

# Design of Double-rows Sugarcane Harvester Control System Based on PLC

Liping Xu<sup>1, a</sup> and Liujin Cai<sup>1, b\*</sup>

<sup>1</sup>School of Mechatronic Engineering, Henan University of Science and Technology, Luoyang, 471003, China

<sup>a</sup>email:xlpsz@163.com, <sup>b</sup>email:yycailj@163.com

\*The corresponding author

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**Abstract.** The double-rows sugarcane harvester is a large agricultural machinery, it has complicated working conditions and high failure rate in the process of harvesting, which seriously affect the quality and efficiency of harvesting. Aiming at these problems, the electrical and hydraulic control system using PLC as the control core was designed. Through the PC monitoring program, the system could complete the online settings and monitor the operation conditions of the control parameters to achieve complex logic control and matching control of each actuator's movement speed. The results from the harvesting test in Guangxi farm show that the control system has advantages of convenient and reliable operation, reducing the failure rate, and improving the quality and efficiency of harvesting.

## Introduction

The double-rows sugarcane harvester is a new type of high power harvester derived based on single type sugarcane harvester. The biggest difference is the double-rows sugarcane harvester has two similar machine assemblies, sugarcane cutter group, picking up channel assembly and a larger leaf stripping channel assembly. With greater engine power, greater channel logistics capabilities, greater sugarcane collection hopper, faster walking and better driving experience. As shown in fig. 1. Harvesting system conditions are complex, with multiple actuators, linkage and interlock action, complicated operation, so the development of a set of PLC control system, increase the degree of automation, reduce energy consumption, improve the quality and efficiency of harvesting [1-3].



Figure 1. The double-rows sugarcane harvester

## Sugarcane Harvester PLC Control System

Sugarcane harvester control system is mainly for the engine, hydraulic pump, hydraulic valve (conventional directional valve and proportional direction valve) and actuator (hydraulic cylinder, hydraulic motor) monitoring of hydraulic oil temperature, pressure, speed, switch and other parameters. The hydraulic system and the working state of the harvester are monitored and protected by pressure, rotating speed and temperature sensor, buzzer and fuse. In order to make the system stable and reliable operation and control system using PLC as the control core, the input data related to PLC sensor, integrated operation signal measurement PLC for various sensor value

and setting value and the driver, a control signal to control the engine, hydraulic pump, hydraulic control valves and other machine. The basic structure of the electronic control system is shown in fig 2.

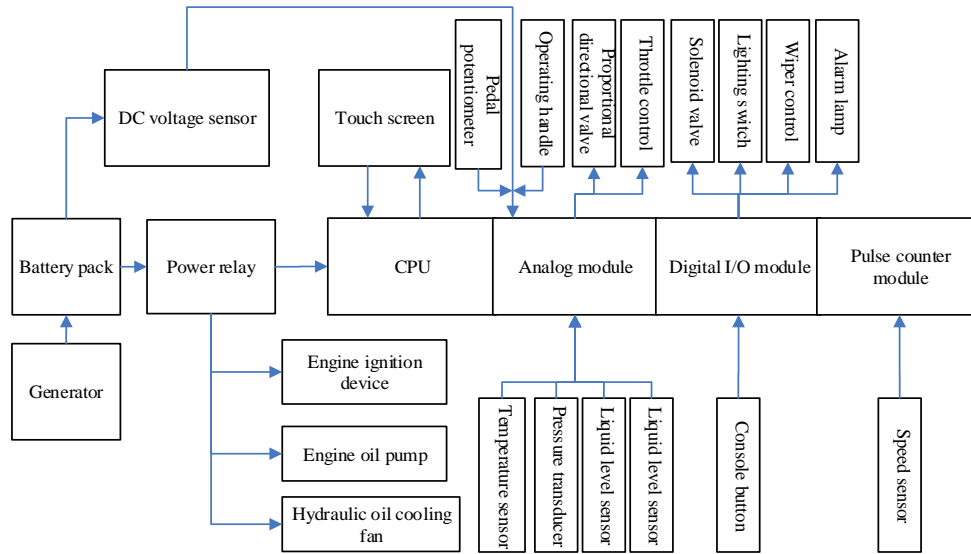


Figure 2. Electronic control system of harvester

### Hardware Composition of PLC Control System

PLC model should meet the control objectives and the number of sensors required to detect the number of interfaces, as far as possible to choose high stability, cost-effective models and modules. Considering the cost, function and data interface of PLC, the CPU 313C-2 DP in SIEMENS PLC S7-300 series is chosen as the control core [4-6]. According to the control object and the type of the sensor, the control object, the control method and the signal type of the sugarcane harvester electrical control system are summarized, which are shown in Table 1 and table 2.

Table 1 Harvester control function

Function	Control input	Control object	Signal type
Forward / backward	Electric control handle	Walking pump proportional valve	Analog quantity
Walking speed	Pedal	Engine Throttle	Analog quantity
Vehicle steering	Electric control handle	Steering solenoid directional valve	Switch quantity
Hopper lift	Console button	Electromagnetic direction valve for hopper hydraulic cylinder	Switch quantity
Cutter and sugarcane lifting	Console button	Lifting hydraulic cylinder solenoid directional valve	Switch quantity
Cutter speed	Operation panel	Proportional valve	Analog quantity
Channel speed	Operation panel	Proportional pump and motor	Analog quantity
Sugarcane rotation	Console button	Solenoid directional valve	Switch quantity

Table 2 Harvester test item

	Detection object	Sensor type	Detection method	Signal type
Signal detection	Hydraulic motor speed	Hall sensor	PLC counter module	Switch quantity
	Engine speed	Hall sensor	PLC counter module	Switch quantity
	Motor pressure	Pressure sensor	PLC analog module	Analog quantity
	Cylinder pressure	Pressure sensor	PLC analog module	Analog quantity
	Battery voltage	Voltage sensor	PLC analog module	Analog quantity
	Tank temperature	Temperature sensor	PLC analog module	Analog quantity
	Oil temperature sensor	Temperature sensor	PLC analog module	Analog quantity
	Fuel tank level	Liquid level sensor	PLC analog module	Analog quantity

Table 1 and Table 2 show that the PLC data interface requires 10 digital output, the CPU 313C-2 DP model PLC has a built-in digital I/O interface 16, so it is no need to select a digital module. Proportional valve and pressure sensor is used in analog PLC have 6 analog output interface and 6 analog input interface, so it needs to choose two of 4 input and two output 4 analog control module SM323. There are 8 institutions need to measure the speed, the use of magnetic resistance sensor to measure the speed of rotation, you can use the PLC counter module to measure the number of pulses to calculate the speed. So choose a PLC 8 channel counter module FM350-2. Taking into account the need for the upgrading of electrical and hydraulic systems, a certain amount of standby interface is reserved when selecting the interface module [6-7].

### Software Design of PLC Control System

SIEMENS PLC programming includes the hardware configuration and control program written in two parts. According to the actual use of sugarcane harvester and the requirements of the operation of the process, the main electrical control system flow chart, and software programming. The electrical control flow chart is shown in fig.3.

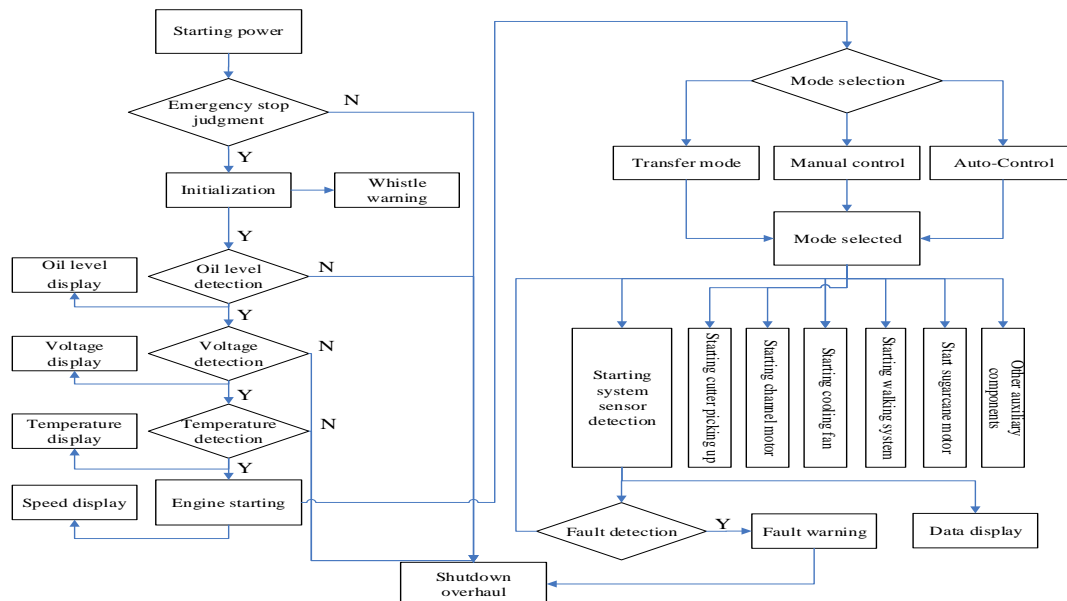


Figure 3. Main flow chart of electrical system control

## Touch Screen Monitor Interface Design

Good touch screen monitoring system allows operators to better understand the operation of the machine, improve work efficiency, reduce labor intensity.

**Structure Design of Touch Screen Monitoring System.** The monitoring system of sugarcane combine is shown in Figure 4. The monitoring system is mainly composed of touch screen, various types of sensors, PLC and related peripherals. Speed measurement by Holzer sensor is used to collect the motor and the speed of the engine speed signal after adjusting circuit, are calculated by the high speed counter of PLC; pressure sensor, voltage sensor and temperature sensor can output 4-20mA standard signal, analog acquisition module can be directly detected by PLC signal. The data exchange between the touch screen and PLC through serial communication, the touch screen can display the important parameters of PLC in real time, and judge the running state of the harvester [8].

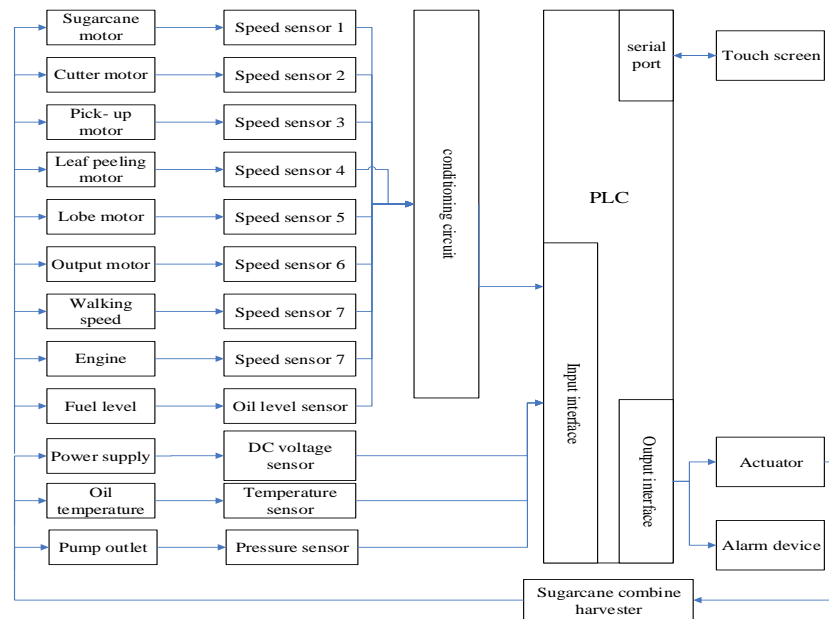


Figure 4. The structure of sugarcane harvester monitoring system

**Interface Design of Touch Screen Monitoring System.** Considering the problems of environment and cost, use YKHMI configuration software to optimize and control the Shenzhen summit as the monitoring platform, touch screen interface editor of sugarcane harvester monitoring system. S1001A model of touch screen, touch screen with 800MHz A8 processor, 128M FLASH storage space, the panel can be waterproof, dustproof, shockproof, strong anti-interference ability. Sugarcane harvester touch screen monitoring system for the main interface, in the configuration, the control variable and the PLC interface of the button in the dashboard, and sensor data connectivity, when the control variables of PLC changes, the color of the button will change. When the system is activated, the button will display the green, and start the relevant functions of the subroutine. Change of oil temperature and fuel level sensor when the relevant data will lead to a change in the interface relative to the corresponding occurrence histogram. When an emergency occurs in the system, and the mechanical emergency stop button mechanical failure occurs, you can stop the operation of the through the touch screen [9].

For the parameter setting interface, set up three working mode, a transition mode, manual mode and automatic control mode, and the parameters of their custom input box, the user can according to the harvest experience, set the main parameters of the touch screen, the system will automatically be batch parameter assignment to the PLC program, implementation of the relevant operation.

The harvester monitoring system also set up a fault diagnosis and alarm history table, fault alarm function is the use of sensor data to realize the comprehensive judgment of running state of the sugarcane harvester is monitored, once the abnormal fault can send out sound and light alarm to

remind the operator early troubleshooting problems, reduce maintenance time and reduce maintenance costs. Not only improve the working environment, but also improve the operation efficiency[10].

## **Summary**

The control system for the field test in Guangxi harvest farm, increase the degree of automation, to achieve complex logic control of the executive mechanism of harvesters, operation, friendly man-machine interface makes the operator can real-time understanding of the system has the advantages of simple operation, high reliability, easy to modify parameters to improve the harvest, the harvest quality and efficiency.

## **Acknowledgements**

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