

# Design of a Fast Measuring System for the Section Size of Automobile Rubber Hose Withhold Parts

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**Abstract.** The quality of withhold parts determines the service life of high- pressure rubber hose to a great extent. Leakage at withholding is the main form of high pressure hose failure in the several forms. The quickest and most effective method to detect the withholding quality is measuring the section size of the withhold parts. As long as the section size is in line with the provisions, that is, the quality of hose withholding is qualified. In this paper, the measurement system which is designed improves low efficiency of manual measurement.

## 1. Introduction

The high-pressure rubber hose assembly is the basic element in the hydraulic system, which reliability has important influence on the stability and reliability of the whole hydraulic system. Several common failure forms of high-pressure hose are: leakage or unplug of withhold parts, hose burst, withhold metal tube burst, high-pressure hose bulge, peeling and so on [1]. Whether the amount of withholding is reasonable or not is directly related to the overall performance of the hose assembly, except for the quality of the hose itself [2, 3]. The practice and experiment confirm that the failure form of leakage or pull-out of high-pressure hose assembly is about 20% of the total failure forms. Therefore, it is the key idea to improve the quality of hose joint to control the withholding quantity accurately [4].

As an important index of the quality of withholding, detecting the section size of the withhold part is one of the important ways to test the quality of withholding. At present, the section size is still measured by hand in the hose manufacturer. Manual testing has many drawbacks such as high work repeatability, the great labor intensity of inspectors, unable to achieve full inspection and susceptible to subjective influence. There is no way to accumulate and save the test data so that the test situation is not conducive to technology and production improvement. If the size of each pair of edges is within the tolerance range and the difference of the maximum and minimum value does not exceed the allowable value in the measuring, that is, the withholding is considered qualified.

## 2. Design of measurement system

In this paper, a fast measurement system of the section size based on the self-recovery linear displacement sensor is provided. The system has eight sensors and electromagnets in the space range. The body of electromagnets and the sensors are fixed. And the push lever of the electromagnet and the sensor rod are connected through the thread. The sensor calculates the distance between the initial



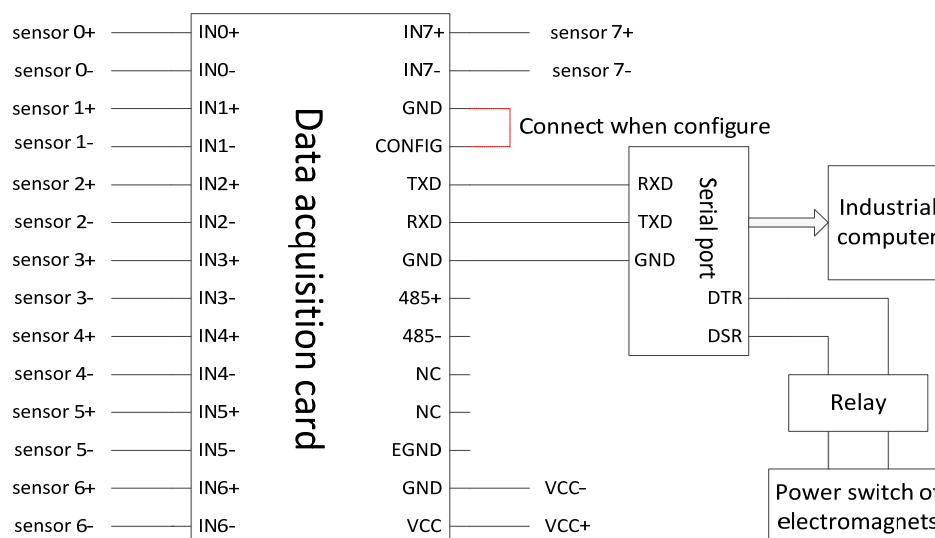
position and the measured position of the sensor head. This measuring device is compact in size and convenient in operation. The system appearance is shown in figure 1.



**Figure 1.** The inspection equipment's appearance.

### 2.1. Design of hardware system

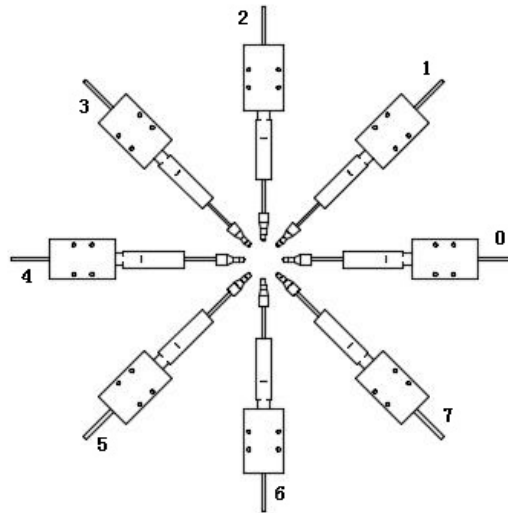
The core hardware of this measuring system includes the linear displacement sensor, the push-pull electromagnet and the voltage signal data acquisition card. According to the size range of 10-30mm, the self-recovery linear displacement sensor with a measuring itinerary of 25mm is selected. The output signal of the sensor is 0-100% input DC voltage value. And the output voltage variation corresponds to the changed displacement. The hardware connection logic diagram is shown in figure 2.



**Figure 2.** Hardware connection logic diagram.

There is no special requirement for the frequency of the power cut-off and turn-on of the electromagnets. The push-pull electromagnet can be adjusted to the complex situation of measurement. In order to connect the electromagnet and the sensor, the inner thread is machined in the front section of the electromagnet's push rod and the sensor back end is fixedly connected by external thread with the electromagnet.

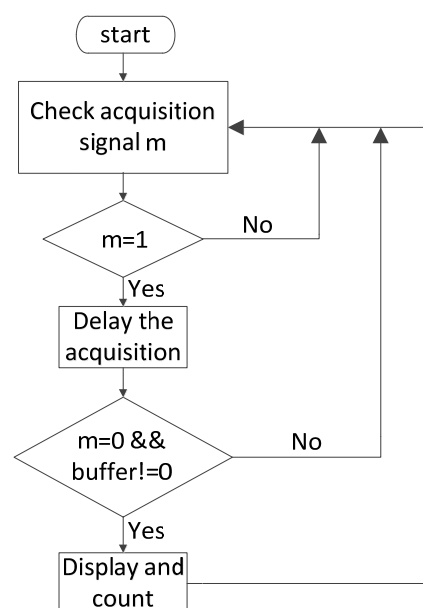
When the electromagnet loses power, the sensor head in the initial position and the distance between the measuring heads is smallest. Then power the electromagnet, drive the sensor pole back, put the work piece to the appropriate position, electromagnets power off and the self-recovery sensors move to measured section. At this time the measurement data (voltage signal) transfers through the serial communication acquisition card to the upper computer to calculate the section size and give a sign of conformity or not. As shown in figure 3, there are eight displacement sensors installed on the circumference, as indicated by 0, 1, 2, 3, 4, 5, 6 and 7.



**Figure 3.** Sensors and electromagnets layout diagram.

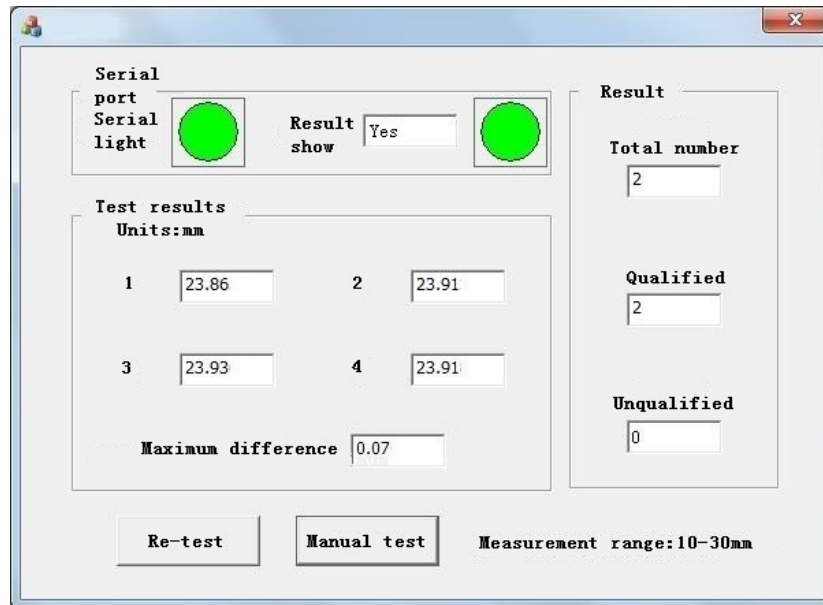
## 2.2. Design of software system

The software of this system is serial communication software based on VS2010 Mscomm control [5]. The main idea is cooperated with the work flow of the hardware operation and inspection system. The flow chart of the software is shown in figure 4.



**Figure 4.** System software flow chart.

The main interface of the software (showing in figure 5) mainly includes three parts, the analog signal lamp hint part, the measurement result display part and the result statistic part respectively.



**Figure 5.** Software main interface diagram.

The data collected by the serial capture card is a string which has fixed format such as  $+2.5494+2.5654+2.1534+2.4941+2.7063+2.9804+2.9743+2.7495$ . To convert the voltage data into displacement data, the idea of this paper is to calibrate the sensor of each channel, mainly to obtain the linear fitting formula of each sensor which is the relationship between voltage value and displacement.

**Table 1.** Fitting formula of the sensors.

number	Voltage (V)	Fitting formula (mm)
0	$f_0 > 4$	$f_8 = -4.7540xf_0 + 25.318$
	else	$f_8 = -5.0235xf_0 + 26.404$
1	$3.25 < f_1 < 3.7$	$f_9 = -4.7605xf_0 + 26.472$
	else	$f_9 = -4.9749xf_0 + 27.240$
2	$f_2 > 3.4$	$f_{10} = -4.8511xf_0 + 25.034$
	else	$f_{10} = -5.1071xf_0 + 25.993$
3	$f_3 > 4$	$f_{11} = -4.7248xf_0 + 25.038$
	else	$f_{11} = -5.0771xf_0 + 26.458$
4	$f_4 > 4$	$f_{12} = -4.8744xf_0 + 25.325$
	else	$f_{12} = -5.0754xf_0 + 26.112$
5	$f_5 > 4.1$	$f_{13} = -4.7698xf_0 + 25.574$
	else	$f_{13} = -5.0564xf_0 + 26.743$
6	$f_6 > 4$	$f_{14} = -4.8088xf_0 + 25.281$
	else	$f_{14} = -5.0571xf_0 + 26.281$
7	$f_7 > 4$	$f_{15} = -4.8403xf_0 + 25.535$
	else	$f_{15} = -5.0474xf_0 + 26.296$

### 3. Experiments

In order to obtain accurate section size, the compensation value of each pair of sensors needs to be determined by gauge blocks because of the initial distance between sensors and other factors. The experiments show that the compensation value of each sensor is as follows:

**Table 2.** Compensation value of the sensors.

Sensor	Compensation value (mm)
0-4	-2.3
1-5	-2.24
2-6	-2.38
3-7	-2.87

The data of measurement of nominal diameters of 24 is shown in table 3. When the diameter difference is greater than 0.1mm, it is considered unqualified.

**Table 3.** Experimental data of measurement.

Sensor	Voltage (V)				
0	2.6543	2.7027	2.7850	2.9304	2.7549
1	2.9707	2.9488	2.9795	3.0458	2.9381
2	2.5899	2.5147	2.4867	2.4434	2.4602
3	2.7032	2.6140	2.5294	2.3951	2.5388
4	2.5534	2.5044	2.4225	2.2857	2.4621
5	2.5768	2.5969	2.5635	2.5098	2.6076
6	2.5229	2.6035	2.6402	2.7085	2.6682
7	2.5053	2.5965	2.6838	2.8273	2.6751
Dmax-Dmin	0.02mm	0.01mm	0.06mm	0.14mm	0.06mm

### 4. Conclusion

This paper makes use of the measuring equipment to realize fast and accurate measurement of the section size of the high pressure hose joint. The research work presented in this paper improves the disadvantages of traditional manual measurement and increases detection speed. The detection system is able to provide fast measurements with highly satisfactory profile measurement results. From the results presented in this paper, it is evident that the measurement system is a suitable system for the roundness error of pressing structure of high-pressure rubber hose in terms of speed, accuracy and cost-effectiveness.

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