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A SIMPLE METHOD TO MEASURE PISTON ROD POSITION BY USING CIMS SENSOR WITH HIGH ACCURACY

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Abstract:

Cylinder stroke measurement is an important factor in cylinder position control, especially synchronous cylinder's velocity control, where measurement deviations can cause warping, cylinder failure or even system damage. There are many methods to measure the piston rod position such as using an independent encoder, variable resistor, etc. mechanically linking to the piston to measure the position rod position when the piston moves. However, these methods have not high accuracy, are difficult to install, and have limited applicability. The following article will introduce a simple method for easily integrating CIMS sensors for Cylinder Integrated Measurement System (CIMS) for the construction of big and flexible control systems. High accuracy and reliability using low cost equipment, simple installation, the same application used by the author to measure and control the prevention tide flooding system on the Saigon River.

Keywords: *Cylinder position control, piton rod measurement, CIMS sensor.*

1. Introduction

For controling systems using large cylinders there is often a requirement to measure the position of the piton rod with high precision in oder to be able to control. In the past years, many methods have been used to do this, such as using a encoder attached to the piton. (Fig. 1), using laser sensors, ultrasonic sensors or at least proximity sensors to determine the position. However, these methods not only have low accuracy but also are difficult to fabricate and install. Besides, measuring distance is limited and measurement results are influenced by external factors

One way of measuring the piton stroke with highly accurate results and used for very big cylinders of unrestricted size is to use a method of encoding the piston rod profile, then integrate with signal converters, signal processing to generate electrical signals proportional to the piton stroke, but sensors of this type are now available due to the use of Modbus networking equipment with fixed Modbus RTU address is not allows using mors than one sensor in a system with one master control device, while the linking elements is very expensive, leading to system expansion difficulties and big costs.

In the following, a measuring method to overcome the above disadvantages and allows to build the system with high reliability has been applied in practice by the author.

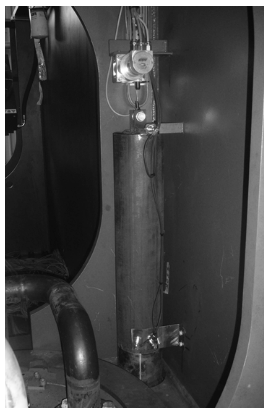

Figure 1. Mesurement of piton rod position using an encoder in a press machine

2. Cylinder Integrated Measurement System-CIMS

As introduced above, in order to measure the cylinder stroke by this method, it is necessary to format the piton rod surface: First, the ferromagnetic surface of the piton rod is turned into small trapezoidal grooves. The surface is then coated with a non-magnetic or low-magnetic material. Most of these coating processes will result in a more or less uniform coating thickness over the trapezium-like profile (see Fig. 2). Consequently, the coated land-areas (the areas between the grooves) need to be removed afterwards in order to obtain a smooth piston rod surface (see Fig. 3). This implies, of course, that the coating thickness needs to be higher than the depth of the groove of the trapezium-like profile.

After the piton rod surface has been formatted, the next step is to convert the piston rod encoding to an incremental position signal. First, a permanent magnet is placed near the surface of the piton rod, so that a magnetic field is generated between the permanent magnet surface and the piton rod. When the piton moves, this magnetic field will change, a Hall-effect sensor is placed in the variable magnetic field between the permanent magnet and the piton rod surface to create a variable electrical signal sinusoidal bias with movement of the piton rod.

However, in order to determine the movement direction of the piton rod, it is necessary to create a pair of 900-phase out-of-phase signals distance between the two grooves, so these two sensors will generate two sine and cosine signals with 900 out of phase (Figure 4).

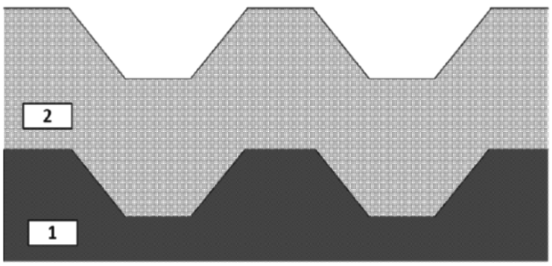

Figure 2. Trapezium profiled rod surface (1) with uniform coating (2)

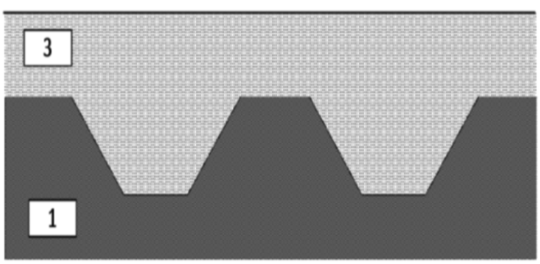

Figure 3. Trapezium profile rod (1) with reworked smooth surface (3)

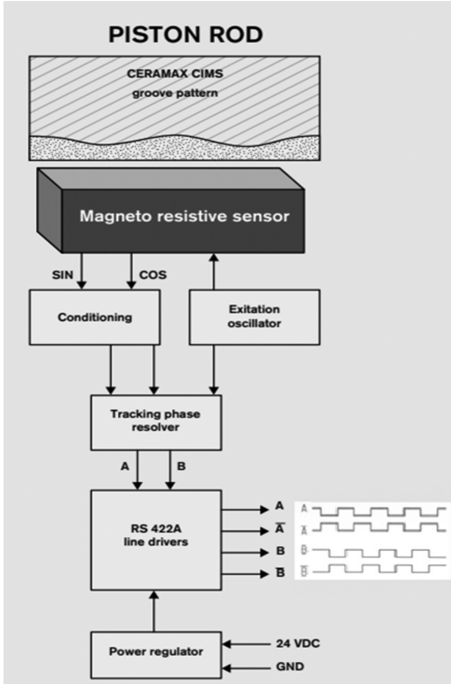

Figure 4. Mesurement circuit and the form of output signals

3. Limitations of CIMS sensors when applied in large systems and method to increase reliability and reduce costs

As shown above, the CIMS sensors allow for highly accurate cylinder stroke measurement and are easy to install, but one problem facing these days is that these devices use interconnecting elements that has been preconfigured at the factory, so it is not possible to change the parameters and communication address. This leads to only one sensor being allowed in a network, which will lead to there are many limitations: in systems requiring high reliability there is no guarantee because the results of only one measuring device cannot be used, nor can the results be applied in large systems with a lot of movement. Because this will need to build a system with many master devices which will increase complexity and increase costs, etc.

To solve the above problem, right at the output of the encoder on the CIMS sensor, a signal converter circuit from RS422 to incremental position ouput using IC MAX14890E is needed , and the Modbus signal output will be grounded (Fig. 5). Since today's control devices have built-in high-speed counter inputs, connecting controllers that read information from multiple sensors in this way for processing is very easy. (Fig. 6), it is possible to use only one controller to measure and receive information from multiple sensors, allowing complex control systems with a variety of movements to be built.

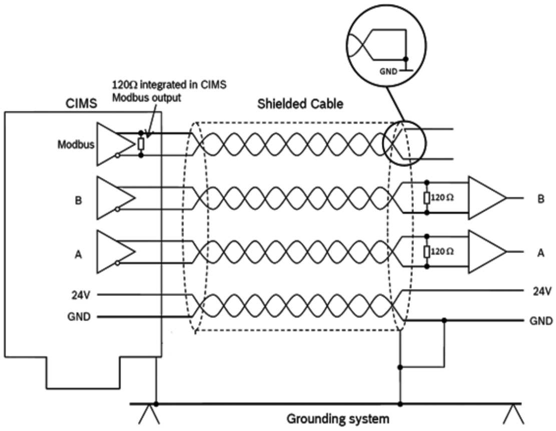

Figure 5. Interface circuit to connect CIMS sensor and controler

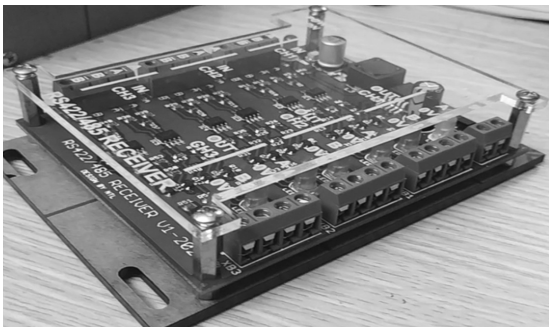

Figure 6. Interface board connecting three sensors using IC MAX14890 E

4. Application of CIMS sensor to measure piston rod position in preventing tides control system on Saigon river

In the anti-flooding tide prevention system, there are many sluice gates to prevent high tide during high tide, each sluice gate is raised and lowered by two large cylinders installed on both sides. These two cylinders require moving synchronously with the displacement of the plunger levers less than 15mm, otherwise it may destroy the entire manhole system. To solve this problem, three CIMS sensors were used with each cylinder (Fig. 7) to measure the stroke of the cylinders and send information via Interface circuit (Fig. 6) to the master controller. The master controller is programmed so that the system will function normally if at least two CIMS sensors on the same cylinder give the same information. The system stops immediately if it detects a deviation in the position of the piton rod beyond the permissible limit or two of the three sensors on each side give a different signal.

Using the combination of three smart sensors CIMS 4th generation Mk IV from Bosch Rexroth for each cylinder, the system operates with very high reliability, allowing precise control of the position. In addition, access to sensors for history information also makes it easy to operate, check, and handle situations occurring with the system (Fig. 8).

Figure 7. CIMS intergrated in cylinder of preventing tides control system in Saigon river

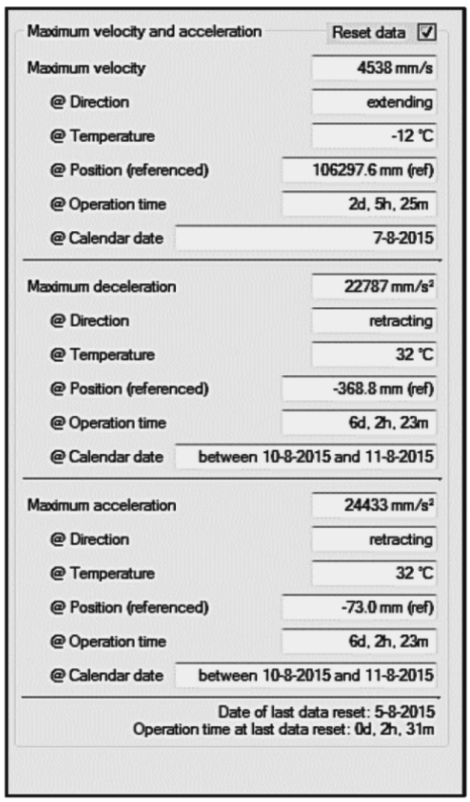

Figure 8. Information from CIMS sensor

5. Conclusions

Currently the trend of manufacturing smart process devices (field equipments) has become popular, this is also an inevitable trend to create intelligent systems to serve people in the revolution Industry 4.0. Therefore, overcoming the limitations of CIMS sensors for measuring cylinder rod position or the position of any moving object will allow the creation of highly reliable, high-precision systems with many outstanding advantages. It can be measured without contact, no need to add more mechanical parts, and easily coordinating with other sensors such as pressure and flow measurement to create quality control systems. good at a reasonable price. This will also be a choice for engineers in smart mechatronic systems design.

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MỘT PHƯƠNG PHÁP ĐƠN GIẢN SỬ DỤNG CẢM BIẾN CIMS ĐO HÀNH TRÌNH XY LANH ĐỂ XÂY DỰNG HỆ THỐNG ĐIỀU KHIỂN PHỨC TẠP CÓ GIÁ THÀNH HẠ VÀ ĐỘ CHÍNH XÁC CAO

Tóm tắt:

Đo hành trình xi-lanh là một yếu tố quan trọng trong điều khiển vị trí xi-lanh, đặc biệt là điều khiển xi-lanh đồng tốc, các sai lệch khi đo vị trí có thể gây cong vênh, hỏng hóc xi-lanh và các kết cấu cơ khí hoặc thậm chí phá hủy hệ thống. Trước đây có một số phương pháp để đo hành trình pít-tông như dùng bộ mã hóa (encoder) độc lập, biến trở (variable resistor)... liên kết cơ khí với pít-tông để đo vị trí khi pít-tông di chuyển. Tuy nhiên các phương pháp này có độ chính xác không cao, khó lắp đặt, khả năng ứng dụng hạn chế. Bài báo sau đây sẽ giới thiệu một phương pháp đơn giản có thể tích hợp dễ dàng các cảm biến CIMS để đo vị trí xi-lanh (Cylinder Integrated Measurement System - CIMS) cho phép xây dựng các hệ thống điều khiển phức tạp, có độ chính xác và độ tin cậy cao sử dụng các thiết bị có giá thành hạ, lắp đặt đơn giản, cùng một ứng dụng đã được tác giả sử dụng để đo và điều khiển cho hệ thống ngăn triều chống ngập trên toàn bộ sông Sài Gòn.

Từ khóa: *Điều khiển vị trí xi-lanh, Đo vị trí cần pít-tông, Cảm biến CIMS.*