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Conversion of Fuel-Operated Tractor to Electric Operation: Design, Feasibility and Performance Analysis

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Abstract:
A tractor is a compact and versatile vehicle designed for use in agricultural activities and other outdoor usage. Tractors normally use diesel as fuel that provides ample power for a range of tasks, including plowing, tilling, and hauling. Operational cost of tractors on fuel is high, produces noise pollution and environmental pollution which is a global concern now. Some companies have started electric operation of tractors but the price is very high because of less players in the market and high price of battery bank. In this paper a Garden tractor has been used for conversion from fuel operation to electric operation. The compressor of hydraulic oil has also been operated by the same motor by adding a pulley on the shaft of motor coupling assembly with power transmission system. The research includes component selection, mechanical and electrical design adaptations, energy requirements, economic analysis, and performance comparison. The prototype demonstrates that electric tractors can meet the functional needs of small- to medium-scale farms while contributing to sustainable agriculture.

Keywords: tractor, fuel, battery bank, controller, motor, converter, wiring

INTRODUCTION:

Tractors have played an important role in farmer's life since the beginning of civilization, as almost the entire farming process is dependent on them. Tractors are classified according to their use, for example, utility tractors are used in farming, whereas industrial tractors are used on building sites and are responsible for lifting and carrying heavy loads. Farmers use tractors for tasks such as ploughing, sowing, tilling, and other agricultural tasks. At times of non–cropping season so called off season, farmers are left with no source of income, a farmer can lend his tractor to those who require it on custom hiring basis to earn money.

Figure 1

Tractors, particularly the most recent ones, include an automated transmission system that makes operating

much easier and more seamless moreover the power steering has reduced ergonomics and aids the operator for turning. These new measures ensure that operating the tractor is much safer. Apart from using tractors over the field tractors can be used in a wide range of operations. Furthermore, they can be fitted with a range of equipment, such as backhoes or front loaders, to carry even larger duties. In our country, it becomes extremely important to check the durability of farmland as well as the equipment. Unfavourable climatic conditions such as excessive heat, humidity, rains, or dry or rough landscapes may lead to certain damage. The tractors are typically designed with powerful engines strong engines capable of loading/pulling huge loads and appropriate for all weather conditions.

e-tractors have been manufactured by many companies and is an encouraging step for reduction on operational price and environmental pollution. The price of e-tractors will get reduced after the battery price is reduced and other players come into the market for manufacturing process.

Many researchers have converted fuel operated tractor to electric operation. This paper gives the details of chassis management with modification for incorporating battery bank, motor and other accessories. The housing of these items is executed in consideration with centre of gravity of the machine for the safety measure of operator.

Methodology:

The garden tractor (Mitsubishi Shakti, MT 180D) is for conversion purpose is shown in Figure 2, this tractor was irreparable and was left in shambles in the field for years which would have decayed by weathering. Figure 3 shows banat removed engine visible, Figure 4 shows tractor split into two parts as engine connects the two parts for completion of chassis, Figure 5 shows laboratory testing of battery bank, motor, controller and accessories. Figure 6 shows the space for motor installation for power transmission and Figure 7 depicts installed motor. Figure 8 and Figure 9 shows the status of each cell inside battery bank by battery management System BMS installed inside the battery bank.

Figure 2

Figure 3

Figure 4

Figure5

Figure 6

Figure 7

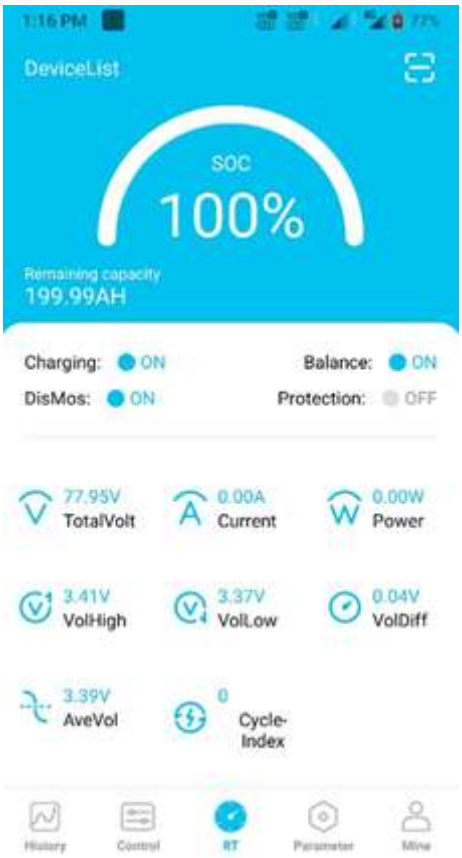

Figure 8

Figure 9

Since marginal farmers usually did not effort mechanization in their farm practices because of high price. The emerging of e-tractors in the market will reduce operational cost to half or still lower thereby will facilitate marginal farmers to use mechanization on custom hiring basis. The mechanization will be cheaper when the rechargeable batteries cost is reduced by increasing its production in the market.

Breakup of components used for conversion

Selection of Tractor:

- Model: VST Mitsubishi, Model MT 180D (garden tractor)
- Diesel engine: 18 HP

Power transmission system Used:

- Equivalent power output: ~10 kW (PMSM) electric motor, ~5000 RPM
- Continuous torque: 19.08-32.07 NM
- Battery range: Minimum 4 hours of field operation

Electric Motor:

- Battery Pack: 72V, 200 Ah LiFePO4
- Motor Controller: Programmable inverter with regenerative braking support, rated current 180 Amps, peak current 250 Amps
- Charging System: Off-board AC charger, 30 Amps

Low running cost

The running cost of an electric vehicle is much lower than an equivalent petrol or diesel vehicle. Electric vehicles use electricity to charge their batteries instead of using fossil fuels like petrol or diesel. Electric vehicles are more efficient, and that combined with the electricity cost means that charging an electric vehicle is cheaper than filling petrol or diesel for your travel requirements. Using renewable energy sources can make the use of electric vehicles more eco-friendly. The electricity cost can be reduced further if charging is done with the help of renewable energy sources installed at home, such as solar panels.

Low maintenance cost

Electric vehicles have very low maintenance costs because they don't have as many moving parts as an internal combustion vehicle. The servicing requirements for electric vehicles are lesser than the conventional petrol or diesel vehicles. Therefore, the yearly cost of running an electric vehicle is significantly low.

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