Application of Sensing Technology in Intelligent Monitoring System of Gravel Pile Machine

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Keywords: Vibrating sinking gravel pile machine; sensing technology; intelligent monitoring system

Abstract: In order to real-time monitor the construction quality and efficiency of Vibrating Sinking Pipe gravel pile machine, and reduce manual investment. Based on the geological characteristics of Yibin area, based on the working principle of vibrating sinking gravel pile machine, this paper discusses the application of modern sensing technology in the intelligent monitoring system of gravel pile machine.

1. Introduction

With the rapid development of China's infrastructure industry, vibration immersed stone gravel piles are often used for treatment in roadbed soft foundation treatment. Crushed stone pile is a kind of cheap construction. At the same time, the foundation treatment technology which can effectively improve the bearing capacity of foundation, reduce the uneven settlement of foundation and accelerate the consolidation settlement of soft foundation has been widely used in road engineering.

The first phase of the Yangtze River South Road, Songyuan Avenue, Expressway, sub-trunk road of the first phase starting area and Housing installation project in Sichuan Yangtze River Industrial Park are municipal works, in which the deep soft foundation treatment (soft foundation (> 4m) of the 30km road project is Vibro-sinking gravel pile [1]. The designed diameter of gravel pile is 0.5m, which is arranged in an equilateral triangle. The bottom of the pile is deep to the bedrock or the hard layer with low compressibility. The spacing between the piles is 1.5m and the particle size of the gravel is 2~5cm. The main control parameters of the gravel pile include: the current value when the drill bit enters the bearing layer, drilling Hole depth, gravel inflow, verticality of the drill pipe.

At present, the mechanical control unit of the traditional gravel pile machine (Fig. 1) is completely controlled by a single electrical circuit. No intelligent components such as sensing devices and communication modules are installed. Observing the motor current is still using the old pointer current meter (Fig. 2).. On-site technicians are required to manually measure the verticality of the drill pipe each time the drill is drilled. The drilling depth should be observed and recorded manually according to the length of drilling (Figure 3), and the relevant records should be filled out manually. The grouting amount of gravel is estimated artificially on the spot; whether the bearing stratum is reached or not is judged by the field managers according to the current value and the sinking speed of the drill pipe, and there is no intuitive index of soil strength at the bit. The traditional manual site management and control method has seriously affected the construction efficiency, increased the management cost, and the manual site record can not completely reflect the real quality of gravel pile construction, there are quality risks.

Fig.1. Drawing of traditional gravel pile machine

Fig.2. Pointer ammeter

Fig.3. Traditional gravel pile machine diagram

2. Sensing Technology

Since the beginning of this century, due to the need of green construction, the limitation of environmental noise and vibration, and the high standard requirement of construction environment, safety and quality, the construction machinery of prefabricated piles mainly based on strike method has gradually withdrawn. The vibrating immersed stone gravel pile machine has become the main type of small-diameter drill pile construction because of its high construction speed, high quality of hole formation, small environmental pollution, flexible operation and strong applicability.

There are many countries that produce pile drivers in the world, mainly Germany, Italy, Japan, and the United States. In the 1990s, foreign bored pile drivers have been basically intelligent, such as the optimal matching output control of the engine and pump, reducing fuel consumption and exhaust emissions. Real-time monitoring of mast verticality, to achieve manual and automatic switching, to ensure the verticality of construction piling; drilling depth measurement and display, body working status and display.

In China, the pile machine industry has a history of nearly 60 years. Due to the influence of the level of economic development and economic model, it is still in a state of "small, weak and scattered". Since the beginning of this century, China's economy has grown in size, and large-scale infrastructure projects have been put into construction. The pile-driving machinery has also been continuously developed. The main features: the introduction of smart sensors in pile-driving machinery has improved its performance. And promote the application in a certain range [2], for example, the rotary excavator uses PLC (programmable logic controller) as the control system, and combines the sensor with the text display.

Intelligent sensor refers to its ability to detect, self-diagnose, data and adapt to external information. It is the combination of microcomputer technology and detection technology. Intelligent measurement is mainly based on microprocessor, which integrates the sensor signal conditioning circuit, computer, memory and interface into a chip, so that the sensor has certain artificial intelligence. Later, with the further improvement of intelligent measurement technology, intelligent sensor level is realized, which has self-diagnosis function, memory function, multi-parameter measurement function and networking communication function.

Inclination sensor (Fig. 4) is often used to measure the horizontal distance of the system and the height of the object. It can be divided into solid pendulum sensor, liquid pendulum sensor and gas pendulum sensor. All three inclination sensors use the gravitational force of the earth to determine the attitude angle of the sensor to the earth. That is to say, the angle (inclination) with gravity is converted into analog signal or pulse signal, which is a very precise measuring tool for small angle. It can be used to measure the tilt of the measured plane relative to the horizontal position, the parallelism and perpendicularity of the two components.

Distance sensor is a kind of sensor which uses ultrasonic or laser to measure the distance of objects. It is mainly used to measure the law of the position of moving objects changing with time. It can be used to complete a variety of kinematic and dynamic measurements. The principle is a device that detects the amount of physical change of an object by using various elements, and measures the distance displacement from the sensor to the object by converting the amount of change into a distance.

The current sensor (Figure 6) is a detection device that senses the current being measured. And the information that is detected and detected can be transformed into an electrical signal or other required form of information that meets certain standards according to certain rules to meet the requirements of information transmission, processing, storage, display, recording and control [6]. Current sensors can be divided into shunts, electromagnetic current transformers and electronic current transformers according to different measuring principles.

Fig.4. Tilt angle sensor

Fig.5. Distance sensor

Fig.6. Current sensor

3. Model building

The intelligent monitoring system model of the vibrating sinking gravel pile machine is mainly composed of two parts (Fig. 7). On the one hand, the data are collected by laser range sensor, current sensor and tilt angle sensor. On the other hand, the embedded system developed by the Linux operating system, LCD capacitive touch screen, automotive grade I.mx6 motherboard and software development tool QT.

Drilling verticality detection: In order to realize the three-dimensional positioning of the drill pipe of the vibrating burrow gravel pile machine, the platform rotation angle detecting device and the platform inclination sensor are installed on the basis of installing the joint angle sensors of the working device. A laser receiver is mounted on the mast for detecting the height of the horizontal mechanism emitted by the drill rod laser emitter relative to the zero position of the receiver. The kinematics model of the drill pipe of the vibratory sinking gravel pile machine is established, and the coordinate transformation matrix of the drill pipe relative to the earth is deduced, that is, the drill pipe positioning in three-dimensional space is completed. Simple formula of drill pipe elevation positioning is obtained to realize three-dimensional positioning of drill pipe trajectory of vibratory sinking gravel pile machine.

Drilling depth detection: In order to detect the depth of drilling in real time, the laser ranging sensor is used to measure the drilling depth of vibrating immersed gravel pile. Laser ranging sensor is installed on the top of mast, and an initial distance is measured before drilling. During the drilling process, a set of real-time distances are measured according to the data frequency collected by the laser ranging sensor. Thereby obtaining the current drilling depth data set. The least squares method is used to obtain the depth value of the current time drilling in seconds.

Pile motor current detection: In order to detect the current intensity of the pile machine in real time, the current transformer of the original control cabinet is connected to the motor control management unit, and the current is measured by the digital display value through the smart current meter of the domestic Jiangsu Sfeier meter.
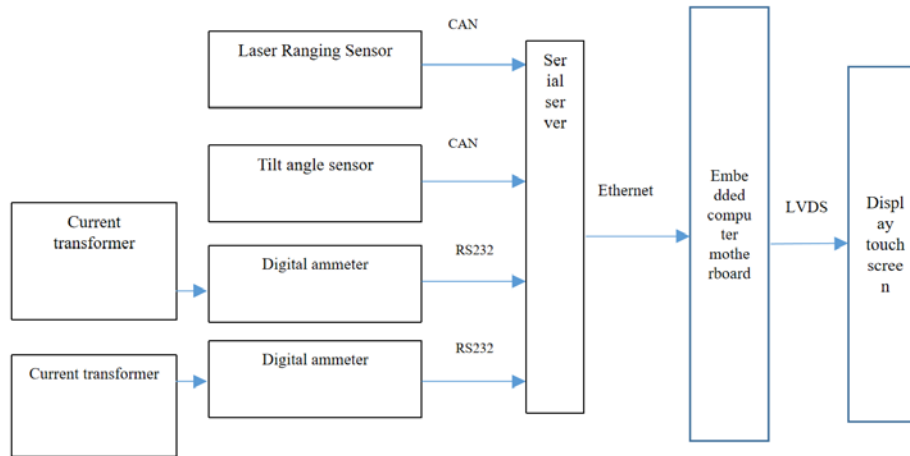
Fig.7. Intelligent Monitoring System Model

4. Conclusion

This paper combines embedded computer system and QT software technology to explore the application of modern sensor technology in the intelligent monitoring system of vibrating sinking gravel pile machine. The main function is to automatically measure and display the current working parameters of the vibrating sinking gravel pile machine such as current value, drilling depth and verticality of the drill pipe. With the rapid development of infrastructure construction in China, the problem of roadbed soft foundation is increasing. Therefore, as a low-cost, fast construction technology, Vibro-sinking gravel pile can effectively improve the bearing capacity of foundation and accelerate the consolidation settlement of soft foundation, has been widely used. Therefore, the gravel pile machine with intelligent monitoring system can greatly improve the construction efficiency and quality, reduce labor input and save management costs.

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