe. The gears required for power transmission were created using a milling machine.

Afterward, the project proceeded to manufacture the frame using mild steel, ensuring it closely matched the design specifications. Later, attached a battery box to the frame and positioned bearings at the top and bottom of the frame to provide support for the lead screw. The lead screw was designed to lift weights up to a height of 1 meter. At one end of the lead screw, a gear was attached, which meshed with a gear connected to the 24V, 250W DC motor. This motor was accurately positioned above the lead screw on the frame. For the attachment of the tri-wheel mechanism to the main frame, connected a 12V, 250W DC motor to a shaft with a gear. At the outer end of the shaft, we affixed the Y-shaped structure, and the main power transmission gear was added to it. Two gears with identical dimensions were then linearly meshed in all three directions. Finally, the wheels were attached to the final gear. Additionally, placed the batteries in the battery box and made the necessary connections. After carefully inspecting all the connections and ensuring proper gear alignment, we switched on the device and tested its functionality.

Figures 9.9 to 9.12 shows various processes accomplished during the fabrication processes of mini – forklift.

Fig 9.9 Machining of gear

Fig 9.10 Fabrication of the frame

Fig 9.11 Assembling of tri – wheel mechanism

Fig 9.12 Assembling all the parts to main frame

CHAPTER 10

RESULTS AND DISCUSSION

10.1 TESTING OF MINI – FORKLIFT

The testing of the mini - forklift with a load of 10 kg was conducted to understand the stair climbing and also to understand the effectiveness of lifting and moving. The fabricated product was functional. However, some limitations were found which decreased the efficiency of the mini – forklift. The following are the observed limitations of the product:

1. There is some misalignment in gear meshing which increased the lifting time and decreased the lifting efficiency.
2. A wheel motor is wrongly positioned which hits stairs during climbing motion which forces the user to apply more force for stair climbing.

Necessary modifications were done based on the observations mentioned above and the fabricated mini – forklift satisfied the objectives of the project.

10.2 RESULT AND DISCUSSIONS

- The machine takes approximately 180 – 200 seconds to lift the plate to a height of 1 meter.
- The mini – forklift can easily climb stairs with a height of 14 cm.
- The mini – forklift moves with a speed of 10 – 15 km/hr.
- This makes the product more adaptive for domestic purpose applications.

Tables 10.1 and 10.2 exhibited the lifting time and linear movement for 1m. This is observed without weight and with a mass of 15 kg on the platform. Forklift takes 192 seconds to lift the platform for 1m without weight on it and at the same time it takes 273 seconds to lift a weight of 15 kg.

Table 10.1 Time required for lifting

Weight	Time required to lift to 1 meter
Without weight	192 seconds
15 kg	273 seconds

The linear movement of the forklift takes 6 seconds to reach 1m without weight on the platform and 7 seconds with a weight of 15 kg on the platform. It can also climb the staircase with 14 cm height with a little effort from the operator. Referring to the aim and objectives (section 3.3), the project accomplished all of these with some limitations and modifications in the final design. The design and fabrication of mini – forklift for domestic applications is achieved through this project.

Table 10.2 Time required for linear motion

Weight	Time required to move 1 meter
Without weight	6 seconds
15 kg	7 seconds

CHAPTER 11

CONCLUSION, LIMITATION AND FUTURE WORK

11.1 CONCLUSION

The literature survey provided some insight about the necessity of designing and fabricating a mini – forklift for domestic applications. The problem definition, aim and objectives are formulated based on the literature survey. A methodology and work plan were decided by understanding the steps required to accomplish the objectives. Five designs of the proposed mini – forklift was developed and pros and cons of each design was identified. Based on this final design and its dimensions were decided. Analysis of the platform as well as the whole structure of the mini – forklift was conducted. With regard to the analysis, the design found safe and material selection and cost estimation was completed. Components and materials were purchased and fabricated according to the design. The testing put some light on its limitations and corrected the same. The fabricated mini – forklift was working satisfactorily. Mini – forklift takes 192 seconds to lift the platform for 1m without weight on it and at the same time it takes 273 seconds to lift a weight of 15 kg. The linear movement of the forklift takes 6 seconds to reach 1m without weight on the platform and 7 seconds with a weight of 15 kg on the platform.

11.2 LIMITATION

- There is a misalignment of gear in lifting and lowering of load due to positioning error of the new shaft inside the motor. This was corrected by providing additional support and can be avoided in future designs.
- There is power loss during transmission in the right-side tri-wheel due to loose gear meshing.
- The mini forklift is not suitable for climbing stairs with height above 14 cm.

11.3 FUTURE WORKS

- More powered motors can be used to increase the load capacity and replacing wheel motors with speed controllable high-speed motors will help to save time and increase the efficiency.
- The mini forklift can be fully automated or a remote-controlled system can be implemented.
- Solar panels can be used to make a more sustainable energy efficient product.
- Increasing the lifting height will make this product useful in the construction industry.

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DEPARTMENT OF MECHANICAL ENGINEERING
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CERTIFICATE

This is to certify that the report entitled **"CONTROLLED AUTOMATIC BOTTLING SYSTEM FOR SMALL SCALE INDUSTRY"** submitted **by Arun C, Vishnu k, Dheeraj R, Yadhu Krishnan K V** to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the Project work carried out by them under my guidance. This report in any form has not been submitted to any other University or Institute for any purpose.

Project Guide	Project Coordinator	Head of Department
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Principal.V

DEPARTMENT OF MECHANICAL ENGINEERING

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CERTIFICATE

This is to certify that the report entitled '**AUTOMATIC SPEED CONTROL OF AN ELECTRIC VEHICLE USING RASPBERRY Pi**' submitted by **AJITH JAMES, MILAN S CHALIL, MUHAMMED AFLAH M, VINAYAK RAMACHANDRAN** to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the Project work carried out by them under my guidance. This report in any form has not been submitted to any other University or Institute for any purpose.

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CERTIFICATE

This is to certify that the report entitled **"DESIGN AND FABRICATION OF AUTONOMOUS STREET VEHICLE"** submitted by **Ajnas A K, Ajul Sasi MK, Alan Kuriakose, Sanjal Alex Chacko** to APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the project carried out by him/her under my/our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Supervisor	Project Coordinator	Head of Department
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CERTIFICATE

This is to certify that the report entitled **"Design and Fabrication of Biomass Stove with Forced Jet of Air"** submitted by **AJITH JOHNY, JYOTHIS PRAKASH K, PRANAV PV,** and **ASRITH P** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the project work carried out by them under my guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Supervisor	Project Coordinator	Head of the Department
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CERTIFICATE

This is to certify that the report entitled '**Numerical Analysis of Self-aspirating Miniature Combustor**' submitted by **AKASH P, ALAN MATHEW, JEZNEEL J ABRAHAM, P R SARATH** to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the Project work carried out by them under my guidance. This report in any form has not been submitted to any other University or Institute for any purpose.

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CERTIFICATE

This is to certify that the report entitled '**EXPERIMENTAL INVESTIGATION OF OVERALL HEAT TRANSFER COEFFICIENT OF SHELL AND TUBE HEAT EXCHANGER USING GREEN SYNTHESIZED COPPER OXIDE NANOFLUID**' submitted by **Ajo Antony Mathew, Alen Moby, Andrin Sunny and Benedict J Sebastian** to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the project work carried out by them under my guidance. This report in any form has not been submitted to any other University or Institute for any purpose.

Project Supervisor 08/06/2023	Project Coordinator 8/6/23	Head of Department 8/06/23
Dr.S.Christopher Ezhil Singh	**Mr. Mejo M Francis**	**Cdr. (retd.) Raju K Kuriakose**
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External Examiner

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CERTIFICATE

This is to certify that the report entitled **"RETROFICATION OF CONVENTIONAL BIKE TO ELECTRIC BIKE"** submitted by **Alok Babu, Aswin M, Anugrah Jeevan, Vijay Krishna A.K** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the project work carried out by him under my guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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CERTIFICATE

This is to certify that the report entitled **"DESIGN AND FABRICATION OF AUTONOMOUS FIRE FIGHTING ROBOT"**submitted by **Anex Mathew Amal Joshy,Akash P.P,Rhishab Mohan** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the seminar work carried out by him under my guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Supervisor	Project coordinator	Head of the department
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CERTIFICATE

This is to certify that the report entitled **'Tribological Behaviour And Characterization Of Magnesium-Matrix Based Nano Composites'** submitted by **ABHIRAM SURESH, RITHIN MANU P.V, SAYANTH SASINDRAN** and **SOURABH SUGATHAN** to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the Project work carried out by them under my guidance. This report in any form has not been submitted to any other University or Institute for any purpose.

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CERTIFICATE

This is to certify that the report entitled **"DESIGN AND FABRICATION OF STAIRCASE CLIMBING MINI FORK-LIFT"** submitted by **LIBIN SHAJI, ANAND K M, STALIN SANTO, BEN JOHNS PHILIP** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the seminar work carried out by him under my guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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CERTIFICATE

This is to certify that the report entitled **"Experimental Investigation on application of pineapple leaf fiber, epoxy and glass fiber reinforced composite material for prosthetic sockets"** submitted by ABHIN BABU V B, JOMY AUGUSTINE, SREERAJ P, VISHNU PRAKASH to APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the project carried out by him/her under my/our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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CERTIFICATE

This is to certify that the report entitled **" SENSOR OPERATED AUTOMATIC REVERSE BRAKING SYSTEM"** submitted by **SOURAV SAJEEVAN, DYUTHIN E, FAZAL UL HAQUE, ADARSH P R** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of theDegree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the Project work carried out by him under my guidance and supervision. This report inany form has not been submitted to any other University or Institute for any purpose.

Supervisor	Project coordinator	Head of the department
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CERTIFICATE

This is to certify that the report entitled '**Heat Transfer Studies on Shell and Tube Heat Exchanger Using Green Synthesized Silver Nanofluid**' submitted **by ABHIJITH K P, GOKUL P V, NIVED P and SOORAJ C A** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the Project work carried out by them under my guidance. This report in any form has not been submitted to any other University or Institute for any purpose.

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Project Supervisor

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KANNUR

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This is to certify that the report entitled **"DESIGN AND DEVELOPMENT OF A SMART CRADLE"** submitted by **Abhinav Kt, Albin Abraham, Joel Mathew, And Vyshakh M** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the project work carried out by them under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

12/05/2023

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CERTIFICATE

This is to certify that the report entitled **"SMART WALKING STICK FOR VISUALLY IMPAIRED"** submitted by **ALAN VYSHNAV P, ANJU M, NAVIYA GANESHBABU, PRANAV K V** to the APJ AbdulKalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the seminar work carried out by him under my guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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6/6/2022 6/6/22 06/06/2022

Signature Not V

Principal.V

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VIMAL JYOTHI ENGINEERING COLLEGE, CHEMPERI

CERTIFICATE

This is to certify that the report entitled **"DESIGN, ANALYSIS AND FABRICATION OF SEMI-AUTOMATIC MULTIPURPOSE WHEELCHAIR"** submitted by **Chinmay Nambiar C K, Ulsav Ullas, Vinshith V V, Vishnu M** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the project work carried out by him under my guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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05/06/2023 5/6/23 05/06/2023

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