ASPECTS OF BATTERY POWERED FARM MACHINES FOR FARMING 4.0

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Abstract

The pressure to produce more food has led to the need for identification of applicable solutions, to solve, to improve the sustainability of production processes and accelerate innovation in the agriculture. These solutions based on the technical revolution can be characterized by the Farming 4.0 concept.

This concept is primarily based on the application of precision agriculture methods with the help of new technical achievements such as IoT (Internet of Things), AI (Artificial Intelligence), Big Data, Cloud and battery modernization.

Among the important technological achievements, we list the automatic steering based on GPS, autonomous tractors and agricultural machines, the replacement of the thermal motors with electric motors, using batteries as the main source of energy, robots and drones for agriculture, direct communication between agricultural machines and centralization of all information in Cloud-based software applications.

This article gives a brief overview of the achievements based on the use of batteries in agricultural machines and tries to synthesize the main future directions.

Key words: battery, Farming 4.0, IoT, precision agriculture, robots for agriculture.

INTRODUCTION

The Department of Economic and Social Affairs, Population Division, of the United Nations, (United Nations, 2017) has predicted that the global population will reach 8.55 billion people by 2030 and almost 10 billion people by 2050. In order to feed this growing population, according to FAO, food production must increase with 70 percent by 2050 and a 60 percent increase in demand for high quality protein such as milk, meat, and eggs.

Agriculture is energy intensive and the pressure to produce more food requires more energy, an increasingly costly input to the production process.

Electric driven farm vehicles are nothing new. Probably the first attempt to use electricity to power field equipment was in 1894, when the Zimmermann Company in Germany demonstrated its self-propelled electric ploughs. They were common in the 1930s but were tethered to the supply by trailing cables. Today, John Deere's developed GridCON, a tractor which operates autonomous and therefore has no cabin. It is supplied with a 1 kilometer long cable which rolls on and off automatically. This tractor was built after the battery problems of the Sesam, a fully electric 6R-series tractor, in which the engine and fuel tank were replaced by a huge battery package.

MATERIAL AND METHOD

This study analyzes the stage of achievements and the possible directions of battery powered farm machines, in accordance with the requirements of the new agricultural revolution.

In the case of passenger cars, every major automotive company currently has such a vehicle produced in series. It is a good prognosis for electric drives to have a significant market share in the future in the agricultural machinery sector as well.

Farming requires powerful machinery to perform ground preparation functions and other energy intensive operations, so the tractor is the heart of most farming operations. The tractor not only provides transport and traction power, but is also used to drive attached machinery in a stationary operation.

Several agricultural machinery manufacturers have introduced battery powered tractors into the market. Examples are in Table 1.

Table 1

Battery powered tractors on the market or under trial.

Manufacturer	Model name	Power rating kW	Battery size kWh	Operation time h	Recharge time	Charging cycles
John Deere	Sesam	130	150	4	3 h	3100
Solectrac	eUtility (and eFarmer)	15	26	5 to 8	3 h to 80%	3000
Rigitrac	Rigitrac SKE50	50	80	5	–	–
Agco / Fendt	Fendt e100vario	50	100	5	0,75 h to 80%	–
Escort	Farmtrac				6 - 10 h	

Another new category of battery powered farm machines are telehandlers (telescopic handlers).

Table 2

Battery powered telehandlers on the market or under trial.

Manufacturer	Model name	Max. Load kg	Max. Height m	Operation time h	Recharge time h	Charging cycles
Faresin Industries	Faresin 6.26	2600	5.9	6	4	2000
Manitou	MHT-790E	9000	6.84	8	8 (1.5h fast charge)	3000
JCB	JCB 30-19E	3000	4.1	8	2-minute battery change	-

To extend battery life have appeared the so-called solar powered tractors, which have power derived from PV panels attached to the tractor.

Options for battery swap out are also considered, i.e. one battery can be on charge during the morning session and swapped at the midday break for a second battery that would then charge during the afternoon shift.

One of the biggest impacts of the decreasing cost of solar panels and batteries is in the field of robots for agriculture. This systems range from small low weight machines powered entirely by solar, used for weed eradication, to larger machines using stored energy for more complex tasks, such as sowing, fertilization, crop assessment, harvesting etc. They use a very small amount of power, have electric motors, they can be positioned very precisely. One of the advantages of battery-powered robots is that they can operate continuously and do not require daylight for operation. This robots have the advantage of small size and low weight, causing less soil compaction than would happen if tractor based planters and cultivators were used, as well as a massive savings in time and energy.

There are several weed eradication robots on the market, some entirely solar powered and others relying on battery storage. The robots detect the presence of weeds and eliminate them either by a controlled dose of herbicide, mechanical removal, or mechanical destruction.

A typical example would be the machine designed and under test by Ecorobotics of Switzerland. The robot is completely solar powered and can operates by detecting weeds and delivering a controlled amount of herbicide to the weed. The robot can cover 3 ha per day, up to 12 hours a day. It is powered by a 380 W solar array and an on board battery is fitted. It has 2 x 15 l herbicide tanks and is a relative lightweight, at approximately 130 kg.

Similar is RIPPA (Robot for Intelligent Perception and Precision Application) which is equipped with VIIPA™ (Variable Injection Intelligent Precision Applicator), which is capable of autonomously shooting weeds at high speed using a directed micro-dose of liquid.

Among the more powerful robots we must remember Bonirob, designed and developed by a Bosch company "Deepfield robotics". The unit can operate for eight hours and can cover up to five hectare per day. Another example are the French-made Dino robot which is guided by accurate GPS signals to follow a pre-programmed route, straddling vegetable beds while two cameras assess the plant growth and identify weeds to be mechanically dug out from crops. Once under way, the battery-powered unit can work for up to ten hours on a full charge, covering up to five hectare in a day, without the need for further human interference – even sending its operator a text message when the job is finished.

A different concept are represented by the Digital Farmhand robot, developed by University of Sydney engineers, which uses low-cost robotics technology to increase food quality and production output for small-scale farmers.

Mobile agricultural robot swarms MARS, developed by Ulm University of Applied Sciences, the EU research funding, AGCO and Fendt, is an approach for autonomous farming operations by a coordinated group of robots. One key aspect of the MARS concept is the low individual intelligence, meaning that each robot is equipped with only a minimum of sensor technology in order to achieve a low cost and energy efficient system that provides scalability and reliability for field tasks. The key advantage of this approach is the energy efficiency compared to other methods using robots. The robot swarms is coordinated by a centralized entity, which is responsible for path planning, optimization and supervision. It also serves as a mediator between the robots and different cloud services responsible for the documentation of the procedure. The swarm approach allows robots to concentrate on areas where action is required and devote less attention to areas not needing attention, whereas individual robots have to cover the whole area.

An entire system, including small robots operating in swarms and a cloud-based system control, is available under the product name Xaver, which fits in with the swarm concept of using a large number of small autonomous machines to do precise agricultural work.

Australian-based SwarmFarms is building modular system of small self-driving frame to which components can be added or subtracted.

The most complex robots are those made for harvesting in horticulture. An example is BayWa picking robot for apple harvest developed by the US start-up Abundant Robotics, in which Munich-based BayWa Group acquired a stake in 2017. Another example is AI-equipped tomato harvesting robots from Panasonic.

Designed for strawberry fields, Agrobot E – Series has twenty – four robotic wireless arms that can not only quickly pick strawberries, but can also identify a strawberry's maturity in the field.

Sweeper, backed by the EU as part of its Horizon 2020 innovation program, is built to pick ripe peppers in a greenhouse. To do his job, Sweeper uses a camera that recognizes a pepper's color. Computer vision then helps the robot decide whether to pick the fruit. If so, Sweeper uses a small razor to cut the stem before catching the fruit in its "claws" and dropping it in a basket below. The Technology University of Queensland developed a prototype robotic sweet pepper harvester nicknamed Harvey, combining robotic vision and automation expertise to benefit farmers. The camera system and harvesting tool are mounted at a standard robotic (arm) manipulator end. Combining robotic-vision techniques and crop manipulation tools are key factors in harvesting these crops.

RESULTS AND DISCUSSION

All over the world is a growing concern for the development of intelligent machines for agriculture. This concern is given on the one hand by the increasing need for food to feed the population but also due to the decrease in the workforce in agriculture and the need to protect the environment.

This concern has materialized through the emergence of precision agriculture technologies and Digital Farming or Smart Farming concepts, which has transformed into Farming 4.0, the fourth revolution in agriculture.

In contradiction with the present tendencies, based on agricultural machines as high as possible to have the highest productivity but which strongly pollute the environment, we try to make smaller agricultural machines, less polluting, to apply precision agriculture and to protect the environment. One of the challenges facing development of electric farm machines is the need for sufficient stored energy to run a large vehicle for a full day on a single charge. This has currently restricted the sector to small and medium sized machines. Small machines have an advantage of reducing soil compaction and unlike their larger counterparts, can be used in wet conditions without creating as much damage on soil. The ability to work just after rain when weeds are beginning to sprout can translate to less herbicide being needed. This machines need around 70% less energy to do the same work as diesel driven machinery, and since neither diesel nor oil is required to operate the machines, there is no leakage and there are no local emissions.

CONCLUSIONS

We can conclude that the agricultural industry is about to be disrupted and will transform into a high-tech industry and will need a high skilled farmers.

With the exception of large energy-consuming agricultural works, such as plows, most agricultural machines will be electrically powered and will have the battery powered by solar panels as an energy source. Even for the plowing it is possible to have a machine with a single furrow, working 24 hours a day, by replacing the battery, to cover the farm needs. Battery research is being supported by all governments around the world and will change that situation.

These machines will be modular, meaning there will be the possibility to perform several types of agricultural work and will be able to work in a team, communicating both with each other and with a command center. The farmer will be able to access the control center and drive this machines through a mobile phone or tablets. Harvesters, which will be primarily robots, will specialize in a range of similar products.

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