Electrical Multipurpose Agricultural Vehicle

Mahesh S[1], Keshav A[2], Ambaprasad G Hegde[3], M Amritha Nair[4], K Akash Hebbar[5]

[1]Assistant Professor, Department of Mechanical Engineering, Sapthagiri College of Engineering, Karnataka, India
[2-5]BE.Student, Department of Mechanical Engineering, Sapthagiri College of Engineering, Karnataka, India

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Abstract - *Agriculture is the science and art of cultivating the soil, producing crops and raising livestock. It is the backbone of the economy. Cultivation of any crop involves sequence of classified steps like ploughing, sowing, irrigation and harvesting. Considering the advancements in the technology farmers get to use various agricultural equipment's and labors for caring out the necessary operations. But the main setback with the already available technology is the absence of modularity. And it was also observed that majority of the farmers in India are marginal and small-scale farmers with less than 2 hectares of land. The agricultural equipment's available are extremely costly and prove to be impractical for these small-scale farmers. Thus, a demand has been noticed for low cost equipment and hence a concept is been developed to investigate if multiple small machines could be integrated and made more efficient than traditional large tractors and human forces with cost factor in mind. The main objective of our project was to combine all the individual tools and develop a modular design that provides farmers with equipment loaded vehicle that can be used for multiple purposes. The secondary objective of the design includes a vehicle which is small, compact in size and is easily accessible and controlled by an individual. At the same time to make use of green energy and provide a cleaner environment for the vegetation around it. The design of the vehicle is created in such a way that it is suitable for all the required activities such as ploughing, sowing the seeds, levelling the soil, sprinkling water. Thus, the project provides a machine design which can make cultivation much simpler, affordable and accessible. The vehicle is built to suit the middle-class farmers both men and women. The various systems of the vehicle is controlled by a toggle switches. In recent years the development of the autonomous vehicles in the agriculture has experienced increased interest. Most of the farming activities are stop-start and low speed, and high-torque required, thus making them ideally suited to electric vehicles with their electric motors which have low-speed, high-torque characteristics. The advantages of these vehicles are low labor wages, ease of maintenance, faster operations and zero fuel emissions.*

Key Words: Agriculture, Modularity, Agriculture Equipment, Multipurpose, Green Energy, Toggle switches

1. LITERATURE REVIEW

Dr. Smita Joshi, Vinit Joshi and Shah Kalp (2017) proposed a paper that points out the disadvantages of a conventional tractor that can perform one function at a time. A prototype was designed which uses solar energy to perform the task and it also favored the use of Lead Acid Battery pack over Lithium ion battery pack which had the capability of functioning 3 farming processes in a single run. Dr. C. N. Sakhale (2016) proposed a paper which concluded the importance of mechanization in the field of agriculture by using multifunctional single axle vehicle. For a sustainable and low weight vehicle the use of power tiller and hopper was taken into consideration. An auger bit drill tool was used to sow the seeds into the soil and a T-shaped structure was used for fertilizer spraying operations. Sharath. T. D, Sachin R. K and Keshavanth B. G (2019) proposed a paper in which the drawbacks of the conventional farming were eliminated. The prototype satisfied the needs of small-scale farmer as less man power and time was consumed in farming. The use of wireless technology was an ultimate future scope which would solve the labor problem in India and the use of soil moisture sensor to prevent flooding of fields. Patil Nikhil, Shaikh Ajaharuddin G, Prof. P. G. Tathe (2018) proposed a paper that points out the multitasking of the multipurpose vehicle, that is the two operations are multitasked in a single assembly. The vehicle was adopted with the scientific and precision forming technology and variable dimensions and farming specifications. For higher yield and better quality of the crop the implementation of the scientific farming was done. The vehicle was made in order to perform 4 different cultivation operations. David D. Wilson and John H. Lumkes (2015) proposed a paper about the agricultural attachments such as maize grinder, two-row planter and 3-point hitch caddy which was designed and tested with practical utility platform. The maize grinder was able to ground around .68kg of the maize in just 4 minutes. Prof. P. V. Bute, Shailesh Deshmukh and Vishal Deshmukh (2018) proposed a paper to develop the need mechanism that is capable of doing the specific farming operations automatically with the help of RF module for wireless communication. A hollow cylinder having multiple holes on the surface was placed horizontally and was driven by the motor for the distribution of seeds.

2. INTRODUCTION

Farmers nowadays pay plenty of cash on machines that facilitate them with decreased labor work and increase in the yield of crops. They purchase numerous machines that are used for tilling, harvesting, spraying pesticides etcetera but these machines ought to be operated by hand to perform the specified operations and furthermore separate machines are required for different tasks. The yield and profit returns from using these machines or vehicles are terribly less as compared to the investment. In an effort to help to improve the returns of farming in an environmentally acceptable way, the project's objective is to investigate the feasibility of a small size electric farming tractor fixed with various tools operating time on field without stopping for a change to a different function and to minimize the cost.

2.1 UNDERSTANDING THE DEMAND

Marginal farmers and Small-scale farmers can be defined as farmers with less than 2 hectares of operational land holdings. According to the 10^{th} Agricultural census carried out in 2015-2016 these farmers make up for about 86.2% of all the farmers in India. When compared to the data from the previous year's census it becomes clear that the numbers of small-scale farmers has been on the rise due to the fragmentation of the land. These farmers barely make it even between the investments and returns from their operational holdings. The agricultural equipment that are readily available in the market range between 7,00,000 to 15,00,000 and it is highly uneconomical for these farmers to invest such a large sum of money for such a small operational holding. Thus, a demand for cheaper agricultural equipment has been on the rise.

2.2 ELECTRIC DRIVERS OVER IC ENGINES

Electric motors can provide constant torque output and provides quick response to load changes. These systems may or may not require a gearbox since the speed and torque can be controlled by varying the frequency and voltage of the electricity. The usage of conventional fuels produces pollutant that mainly comprises of Carbon monoxide hydrogen, Sulphur dioxide, particulate matter and major proposition of Nitrogen. The emission gases varies with respect to several factors such as;

1. Terrain
2. External load such as carriage or trailer
3. Secondary usage such as running a compressor for pumping water.

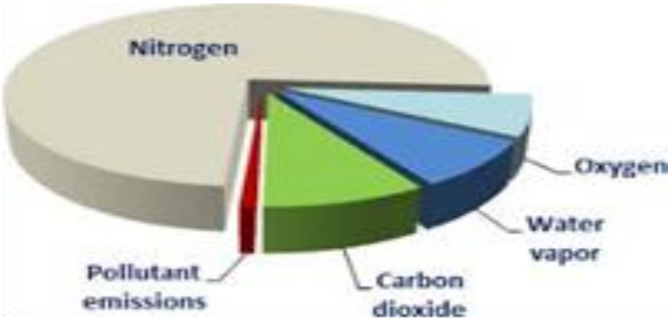

Fig -1: Emission Details

On Comparing the electric system with the IC engine, although the energy stored in batteries is too low compared to fuel of IC engine and recharging the batteries is time consuming but these problems are overcome by easy installation of electric system, low mechanical parts, and low maintenance of the system

3. DESIGN

The modelling of the project was done through a computer aided design software Unigraphics\NX

3.1 CHASIS DESGIN

The vehicle is built to sustain a load of 400 kg, the chassis is made of 1" L-angle reinforced at certain locations. The chassis is fitted with rack and pinion steering assembly. The rear axle is made of 30 mm mild steel rod and mounted with a fixed speed reducer and a common disc brake. Frame is provided with 13" wheels that are assembled to the chassis using wheel bearings.

The chassis has a parallel bed structure. The lower bed supports steering assembly, rear axle, plough rod and weed remover, while the upper bed supports a seed tray, a water/fertilizer tank, motor controllers and batteries.

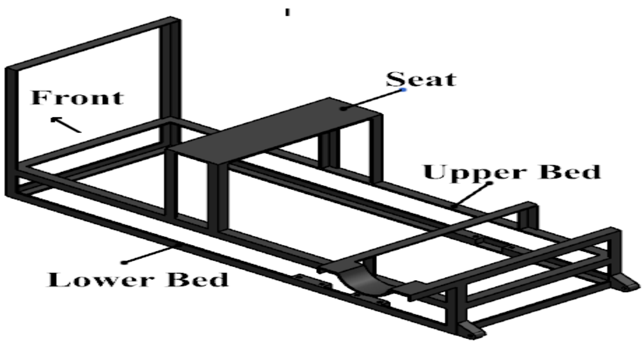

Fig -1: Frame

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3.2 PLOUGH

The plough is made by 10 mm bar having rectangular cross section where one end is made in shape of trowel and other end is fitted to a common rod. The plough is designed to sustain the resistance of soil. The common shaft is then connected with a lever that is placed next to the driver seat.

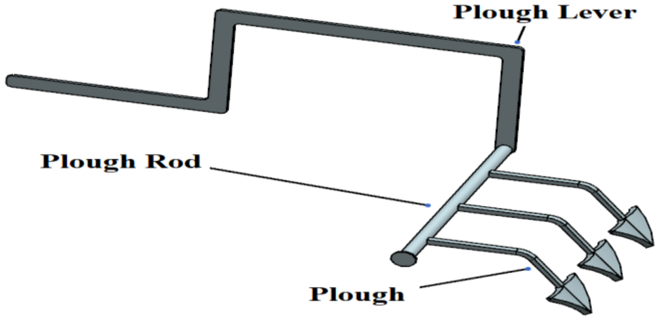

Fig -1: Plough Setup

3.3 SPRINKLER

A 20Ltr vessel is mounted on the upper bed of chassis. A 12V submersible pump is placed inside the container. The outlet of pump is connected to a T shape sprinkler that is fixed just behind the driver seat. A flexible pipe is used to deliver the water/fertilizer.

3.4 LEVELER

Leveler is used to cover the sand after the seeds are in the soil. It also makes the surface uniform so as to prevent the vehicle getting stuck into the soil. A metallic plate having max load concentrated at end is used for this process. The plate is hinged to the end of chassis. And is bolted to upper bed frame when not in use.

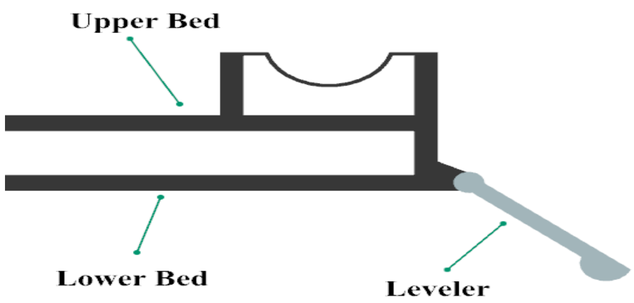

Fig -1: Leveler

3.5 SEED TRAY

A vessel used to store seed is mounted on the upper bed of the chassis. A revolving bucket like mechanism is made to deliver seeds at fixed intervals. This shaft is driven by a 12-volt DC motor that is rotated at lower rpm. The speed of motor is controlled by an Arduino based motor controller that controls the speed of motor with respect to speed of vehicle.

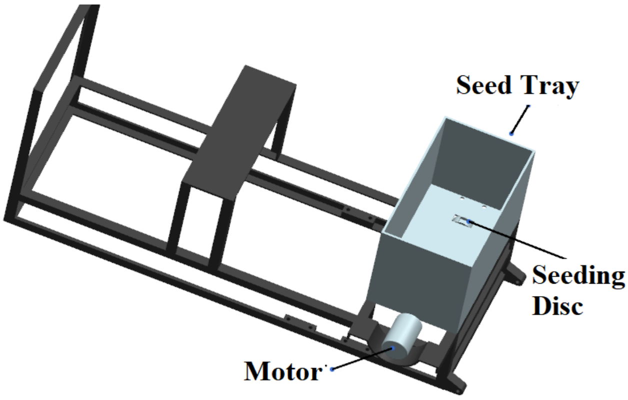

Fig -1: Seeder Tray

3.6 ELECTRICALS

3.6.1. 48V, 1.2KW, 3100RPM BLDC Motor - A motor is a device that converts supplied electrical energy into mechanical energy. A BLDC motor (Brushless DC motor) also known as ECM (Electronically Commutated Motor) is a synchronous motor which is powered by DC (Direct Current). A BLDC motor is highly efficient and has excellent control-ability. It is also known for its power saving capacity compared to other motors in the market. The controller supplies pulses of current to the windings present on the motor to control the speed and the torque of the motor. There are several advantages of BLDC such high power to weight ratio, high ranges of speed, low maintenance and electronic control.

3.6.2. 48V, 1.2KW Motor Controller - Is a unit containing a group of elements used to predetermine the performance manner of an electric motor. It can have both automatic to start and the stop the motor, reverse or forward rotational motion, regulating the required speed, limiting or regulating required torque, protecting against electrical faults and overloads. It consists of high speed, small switches which are turned off and on thousand times a second. Each of these small switches create voltages which increases and decreases on its open and closed positions. This causes a wave in the form of stair-step, this is similar to the AC power. The motor spins faster depending on how fast the current direction changes.

3.6.3. 12V, 1000L/H Submersible DC Pump - Is a device having hermetically sealed motor. Hermetical seal is a category of seals that prevents the movement of air, oxygen or any other gases making it air tight. The whole component as a set is submerged in the fluid that is needed to be pumped. A submersible pump can eliminate the common problem caused by high elevation difference between the fluid surface and the pump causing pump cavitation. Hydraulic Submersible Pump (HSP) uses the pressurized fluid present at the surface to drive the motor down the hole.

3.6.4. 12V, 30RPM Geared DC Motor & 12V, 6000RPM DC motor – Two light weight DC Motors are used for 2 different applications

1. Rotation of the seeding disc – The 30RPM DC Motor is an ideal motor for the rotation of the seeding disc as the slower RPM of the motor allows the disc to grab a perfect amount of seeds between its pickup and drop cycle

2. Working of Weed Removal – The 6000RPM motor along with a sharpened aluminum blades mounted in the front of frame works in the same way as a lawn mower works.

3.6.5. 12V, 25AH Li-ion battery - Lithium Ion batteries are rechargeable and are majorly used for portable electronics and in electrical vehicles. They are also finding their popularity in the aerospace industries. It works on a basic chemical process, the negative lithium ions from the negative electrode move towards the positive electrode during discharge via an electrolyte solution and the motion is reversed on charging the battery. The positive and negative electrodes used are lithium compounds and graphite. Lithium ion batteries are known to have high energy density, low self-discharge and no memory effect. The motor requirement was 48V and 25Ah for the peak load condition. This was achieved using 4nos of 12V 25Ah batteries connected in parallel. The battery pack was placed right next to the driver seat giving it an easy access for replacing or recharging.

4. DRIVE PERFORMANCE CALCULATION

In the working condition of the electric vehicle, the operating speed is about 6~20km/h. Due to the low speed of the electric vehicle, the influence of air resistance can be neglected, the driving equilibrium equation of the vehicle along with plough is defined as

$$F_T = F_{PN} + F_R$$

Where,
F_T= Total force (N).
F_{PN} = Resistance offered during plough (N).
F_R = Rolling resistance of vehicle (N).

The formula to calculate F_P is:

$$F_P = 0.5\ Z\ b\ h\ k \quad \text{……… (1)}$$

Where,
Z = Number of plough
b = Single plough width (cm)
h = Plough depth (cm)
k = Soil resistance (N/cm^2)

Table -1: Plough parameter

PLOUGH PARAMETERS			
Number of Plough	Plough depth /cm	Single Plough width /cm	Soil Resistance (N/cm^2)
3	8	4	5

Substituting these parameters in the equation (1)

$$F_P = 0.5\ Z\ b\ h\ k \rightarrow 0.5*3*4*8*5$$
$$F_P = 240N$$

As the plough is more complex and the driving force varies with respect to soil condition, it is usually defined as the additional driving force of the electric tractor is F_{TN}:

$$F_{PN} = (1.1\sim1.2) * F_P = 1.2*240$$
$$F_{PN} = 288N$$

The formula to calculate F_f is:

$$F_R = mgf \rightarrow 220*9.81*0.35$$
$$F_R = 755.37\sim756N$$

Where,
m = mass of vehicle Kg
g = acceleration, take the value 9.8 m/s^2
f = rolling resistance coefficient.

$$F_T = F_{TN} + F_R \rightarrow 288+756$$
$$F_T = 1044N$$

4.1. POWER CALCULATION OF DRIVING MOTOR:

The driving power of the vehicle is determined by the power of the electric motor. The power of electric motor driving the vehicle along with plough should meet:

$$Pq \geq (Fq * VL)/3600 * \eta_Q$$

Where,
V_L = Maximum speed of plough (m/s)
η_Q = traction efficiency of drive system.

$$\eta_Q = \eta_E * \eta_M$$

Where,
η_E is the efficiency of driving motor
η_M is the efficiency of the transmission system.

$Pq \geq (Fq * VL)/3600 * \eta_Q$ → 1044*203600*0.64*9

$$Pq \geq 1.006KW$$

$$Pq = 1.2KW$$

4.2. TORQUE OF DRIVING MOTOR:

$$T_{max} = 60000\ P_{Qmax}/2*\pi*\eta_E$$

Where,
P_{Qmax} = Maximum driving power
n_E = Drive motor rated speed.

4.3. ENERGY CALCULATION OF POWER BATTERY PACK:

According to the rated working time of the machine, we can determine the total energy of the power pack that is consumed:

$$W_B = 1.2 * P_E * T$$

Where,
P_E = Rated power (W)
T = Rated working time (hr)
W_B = Total energy (KWh)

$$W_B = 1.2 * P_E * T \rightarrow 1.2*1.2*⅔$$

$$W_B = 0.96KWh$$

4.4. CALCULATION OF POWER BATTERY CAPACITY

The total capacity of the battery pack is determined based on the total energy consumed by the power pack:

$$C_B = 1000\ WbV$$

Where,
V = Rated operating voltage of the power Battery (V)
C_B = total capacity of the battery (Ah)

$$C_B = 1000\ WbV \rightarrow 1000*0.9648$$

$$C_B = 20Ah$$

5. CONCLUSIONS

- The vehicle is developed for small scale farmers and is made affordable to them.
- The prototype is build considering the environmental issues and understanding the economic scourges of a farmer. This project encourages zero emission.
- Since Government of India is keen to provide with facilities such as solar energy, this prototype comes handy to them.
- The size of vehicle is reduced compared to traditional agricultural machines, suiting limited parking space.
- An electrical motor is best suited for this machine as they provide a long run without any maintenance. The motor performance is calculated based on the possibly difficult situation that a vehicle could be made to run.
- The integration of the tools to a single machine allows a farmer to utilize much of his production hours on field.
- The annual maintenance cost of this project is estimated to be lower than Rs500, making the most affordable agricultural equipment to be used.

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