

# Research on the Evaluation Model of the Economic Life of Agricultural Machinery Driving System

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**Keywords:** Agricultural machinery driving system; Parameter matching; Optimization; Evaluation Model

**Abstract:** The energy crisis and environmental pollution caused by the traditional agricultural machinery driving system are the problems that must be solved in vigorously developing the energy-saving industries and implementing the sustainable development strategy in China. As a new energy agricultural machinery, the pure electric tractors can achieve zero emissions and effectively solve the problems arising from the traditional fuel tractors because of its wide range of sources of energy. Therefore, the basic research on the driving system of small farm pure electric tractor has certain significance and guidance for the research and development of small pure electric tractor in our country. Firstly, through the analysis and comparison of the driving system structures of four typical pure electric cars, considering the specialties of tractors for plowing, this paper determines the driving system solution for the pure electric tractors, and creates the evaluation indexes, including the evaluation index for the driving system of agricultural machinery and the economical evaluation index, to provide a basis for the parameter matching of the main components of driving system.

## Introduction

China is a large traditional agricultural country with a large cultivated land area and a high agricultural machinery ownership. As an important power machinery in agricultural production, the total number of tractors is increasing steadily year by year. According to statistics, the small agricultural tractors ownership is more than 3.33 times the total number of the medium and large tractors. The total fuel consumption of small agricultural tractors accounts for about 36% of China's annual fuel output, and the proportion is quite high. At present, the small tractors used in agricultural production in our country are basically the traditional fuel tractors. Because of their long history, they have many advantages such as the mature manufacturing technology, high reliability and low price. However, because of the extremely harsh and complex working environment of tractors, the requirement of their performance is very high. The frequent switching of operating modes and gears is needed to meet the requirements of different working conditions. Moreover, because of the special working environment, the engine works mostly in the high-power and low-speed status, which causes the low work efficiency, huge fuel consumption and bad emission.

In conclusion, it is one of the effective ways of solving the current energy and environmental problems to develop the pure electric tractors with many advantages such as high efficiency, zero pollution and low noise. At present, due to the relatively backward agricultural development, the development of pure electric tractors is relatively slow in our country, especially for the research on electric tractor driving system, which is almost in the initial stage. Through the analysis and comparison of the driving system structures of four typical pure electric cars, this paper determines the driving system solution for the pure electric tractors, i.e., modifying the driving system of the traditional fuel tractor.

## **Issues for Reforming the Current Economic Life Statistical Index System**

### **Carrying out the purchase and sale statistics for agricultural machinery driving system.**

We should take the social economic life as a statistical population and minimize the middle index for the total amount indexes of purchase and sale of agricultural machinery driving system. The total amount index of purchase and sale of agricultural machinery driving system taking the economic life of the government-owned company as a statistical population can no longer reflect the basic situation of circulation of domestic agricultural machinery driving system. The statistical population should be changed from the economic life of the government-owner company to the social economic life. In other words, all the economic life organizations and individuals should be taken as the statistical population in the statistical index system.

### **Strengthening the inventory statistics.**

It is a necessary link in the circulation of agricultural machinery driving system to improve the statistical index system of agricultural machinery driving system inventory. The structure and quality of the agricultural machinery driving system in stock are the preconditions of the normal circulation of the agricultural machinery driving system. It is suggested that the above statistical index system should be gradually improved in the process of reform.

### **Adding the statistical index to reflect the economic benefits of enterprise.**

When reforming the economic life statistics index system, we can consider adding some economic benefits statistics indexes such as the total pre-tax profits of the current period, the return on sales of agricultural machinery driving system and the whole staff labor efficiency. This can comprehensively reflect the economic effect of the circulation activities of agricultural machinery driving system, and is conducive to improving the management and economic benefits of enterprises.

## **Vehicles With the Agricultural Machinery Driving System**

### **Introduction of vehicles with the agricultural machinery driving system.**

Compared with the traditional internal combustion engine driven vehicles, the hub motor driven vehicles have no engine, clutch, transmission shaft, transmission and other components. Unlike the in-wheel motor driven vehicles, the hub motor driven vehicles have internal motor in their hub, and which is indirectly or directly connected with the hub. In a word, the hub motor can directly drive the vehicle.

### **Characteristics of vehicles with the agricultural machinery driving system.**

Because of the use of electric drive and control-by-wire modes, the vehicles with agricultural machinery driving system are different from the traditional internal-combustion engine driven vehicle in nature. The characteristics of vehicles with agricultural machinery driving system are as follows:

Firstly, compared with the traditional vehicles, the vehicles with agricultural machinery driving system have no the transmission system. The hub motor is directly or indirectly connected with the hub, which increases the available space of the vehicle. In the hub motor drive mode, the use of cable in the process of energy transmission greatly improves the transmission efficiency.

Secondly, compared with the traditional vehicles, for the electric driven vehicles, the speed of electric wheels depends on the wheel speed sensors, and the torque and speed of electric wheels can be obtained by the feedback information of motors, which can provide the favorable conditions for more accurate dynamic control of vehicles.

Thirdly, the vehicles with agricultural machinery driving system can achieve the accurate and fast separate control by applying driving or braking torque to different wheels. Therefore, it has higher potential in handling stability and active safety.

## Evaluation Index of Agricultural Machinery Driving System

As an agricultural power machinery, the pure electric tractors need to meet the requirements of various working conditions. The requirement of power is very high for each working condition. The tractor must have enough power to complete the work. Therefore, the evaluation index of agricultural machinery driving system is an extremely important index in its overall performance evaluation system. The small pure electric tractor designed in this paper is mostly used in greenhouse and dry farmland for cultivating, harrowing and rotary tilling the land. Therefore, it is necessary to set up the evaluation index of agricultural machinery driving system based on its working characteristics instead of fully applying the pure electric cars. The small pure electric tractor is mainly used for traction and low-speed transportation, so it usually needs a large traction. Of course, it also needs a certain climbing ability. Considering the evaluation index of pure electric cars, the author considers that the driving system of small pure electric tractor should be evaluated from three aspects: traction performance, acceleration time and the maximum climbing degree.

### **Traction performance.**

The pure electric tractor is based on the traditional fuel tractor, its essential roles are traction and providing the power. Therefore, the rated traction force should be selected to evaluate its traction performance.

### **The maximum climbing degree.**

The maximum climbing degree is another important index to evaluate the power performance of pure electric tractors. The small pure electric tractors studied in this paper mainly work in the flat field with small slopes instead of the mountains with large slopes. Therefore, its climbing performance is usually evaluated by calculating the climbing degree that can be overcome in the road transportation operation.

### **Acceleration time.**

The small pure electric tractors are generally used for low-speed operation, and there is no overtaking and acceleration. Therefore, it is only necessary to calculate the time from a still state to a certain speed, and the shorter the starting acceleration time, the better the power performance. The evaluation index of agricultural machinery driving system includes the simulation task of climbing performance, the simulation task of performance calculation for each gear, the simulation task of acceleration performance calculation for the initial starting shift and the simulation task of the maximum traction force calculation. The simulation task of economic evaluation index includes the low-speed EUDC transportation operation conditions for the pure electric tractors, which has a total mileage of 1.39 km, as shown in Figure 1.

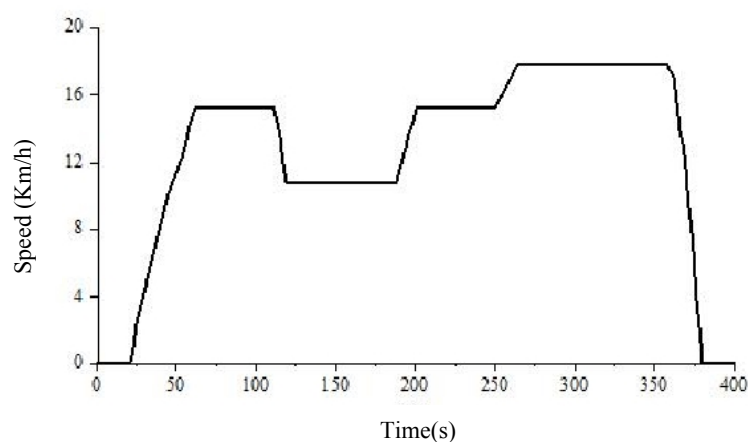


Figure. 1 Low-speed EUDC Transportation Operation Conditions

Seen from the comparison of climbing degree curve of each gear before and after optimization in Figure 1: firstly, the trend of climbing degree curve after optimization is still in good agreement with the characteristics of the driving motor. The climbing degree remains at a certain level first,

then decreases with the increase of speed; secondly, compared with the conditions before optimization, there is no power overlap problem and the power limits of each gear are distinct; thirdly, the climbing degree of the optimized I-gear for ploughing is equivalent to the sum of the first three gears before optimization, and the climbing performance is basically unchanged. The climbing degree of II-gear for field transportation is equivalent to that of the IV-gear before optimization. The climbing degree of III-gear for road transportation is equivalent to that of the sum of V-gear and VI-gear before optimization. The above gear setting for pure electric tractor is in good agreement with the fuel vehicles, i.e., I/II/III-gear for ploughing, IV-gear for field transfer and V/VI-gear for transportation.

Because the fuel driven tractor's speed range is broad, and there are some problems for the gearbox such as complex gears and power overlap. So in this chapter, the gear is simplified from six gears to three gears while keeping the matched parameters of the driving motor and power battery pack unchanged. Then the parameters of the transmission system are optimized with the aim of economy. The transmission ratio of the transmission system for the pure electric tractor is optimized by using the optimization tool in the Design Explorer of CRUISE software to obtain the optimization solution.

## Conclusion

This paper introduces the background and significance of the research on the agricultural machinery driving system, the current research status of pure electric tractors at home and abroad and the existing problems in domestic related research, and puts forward the main contents of this paper in view of the existing problems: (1) Through the analysis and comparison of the driving system structures of four typical pure electric cars, this paper determines the driving system solution for the pure electric tractors, i.e., modifying the driving system of the traditional fuel tractor, and creates the evaluation indexes of driving system aiming at the specialties of tractors for plowing, including the power evaluation index and the economical evaluation index. (2) Considering the selected technical parameters of the tractor prototype and the power and economic evaluation indexes, the selection and parameters matching of the main components for the driving system are carried out. The matching power of the driving motor is 8kW (permanent magnet brushless motor), and the power battery is 144V/160Ah lithium iron phosphate battery. At the same time, the performance test of the drive motor is performed, which lays a foundation for the later simulation tasks. (3) While keeping the matching parameters of the driving motor and the power battery pack unchanged, the gear is simplified from six gears to three gears, and then the parameters of the transmission system are optimized aiming at seeking the economy.

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