DESIGN AND AUTOMATION OF AGRICULTURAL SMART BOT

A PROJECT REPORT

Submitted by

NIRMAL A J L A	**2019111059**
BHARATH L	**2019111014**
JAYANAND B ANNA	**2019111035**
JAI PRASANTH P	**2019111033**

In partial fulfilment for the award of the degree

of

BACHELOR OF ENGINEERING

in

MECHANICAL ENGINEERING

COLLEGE OF ENGINEERING GUINDY

ANNA UNIVERSITY: CHENNAI 600 025

JUNE 2023

ANNA UNIVERSITY: CHENNAI 600025

BONA FIDE CERTIFICATE

Certified that this project titled "**DESIGN AND AUTOMATION OF AGRICULTURAL SMART BOT**" is the bonafide work of

NIRMAL A J L A	**2019111059**
BHARATH L	**2019111014**
JAYANAND B ANNA	**2019111035**
JAI PRASANTH P	**2019111033**

who carried out the work under my supervision. Certified further that to the best of my knowledge, the work reported here does not form part of any other thesis or dissertation on the basis of which a degree or an award was conferred on an earlier occasion on this or any other candidate.

Dr. S. BALASIVANANDHA PRABU

Professor and Head,

Department of Mechanical Engineering,

College of Engineering Guindy,

Anna University,Chennai – 600 025.

Dr. K. SHANMUGA SUNDARAM

CUIC-Director,

College of engineering Guindy,

Anna University,

Chennai-600 025.

ABSTRACT

The multipurpose agricultural bot is a machine developed by our department in 2020.This bot is capable of tilling, seeding, ploughing and watering the soil in a single operation. The bot has disc harrows in the front to loosen the soil, which is followed by a dibbler type seed drill that sows the seed a few centimetres down the soil. A claw plough attachment can be attached to the rear to close up the soil after sowing. This machine is completely manually operated and does not have any electrical components. Such an agricultural machine that can accomplish multiple operations is still not available in the market on a commercial level.

Our Goal is to completely automate this bot and make it an autonomous agricultural bot. This requires the design and fabrication of an electric drive and steering system that enables the automatic movement of the bot. We also require the integration of IOT components such as a processing board and GPS, so that the bot can automatically determine the sowing paths and sow the seeds without any manual intervention. The electric motor-based drivetrain should have enough power to be able to plough the land and the steering should be manoeuvrable enough to avoid obstacles and make tight turns in the field to be able to show seeds close together. The electric motor-based drivetrain we have created possesses ample power to effectively plough the land, while the manoeuvrable steering system allows the bot to navigate around obstacles and make precise turns, ensuring seeds are sown close together for maximum efficiency.

By achieving these milestones, our project has made significant strides towards revolutionising agricultural practices, reducing labour-intensive tasks, and enhancing productivity in the farming industry.

ACKNOWLEDGEMENT

I am extremely indebted to **Dr. K. SHANMUGA SUNDARAM,** CUIC Director, College of Engineering Guindy, Anna University, Chennai, for his unstinted guidance and encouragement with a dint of will and enthusiasm throughout the project. His timely guidance, practical approach and feedback on the progress helped a lot to complete the project in a successful manner.

I would like to thank, Department of Mechanical Engineering, College of Engineering Guindy, Anna University, Chennai, for helping with the structuring of this project and providing the infrastructure and support throughout the course of work.

I sincerely thank **Dr. S. BALASIVANANDHA PRABU**, Head of the Department, Mechanical Engineering, College of Engineering Guindy, Anna University, Chennai, for extending all the facilities in the department.

I wish to thank **Dr. MURUGANANDAM,** Assistant Professor**,** and Project Coordinator, AUFRG, Department of Mechanical Engineering, College of Engineering, Guindy, Anna University, Chennai, for her valuable suggestions during the course of the project work.

NIRMAL A J L A	**BHARATH L**	**JAYANAND B ANNA**	**JAI PRASANTH P**
(2019111059)	**(2019111014)**	**(2019111035)**	**(2019111033)**

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

Agriculture, being the backbone of our civilization, has undergone significant transformations over the centuries. From manual labour to mechanisation, the quest for efficient and sustainable farming practices continues to evolve. In recent years, the integration of robotics and automation has emerged as a promising solution to address the challenges faced by modern agriculture. Among these technological advancements, an autonomous multi-functional agricultural robot stands out as a game-changer, revolutionising traditional farming methods.

This versatile machine, equipped with an electric drive system powered by two motors, has the potential to transform the landscape of farming practices.

The primary goal of our project is to create an agricultural robot that can autonomously perform various tasks such as ploughing, watering, seeding, and adding fertiliser, among others. By integrating these functionalities into a single machine, we aim to enhance operational efficiency, reduce labour-intensive tasks, and optimise resource utilisation in the agricultural sector.

One crucial aspect that sets the **Multi-Action AgriBot** apart is its electric drive system. Traditional agricultural machinery often relies on fossil fuel-based engines, which contribute to pollution and greenhouse gas emissions. In contrast, our robot utilises an electric drive system that not only reduces environmental impact but also offers improved control and manoeuvrability.

The electric drive system is composed of two motors strategically positioned to ensure smooth movement and precise navigation. This configuration allows the robot to efficiently traverse various terrains while maintaining stability and control.

Additionally, the use of electric motors eliminates the need for frequent maintenance associated with combustion engines, resulting in cost savings for farmers.

1.1 NEED FOR THE PROJECT

The autonomous nature of our agricultural robot sets it apart from other existing solutions in the market. While some robots perform specific tasks independently, such as seed sowing or irrigation, there is currently no autonomous bot available that combines multiple agricultural operations seamlessly. Our robot's ability to handle various tasks autonomously offers a significant advantage, streamlining the farming process and reducing the need for human intervention.

The **Multi-Action AgriBot** represents a significant leap forward in the field of agricultural automation. By integrating multiple agricultural operations into a single machine, we have created a versatile solution that enhances productivity, reduces labour-intensive tasks, and promotes sustainable farming practices. With its electric drive system and autonomous capabilities, our robot offers an innovative approach to address the challenges faced by modern agriculture.

1.2 OBJECTIVES

To completely automate the existing bot and make it autonomous, so that the functionality of the bot is greatly increased. Automation includes the drive system of the bot as well as all the operations that can be performed by the bot. To design and fabricate an electric drive and steering system, and the related chassis, flanges and other mounting and joining fixtures required. Finally, to integrate it with IOT elements such as an on board computer which can operate the bot using sensors and GPS.

CHAPTER 2
LITERATURE REVIEW

The amount of torque that the driving motor delivers is what plays a decisive role in determining the speed,acceleration and performance of an electric vehicle. This Journal ‘Motor Torque Calculations For Electric Vehicle’ by Saurabh Chauhan aims at simplifying the calculations required to decide the capacity of the motor.

As accurate knowledge of draft force is useful for optimal matching of power unit (usually tractor) to tillage implement, this study was conducted by Majid Rashidi, Hamzeh Fathi Lehmali, Mehrdad Salimi Beni,Meisam Malekshahi and Saeb Tabrizi Namin to predict draft force of a double action disc harrow(pull-type) based on soil moisture content, tillage depth and forward speed of the implement.

According to Robert Walters the knowledge of soil, draft and traction is very important to tillage work. This Paper examines the types of soil-machine interactions,their practical significance to tillage work and to the power requirement in farming.

This Study conducted by Paul Okoko in the paper ‘Draft Force Determination for an Offset Disc Harrow in a Sandy Loam Soil’ aims at determining the draft force for an offset disc harrow in a sandy loam soil using five different tractor speeds and three tillage depths.Increasing the tillage depth and implement speed increased draft force and the effects appeared to be linear

According to Kruthika Ramesh,Prajwal,C.Roopini,Monish Gowda and V.V.S.N.Sitaram Gupta, the building up an indigenous low-cost semi-automatic robot prototype that carries out a couple of farming processes.The developed robot can be extended further by mounting it on a DC motor chassis which can be used to move the robot in the entire field.

This paper ‘ An Internet of Thing based Agribot (IOT- Agribot) for Precision Agriculture and Farm Monitoring’ by Kakelli Anil Kumar and Aju. D., documents the steps involved in building an IOT based Agribot and it was tested in variable weather conditions, soil type, moisture content and crops.

The main concern of this paper by Tanha Talaviya,Dhara Shah,Nivedita Patel,Hiteshri Yagnik and Manan Shah is to audit the various applications of Artificial intelligence in agriculture such as for irrigation, weeding, spraying with the help of sensors and other means embedded in robots and Drones. These technologies save the excess use of water, pesticides, herbicides, maintain the fertility of the soil and also helps in the efficient use of manpower and elevate the productivity and improve the quality.

Chenchen Ren,Shen Liu,Hans van Grinsven,Stefan Reis,Shuqin Jin,Hongbin Liu and Baojing Gu analysed the farm sizes that are sustainable for the scale of the agricultural practice being employed. Farm size plays a critical role in agricultural sustainability. This data was essential to get an idea about the size and shape of the fields for different types of crop and to develop a suitable path generation algorithm for the same.

2.1 LITERATURE SUMMARY

An important component that is an integral part of all electric vehicles is the motor.Torque is the turning power of the motor.Rolling resistance,Grade resistance,Acceleration force are the factors affecting Torque.Total Tractive Effort is the sum of these three factors.The torque that is required on the drive wheel will be the one that the drive motor requires to produce so as to obtain the desired drive characteristics.When the required torque has been calculated it is necessary to check if the wheels of the vehicle are capable enough to transmit the required amount of torque for which the maximum torque that can be transmitted through the wheels need to be calculated.We have calculated the required torque with the help of Journal ‘Motor Torque calculations for Electric vehicle’ by Saurabh Chauhan.

Draft Force is the force required to pull a tillage tool through the soil.Draft Force is calculated with the help of the journals ‘Prediction of Disc Harrow Draft Force based on soil moisture content,tillage depth and forward speed’ and ‘Draft Force determination for an offset disc harrow in a sandy loam soil’.The knowledge of Draft and Traction is very important to tillage work,which is learned from the journal ‘Soil,Draft,Traction’.Farm size plays a critical role in agricultural sustainability.The journal ‘The impact of farm size on agricultural sustainability’ explains this.

An Automated Agricultural bot is still not available in the market on a commercial level.So it will be useful to farmers if we automate the manually operated bot.This automation requires design and fabrication of a electric drive and steering system.We also require the integration of IOT components so that the bot can automatically determine the sowing paths and sow the seeds using GPS.This can be achieved with the help of journals ‘Design and development of an Agri-bot for automatic seeding and watering applications’, ‘An IOT based Agribot for precision agriculture and farm monitoring’ and ‘Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides’.

CHAPTER 3

FUNCTIONS OF THE EXISTING BOT

3.1 TILLAGE

Tillage is the agricultural preparation of soil by mechanical agitation of various types, such as digging, stirring, and overturning.The Existing Bot uses disc Harrows made of 3D printed ABS materials for tillage purposes.

Disc harrows are essential agricultural implements used in land preparation and soil cultivation. These versatile tools consist of a series of concave steel discs mounted on a frame, which are responsible for breaking up and smoothing the soil surface. Disc harrows play a crucial role in preparing the soil for planting, improving seedbed conditions. Fig 3.1 shows the disc harrow.

The primary function of disc harrows is to break up and mix the soil, incorporating organic matter, crop residues, and any previously applied amendments such as fertilisers or compost. The rotating discs slice through the soil, breaking up clumps and levelling the surface, creating an ideal environment for seed germination and root development.The designed harrow is given in Figure 3.2.

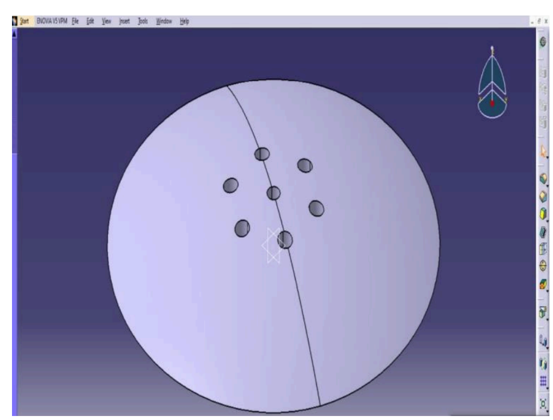

Fig. 3.1 Disc Harrow

Fig. 3.2 CAD Model of the designed disc harrow

Design Parameters of Disc

- Diameter of the Disc, Dd = 500 mm
- Width of the Cut, W = 160 mm
- Radius of Curvature, R = 550 mm
- Disc Spacing in Plough, Sd = 100 mm
- Thickness of the Disc, Td = 50 mm

3.2 PLOUGHING

Ploughing is a fundamental agricultural practice involving the mechanical turning or breaking up of soil to prepare it for planting crops. It is a crucial step in land preparation, creating a favourable environment for seed germination, root development, and overall crop growth.

The Plough tool is used to loosen the soil when the machine acts as a plougher. It has sharp points at its edges that allow us to pierce the soil and loosen it at the Centre of the machine and it is made up of heavy metal in order to resist the opposing force during the plough. A plough tool was modelled in CAD software , it is shown in Figure 3.3.

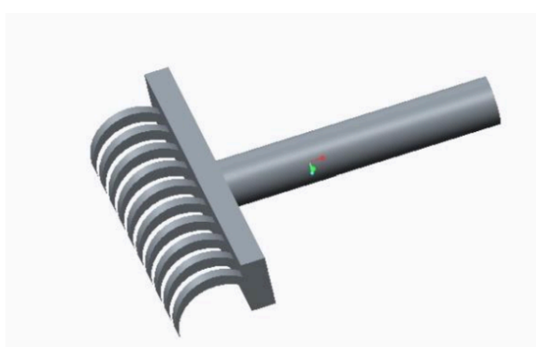

Fig 3.3 CAD Model of the designed plough tool

The dimensions of the designed plough tool are:

- Length of the shaft = 500 mm
- Number of plough bars for piercing = 10
- Radius of curvature of the plough bar = 400 mm

3.3 SEEDING

Seeding, in the context of agriculture, refers to the process of planting seeds in the soil to initiate crop growth. It is a critical step in agricultural practices, marking the beginning of the crop production cycle. Seeding involves the deliberate placement of seeds at an appropriate depth and spacing to ensure optimal germination and establishment of plants.

A rotary dibbler type seed drill was used to make the design simple and the seeding operation fast and accurate.A rotary dibbler is a specialised agricultural implement used for precision seeding. It is designed to create evenly spaced holes or furrows in the soil, providing a controlled environment for seed placement and germination.A commercial rotary Dibbler is shown in Fig 3.4 .

The main advantage of using a rotary dibbler is its ability to ensure consistent spacing between seeds, leading to uniform plant emergence and growth. This precise placement of seeds helps in optimising resource utilisation, reducing competition between plants, and facilitating easier weed control.

The rotary dibbler consists of a rotating drum or wheel with multiple pegs or teeth evenly spaced around its circumference. These pegs or teeth are responsible for creating holes or furrows in the soil as the dibbler is pulled or pushed across the field. The designed CAD model of the designed seeder and it’s exploded view are shown in fig 3.5 and 3.6 respectively.

Fig 3.4 Rotary Dibbler

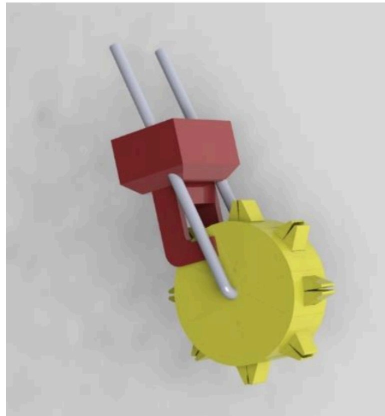

Fig 3.5 CAD Model of the designed Seeder

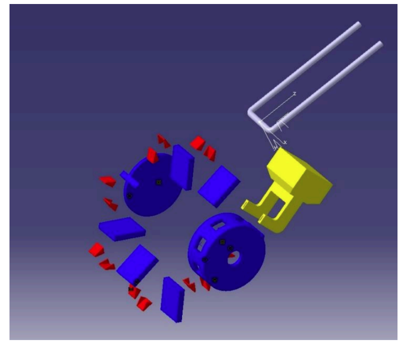

Fig 3.6 Exploded View of the seeder

The specifications of the designed seeder are:

- Seeder Diameter – 350 mm
- Seeder width – 150 mm
- Chamber Distance – 33.485°/131.152 mm
- Attachment from Centre Shaft – 750 mm
- Opening Dimensions – 60 × 70 mm
- Opening Width – 50 mm
- Opening Depth – 60 mm

3.4 IRRIGATION

Irrigation is the controlled application of water to agricultural crops, landscapes, or gardens to supplement natural rainfall and ensure optimal plant growth and productivity. It is an essential practice in areas where rainfall is insufficient or irregular, or when plants require additional water to meet their moisture needs.

The primary purpose of irrigation is to provide plants with adequate water for their growth, development, and survival. It helps maintain soil moisture levels within the plant's optimal range, promoting nutrient uptake, photosynthesis, and overall plant health. Irrigation also plays a vital role in supporting crop yield and quality, as water scarcity or drought stress can negatively impact plant growth and productivity.

The Bot consists of a **25 litre Water tank** that can be filled with water , the tank is provided with the required plumbing such as tubes and nozzles all over the length of the bot for the direct irrigation of the seed once it is sown.

3.5 FULLY ASSEMBLED BOT

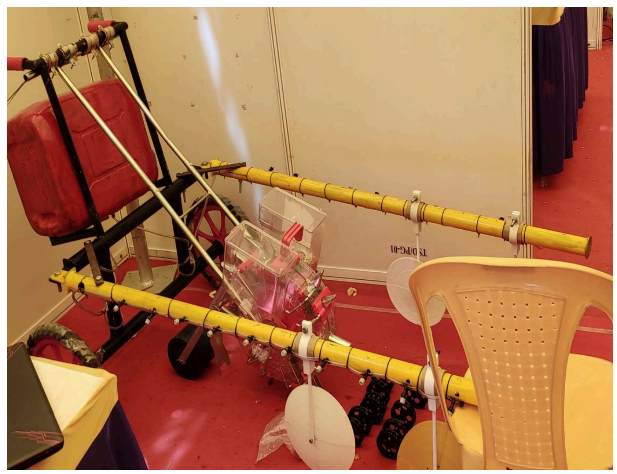

Fig 3.7 CAD Model of fully assembled Bot **Fig 3.8 Assembled Bot**

This bot is fully manually operated and doesnot have any automatic or autonomous functionality. The physical effort required to operate the bot is also very taxing, which makes this bot a perfect candidate for converting to a IOT-enabled smart Robot. Figures 3.7 and 3.8 show the final fully assembled robot.

CHAPTER 4

METHODOLOGY

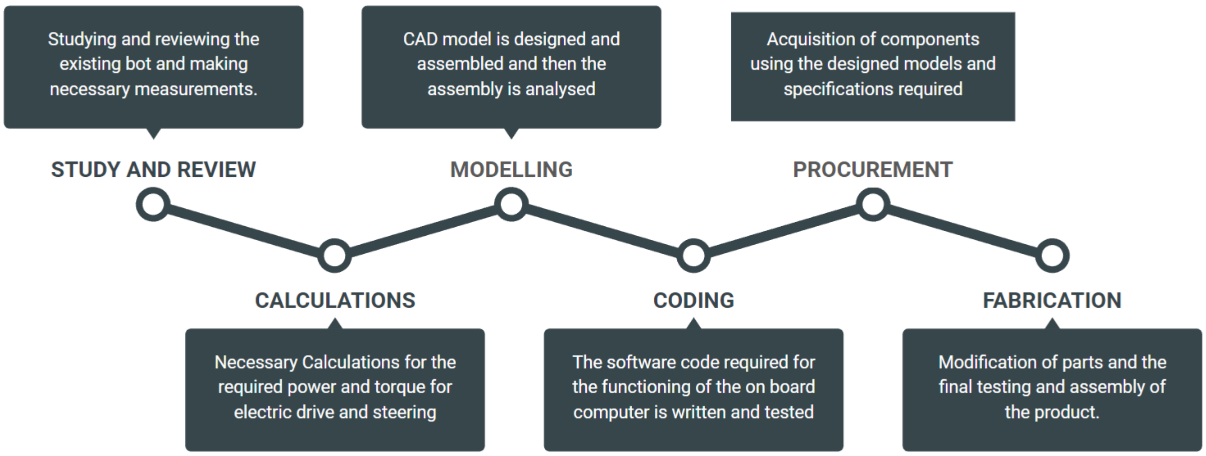

Fig 4.1 Workflow Chart

Figure 4.1 shows the workflow chart followed during the course of the project.

- Studying and reviewing the existing bot and making necessary measurements.
- Necessary Calculations for the required power and torque for electric drive and steering.
- The CAD model is designed and assembled and then the assembly is analysed.
- The software code required for the functioning of the on board computer is written and tested.
- Acquisition of components using the designed models and specifications required.
- Modification of parts and the final testing and assembly of the product was done and documented.

4.1 WORKING PRINCIPLE

The Agricultural Smart Bot uses a electric drive system that has two motors for its movement, the existing design of the previous bot is studied and the proper modifications to be done are identified first and the CAD models are created, then the required frames, connecting flanges and fixtures are designed and then fabricated after the required calculations are done to figure out the necessary specifications of the components, then the bot is finally assembled and then integrated with the IOT based system developed alongside.

CHAPTER 5
AGRICULTURAL SMART BOT

The design of an electric motor-based drive system involves several key components and considerations to ensure efficient and reliable operation. Here is a general overview of the design elements involved in creating an electric motor-based drive system:

1. Electric Motor Selection
2. Power Supply and Control
3. Motor Mounting and Coupling
4. Transmission and Gearing
5. Drivetrain Components
6. Motor Speed Control

A differentially driven steering system was chosen as its complexity is lower and the control mechanisms are also more simpler when compared to the alternative ackerman steering system.

5.1 DESIGN CALCULATIONS

To determine the power and torque required and to inform the selection of the motor and gearbox the following calculations were made:

$$Vehicle\ Mass = \mathbf{50\ Kg}$$

$$Gross\ Vehicle\ Weight = \mathbf{500\ N}$$

$$Max.Velocity = \mathbf{1.5\ m/s}$$

$$Efficiency\ Of\ Transmission = \mathbf{0.95}$$

$$Radius\ of\ Wheel = \mathbf{0.18\ m}$$

5.1.1 POWER AND TORQUE CALCULATIONS

$$\boldsymbol{Rolling\ Resistance} = gross\ vehicle\ weight * co{\sim}eff\ of\ Rolling\ Resistance$$

$$= \mathbf{500 * 0.15} \tag{5.1}$$

$$= \mathbf{75\ N}$$

$$\boldsymbol{Grade\ Resisitance} = gross\ vehicle\ weight * sin\emptyset \tag{5.2}$$

$$= \mathbf{500 * si\ n\ (2)}$$

$$= \mathbf{17.44\ N}$$

$$\boldsymbol{Acceleration\ Force} = mass * acceleration \tag{5.3}$$

$$= \mathbf{50 * 0.5}$$

$$= \mathbf{25\ N}$$

$\boldsymbol{Draft\ Force\ of\ Harrow} = \mathbf{85N}$ (Experimental Reading)

$$\boldsymbol{Total\ Tractive\ Effort} = Rolling\ REsistance + Grade\ Resistance + Acceleration\ Force + Draft\ Force \tag{5.4}$$

$$= \mathbf{75 + 17.44 + 25 + 85}$$

$$= \mathbf{202.44\ N}$$

$$\textbf{REQUIRED POWER} = (Total\ Tractive\ Effort * max.Velocity)/(Efficiency\ of\ Transmission) \quad (5.5)$$

$$= (\mathbf{202.44 * 1.5})/(\mathbf{0.95})$$

$$= \mathbf{320\ N}$$

$$\textbf{REQUIRED TORQUE} = Total\ Tractive\ Effort * Radius\ of\ wheel \quad (5.6)$$

$$= \mathbf{202.44 * 0.18}$$

$$= \mathbf{33\ Nm}$$

Table 5.1 Required torque and power

REQUIRED POWER (N)	REQUIRED TORQUE (Nm)
320 N	33 Nm

5.1.2 BATTERY CALCULATIONS

$$\textbf{Motor Capacity} = \mathbf{500\ w}$$

$$\textbf{Voltage Rating} = \mathbf{24\ v}$$

$$\textbf{Travel Factor} = \frac{Total\ Range}{Max.Velocity} \quad (5.7)$$

$$= \frac{\mathbf{10\ Km}}{\mathbf{7\ Km/Hr}}$$

$$= \mathbf{1.42}$$

$$\textbf{Battery Capacity Required} = \frac{Power * Travel\ Factor}{efficiency\ of\ System} \tag{5.8}$$

$$= \frac{\mathbf{500 * 1.42}}{\mathbf{0.80}}$$

$$= \mathbf{900\ \ W.Hr}$$

Battery specifications:

24 volts

37.5 Ah

Table 5.2 Battery parameters

VOLTAGE RATING (v)	Amp-Hr (Ah)
24 Volts	37.5 Ah

- Required power and torque were calculated.
- A 1KW electric system consisting of two 500 Watt motors and utilising a differential steering system was chosen. (simpler design and removes need of costly servo motor for steering)
- Motors designed to convert bicycles to e-cycles were chosen
- Necessary gear reduction is required to meet the torque requirements. (cycle motors have higher top speed and lower torque numbers)
- A 40:1 single Speed Gear box was chosen

5.2 CAD MODELLING

The first step in a project involving modification of a existing robot or a structure into a improved one is the modelling of the existing bot in a CAD program, This provides flexibility in prototyping and testing the fit of parts.The Existing bot was first modelling in Solidworks Software as shown in Figures 5.1 and 5.2

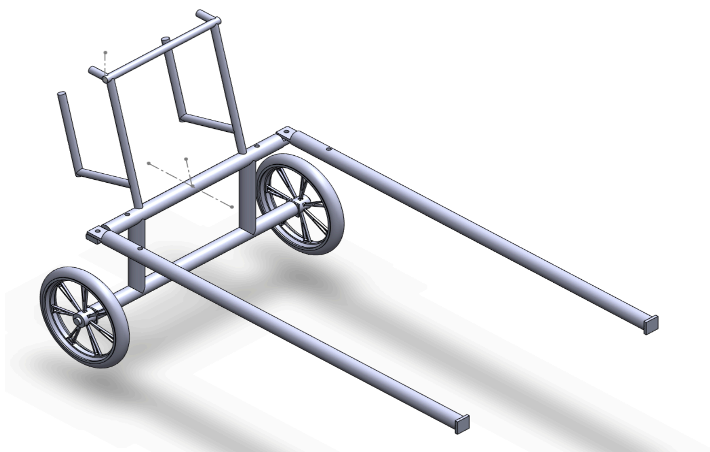

Fig 5.1 CAD Model of Existing bot

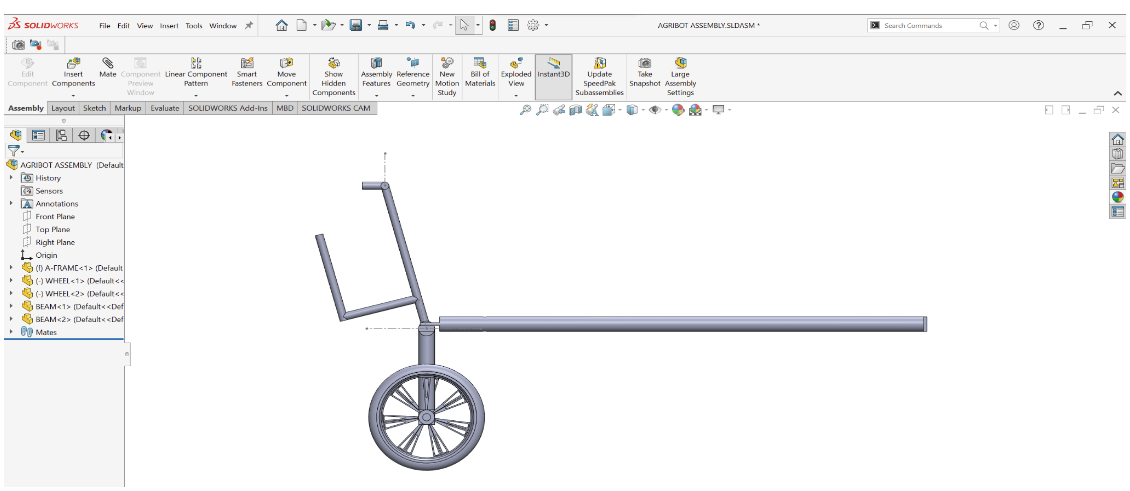

Fig 5.2 Side View in Solidworks

With the help of this model the necessary components for mounting the motors wheels and other components were modelled.Figures 5.3, 5.4 , 5.5 and 5.6 show the modelled parts , that were used for the verification of the final assembly and these parts were then fabricated

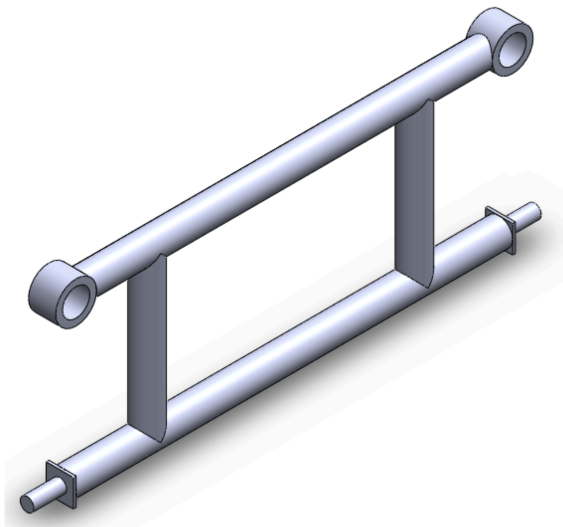

Fig 5.3 B-Frame for front wheels

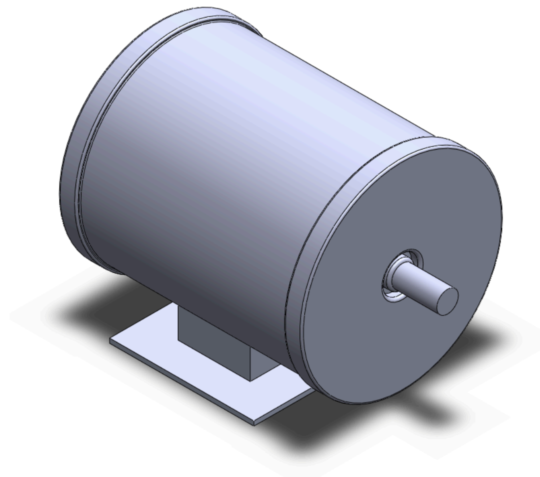

Fig 5.4 250 Watt electric Motor

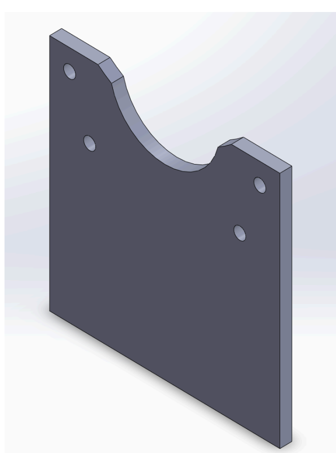

Fig 5.5 Clamp for motor

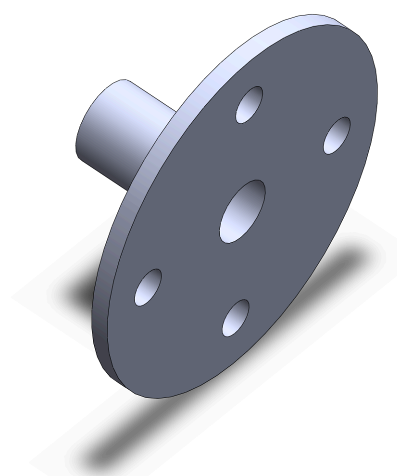

Fig 5.6 Wheel Hub

All the modelled components were assembled in SolidWorks to test the proper fitting of the components and to visualise the final product.The final assembled view of the Bot is given below in Figure 5.7 .

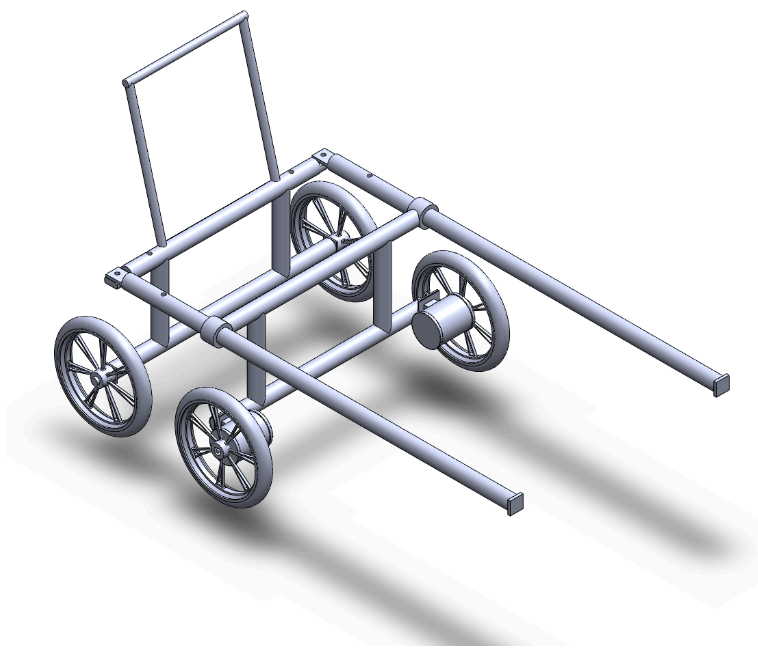

Fig 5.7 Fully assembled Model

5.3 PROCUREMENT

For fabricating the electric drive system the procurement of electric motors is essential.The choice of the Ebike MY1016Z2 250W Geared DC motor for the automated Agri Bot was not arbitrary but based on meticulous load calculations. Determining the appropriate motor for agricultural tasks involves evaluating the torque requirements, operating conditions, and the specific demands of the tasks to be performed.Two 250 Watt Motors were acquired for a total power rating of 500 Watts Figure 5.8 shows the Motors procured.

Fig 5.8 250 Watt Motors

Table 5.3 Specifications of the Motors

Power	Voltage	Current	Output shaft speed/min	Motor speed/min	Reduction ratio	Rated torque
250W	24V	≤3A	75R	3000	40: 1	36Nm

The 250 watt electric motor with a 40:1 gearbox and 36 Nm of torque is a compact and efficient powertrain component used in various applications that require moderate power output and high torque capabilities.

Fig 5.9 Motor Controllers

The Power and Torque outputs exceed the calculated Numbers , therefore the motor is more than capable of driving the bot.

Drivers are required to control the motor; they serve as an interface between the microcontroller and the motor.BTS7960 43A Motor Driver was chosen. Figure 5.9 shows the same.

Since a battery for the calculated capacity costs more than 15,000 rupees , a cheaper SMPS was acquired to directly run the bot on AC power, A 720 watt SMPS was procured. Figure 5.10 shows the SMPS.

Fig 5.10 720 Watt Power Supply

The Arduino Mega was chosen as the Microcontroller to control the entire bot, shown in Figure 5.11 .

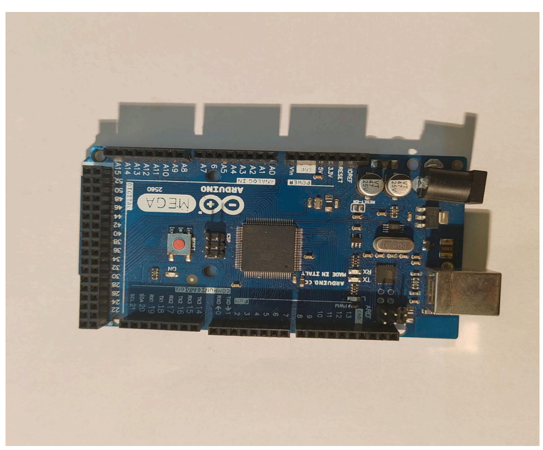

Fig 5.11 Arduino Mega

A 24v - 5V buck converter was used to power the arduino.14” wheels for a wheelbarrow were procured to be used as the powered wheels of the robot. 2.5” and 1” Mild Steel pipes were used to fabricate the B-frame.Figures 5.12 , 5.13 and 5.14 show the same respectively.

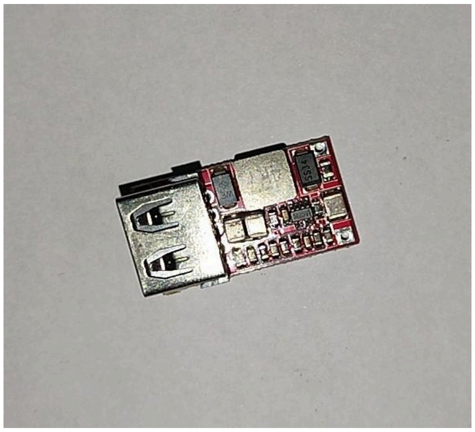

Fig 5.12 24V to 5V Buck Converter

Fig 5.13 14” barrow Wheels

Fig 5.14 2.5” and 1” MS Pipes

5.4 FABRICATION

The clamp for the motor and the disc of the wheel hub required precise and accurate cuts and holes to be mode, this made laser cutting an ideal operation for this job. Therefore a draft was done for the laser cutting and the parts were cut out of a 4mm thick sheet of Mild Steel. The draft for the laser cutting is given in Figure 5.15 . The Final laser cut parts are given in Figures 5.16 and 5.17 .

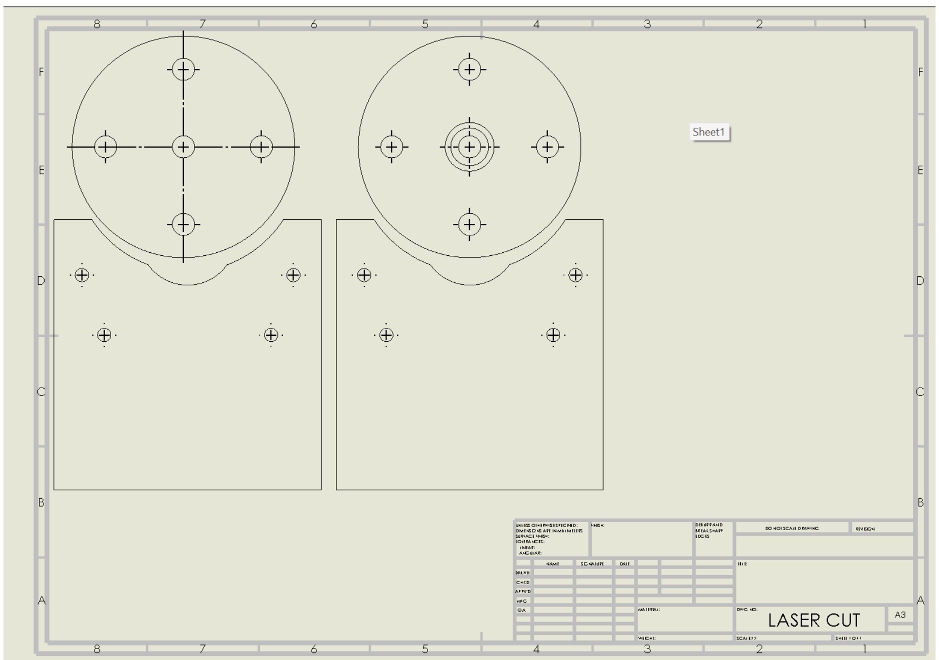

Fig 5.15 Draft for Laser Cutting

Fig 5.16 Laser cut Motor Clamps

Fig 5.17 Laser cut Wheel Hub

The B-frame was fabricated using the MS pipes of specified diameters. The different pipes were first cut to required lengths and then test fitted. The pipes were then welded appropriately to form the B-frame.Figure 5.18 shoes welded B-frame.

Then the motor clamps were further welded on to the frame, making sure to double check the orientation and alignment of the plate, since a misalignment of the plate may cause improper movement. After this the entire assembly was fitted into the mainframe and welded. Gas Metal Arc Welding was employed to weld the components together

Fig 5.18 Welded and assembled B-Frame

A 1” MS rod was machined to fit the motor shaft and then welded to the laser cut wheel hub to form the wheel mount, The shaft of the motor has a diameter of 17mm therefore the rod was cut to length and then a 17 mm hole was bored, then a 5mm tap was made in the centre for the insertion of a grub screw, shown in Figure 5.19 .

Fig 5.19 Wheel Hub

Finally the motors were mounted and the electronics were mounted and wired.The connections were checked and the electronic components were properly grounded to the frame to avoid any residual shocks.

Fig 5.20 Fully assembled prototype

5.5 IOT INTEGRATION

IoT, or the Internet of Things, refers to the network of physical devices, vehicles, appliances, and other objects embedded with sensors, software, and connectivity that enables them to collect and exchange data. IoT technology allows these devices to communicate and interact with each other, often through the internet.

Components involved in IOT :

- GMaps API service
- GPS module
- Arduino Mega
- Motor driver
- Power source
- Code for grid pattern generation (Need to be hosted in an API)
- SKETCH code for microcontroller

To control the motor effectively, the Arduino Mega was selected as the control system. With its ample processing power, extensive input/output capabilities, and compatibility with a wide range of sensors and peripherals, the Arduino Mega offers a robust platform for automating the Agri Bot. Its versatility allows for seamless integration with the BTS7960 43A motor driver, ensuring precise control over the motor's speed, direction, and acceleration.

The BTS7960 43A motor driver was specifically chosen due to its exceptional power handling capabilities. Designed to handle a continuous current of up to 43A. It ensures that the motor receives the required electrical current to unleash its full potential.

```
drawPolygon.jsx > DrawControl > constructor > useControl() callback
import MapboxDraw from '@mapbox/mapbox-gl-draw';
import {useControl} from 'react-map-gl';

function DrawControl(props) {

    useControl(() => new MapboxDraw(props), (a) => {
        let map = a.map;
        map.on('draw.create', props.onCreate);
        map.on('draw.update', props.onUpdate);
        map.on('draw.delete', props.onDelete);
    }, (a) => {
        let map = a.map;
        map.off('draw.create', props.onCreate);
        map.off('draw.update', props.onUpdate);
        map.off('draw.delete', props.onDelete);
    }, {
        position: props.position
    });

    return null;
}

DrawControl.defaultProps = {
    onCreate: function () { },
    onUpdate: function () { },
    onDelete: function () { }
};

export default DrawControl
```

Fig 5.21 a)Code for Pattern Generation

The necessary SKETCH code for the control of the motor drivers was written in the Arduino IDE in C#. The code has functions generating movement patterns, controls for moving the robot forward , backward, left and right turns.Figure 5.21 a) , b) show the code written

```
pin.jsx > ...
import * as React from 'react';

const ICON = `M20.2,15.7L20.2,15.7c1.1-1.6,1.8-3.6,1.8-5.7c0-5.6-4.5-10-10-10S2,4.5,2,10c0,2,0.6,3.9,1.6,5.4c0,0.1,0.1,0.2,0.2,0.3
  c0,0,0.1,0.1,0.1,0.2c0.2,0.3,0.4,0.6,0.7,0.9c2.6,3.1,7.4,7.6,7.4,7.6s4.8-4.5,7.4-7.5c0.2-0.3,0.5-0.6,0.7-0.9
  C20.1,15.8,20.2,15.8,20.2,15.7z`;

const pinStyle = {
  fill: '#d00',
  stroke: 'none'
};

function Pin(props) {
  const {size = 20} = props;

  return (
    <svg height={size} viewBox="0 0 24 24" style={pinStyle}>
      <path d={ICON} />
    </svg>
  );
}

export default React.memo(Pin);
```

Fig 5.21 b)Code for Pattern Generation

By the integration of the two 250 Watt motors, BTS7960 43A motor driver, Arduino Mega control system and the power system the automated Agri Bot benefits from a comprehensive and powerful setup.

Together, these components create a synergistic automation solution that optimises the Agri Bot's performance, enhancing productivity, efficiency. The precise coordination between the motor, motor driver, and control system enables the Agri Bot to navigate challenging agricultural environments, perform tasks with accuracy, and maximise the potential of automated farming operations.

Testing and Calibration:

Thorough testing and calibration are essential to validate the Agri Bot's performance and ensure precise execution of agricultural actions. Verifying the motor's functionality, accurate movement in response to control commands, and adjusting software parameters contribute to optimising the Agri Bot's performance.

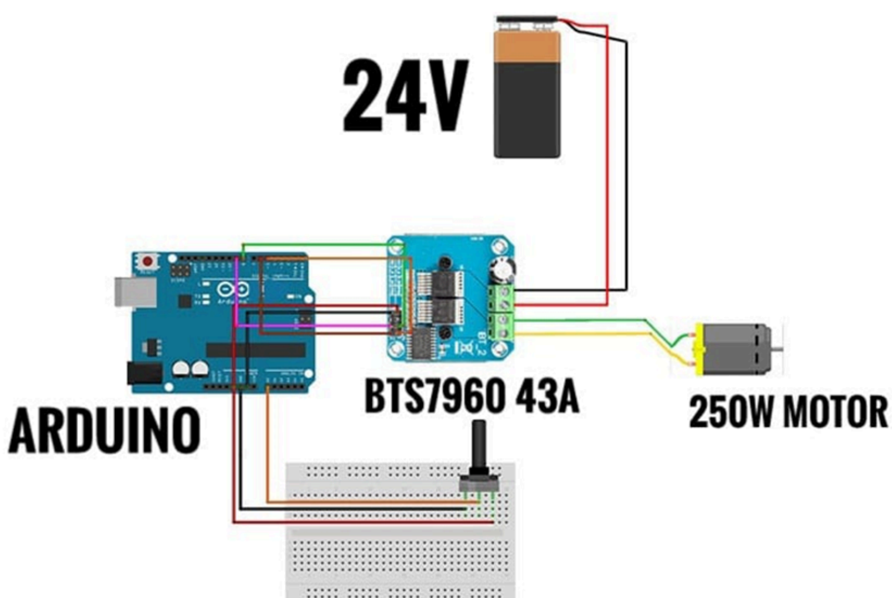

Fig 5.22 IOT Architecture and Wiring

During calibration, fine-tuning the control software, PWM values, or control algorithms may be necessary to ensure smooth operation and optimal performance for different agricultural tasks. Rigorous testing and calibration ensure that the multi-action Agri Bot is capable of delivering reliable and efficient results in various agricultural scenarios.

The Architecture and Wiring Diagram of the Agri-Bot is given in Figure 5.22 .

5.6 TESTING

The Fabricated prototype was tested in rough soil and road conditions and we can see that the designed electric motor based drive system easily provides enough power and torque required for the bot.The IOT based autonomous control system works well in steering and driving the bot, the GPS based navigation system can benefit from a more accurate sensor and the algorithms can be vastly improved in the future.

Fig 5.23 a) Testing of Agribot

Fig 5.23 b) Testing of Agribot

CHAPTER 6

CONCLUSION

In conclusion, this project successfully accomplished the fabrication of an autonomous agricultural bot and conducted initial testing of its electric motor-based drive system and preliminary IoT-based control system. The primary objective was to design a versatile bot capable of performing various agricultural tasks such as ploughing, watering, seeding, and fertilising.

The fabrication process involved careful selection and integration of components, ensuring the bot's structural integrity and durability. The electric motor-based drive system, complemented by a 40:1 gearbox and generating 36 Nm of torque, proved to be robust and capable of delivering sufficient power for efficient operation in agricultural fields. The bot showcased excellent manoeuvrability, allowing it to navigate through diverse terrains, avoid obstacles, and execute precise turns for accurate seed placement.

Overall, this project represents a significant step forward in the field of autonomous agricultural robotics. The fabricated bot, coupled with the electric motor-based drive system and preliminary IoT-based control system, showcases the potential to revolutionise agricultural practices by improving efficiency, precision, and automation. With continued refinement and integration of advanced technologies, this bot holds promise for enhancing crop productivity and sustainability in the agricultural industry.

The existing agricultural bot was modified and converted into an electrically driven, IOT based bot. It was further tested and performance was evaluated.

6.1 FUTURE SCOPE

The future scope of this bot includes the incorporation of advanced technologies and features to further enhance its capabilities and efficiency. Here are some potential future developments:

1. Gyroscope Sensor: Adding a gyroscope sensor to the bot's navigation system would improve its stability and orientation. The gyroscope would provide precise angular rate measurements, allowing the bot to better navigate uneven terrains and maintain balance, especially during turns or on slopes.

2. Optical Cameras for Obstacle Detection: Integrating optical cameras with computer vision algorithms would enable the bot to detect and avoid obstacles in its path. The cameras would capture visual information, which can then be processed in real-time to identify and analyse objects or obstacles, ensuring safe and efficient navigation.

3. Automatic Docking Stations: Developing automatic docking stations would allow the bot to autonomously recharge its batteries or access additional resources. The bot could navigate to designated docking stations when its battery levels are low or when it requires refilling of seeds, fertilisers, or other supplies. The docking stations could also facilitate maintenance and software updates, ensuring the bot's optimal performance.

4. Swappable Modules: Designing the bot with swappable modules would enhance its versatility and adaptability. Different attachments or modules could be easily interchanged to enable the bot to perform specific tasks, such

as ploughing, watering, seeding, or fertilising. This modularity would increase the bot's flexibility in adapting to different agricultural operations and requirements.

These future developments would further enhance the capabilities and performance of the bot, making it a valuable tool for farmers by providing efficient and precise autonomous operations, intelligent decision-making support, and seamless integration into modern agricultural practices.

REFERENCES

1. Saurabh Chauhan, 2015, ’Motor Torque Calculations For Electric Vehicle’, Volume 4, Issue 08.
2. Majid Rashidi, Hamzeh Fathi Lehmali, Mehrdad Salimi Beni,Meisam Malekshahi and Saeb Tabrizi Namin, 2013, ’Prediction of Disc Harrow Draft Force Based on Soil Moisture Content, Tillage Depth and Forward Speed’, Middle-East Journal of Scientific Research 15
3. Robert Walters, 2021, ’Soil,Draft,Traction’, Agrosphere International. Group 21
4. Paul Okoko, 2022,’Draft Force Determination for an Offset Disc Harrow in a Sandy Loam Soil’,Vol. 5, No 2, 140 - 146.
5. Kruthika Ramesh,Prajwal,C.Roopini,Monish Gowda,V.V.S.N.Sitaram Gupta, 2020, ’Design and Development of an Agri-bot for Automatic Seeding and Watering Applications’, 2nd International Conference on Innovative Mechanisms for Industry Applications (ICIMIA), Bangalore, India, 2020, pp. 686-691
6. Kakelli Anil Kumar, Aju. D., " An Internet of Thing based Agribot (IOT-Agribot) for Precision Agriculture and Farm Monitoring ", International Journal of Education and Management Engineering (IJEME), Vol.10, No.4, pp.33-39, 2020. DOI: 10.5815/ijeme.2020.04.04
7. ‘Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides’,volume 4,pages 58-73.
8. Chenchen Ren,Shen Liu,Hans van Grinsven,Stefan Reis,Shuqin Jin,Hongbin Liu,Baojing Gu 2019, ‘The impact of farm size on agricultural sustainability’,Journal of Cleaner Production,220.357-367