



# System for Adhesion Control of Car Steering Column Couplers

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**Abstract.** This paper presents designed and implemented system to measurement of parameters of car steering column couplers. Described system is operating as a quality control machine and it is a part of production line in severe environmental conditions. This paper consist of diagnostic and metrological requirements, design solutions, registered measurement parameters and system software.

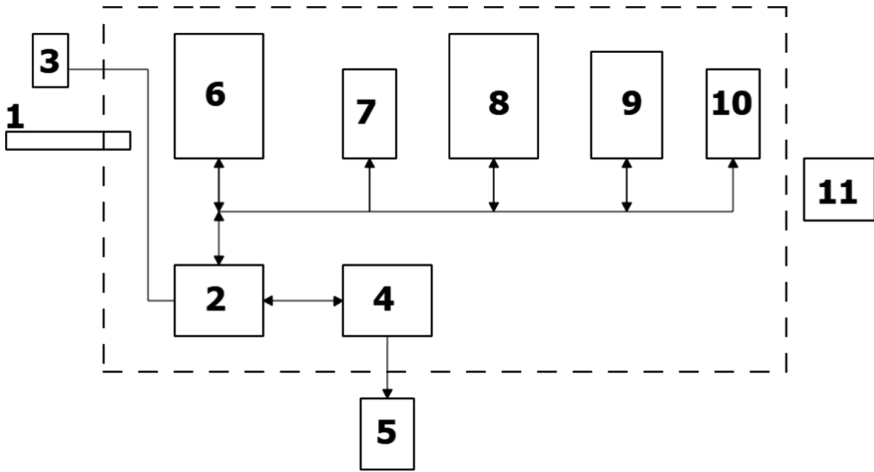
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Industrial measurement system software

## 1 Introduction

Couplers made of steel and rubber are critical parts of car steering column. Mentioned coupler is a component consisting of two steel sleeves connected by rubber sleeve characterized by appropriate adhesion obtained during vulcanization process. The main measurement task is to perform test of each coupler. Test shall consist of compressing the coupler with strength 4 kN and measurement of distortion of rubber connection. Measurement system consists of device to adhesion control and controlling software which is connected with SQL database on the workplace server. The main task of the system is the 100% control of performed measurements as well as necessity of full identification of each coupler which has to be marked with individual permanent sign. Measurements are more difficult because tests are performed in the increased temperature environment caused by the temperature of couplers after vulcanization process and because of vulcanization fumes. This article describes designed and implemented solution of mentioned system.

## 2 Method of Controlling and Marking the Car Steering Column Couplers

The system to full control (100%) of adhesion of steel-rubber couplers, which is operating on the production line was designed for Sanok Rubber S.A. company. System consists of units shown in the Fig. 1.



**Fig. 1.** Block diagram of the system to control of adhesion of car steering column couplers.

1. Operator’s table
2. PLC controller
3. PLC controller’s terminal
4. PC computer
5. Barcode scanner
6. Coupler’s distortion measurement unit
7. Incorrect coupler’s ejector
8. Weld detecting and coupler positioning unit
9. Laser marking machine
10. Correct coupler’s ejector
11. Box for correct couplers.

Operating of the system shown in the block diagram (Fig. 1) is controlled on two levels. The first level is operated by PLC controller (2), which is presenting on the terminal (3) process parameters, the second level using industrial computer (4) connected with rubber type scanner (5). Couplers are placed on the operator’s table (1), using transmission belt are moved to the measurement device. Distortion measurement unit is applying squeezing force (4 kN) which is determined by strain gauge transducer. Distortion of the coupler is determined as a displacement of the fulcrum related to LD-100 laser distance transducer produced by OMRON company. Measured values are transmitted to industrial computer (4) by the measurement unit. Distortion characteristic of each coupler is determined based on 50 measurements and then transmitted to workplace server via internet connection. Simultaneously level of distortion is compared with values set in controller’s software, in case the item is incorrect, it is rejected (7). The next task of the system is to recognize the weld on the surface of the coupler and proper positioning of the item in order to do permanent marking using laser marking machine. After making the marking sign, the coupler is ejected to the box (11) by the pneumatic ejector (10).

### 3 Production, Metrological and Diagnostic Requirements

Vulcanizing machine releases 32 couplers in one series, subsequently two operators manually cut all overflows of the rubber and put couplers into holes in transporting belt. Duration of one operation of putting coupler into belt do not exceed 3 s. Machine is collecting 64 pieces of correct couplers in box at the end of line. Device to control of adhesion of car steering column couplers has to provide respectively.

1. measurement and evaluation of distortion of each coupler
2. rejection of incorrect coupler
3. detection of weld on the surface of the coupler
4. positioning of the coupler in order to correct marking
5. laser burning of pictogram on the surface of coupler
6. ejection of marked coupler to box with correct items.

Points 1 and 4 listed above are the main metrological tasks during operation of the machine. In the first case metrological task is realized by distortion measurement unit placed behind inspection doors E1 (Fig. 3). Described unit consists of pneumatic actuator generating pressure force of 4 kN on the tested coupler, measured by strain gauge force transducer with signal conditioner. Measurement of displacement of distorted coupler is realized using laser transducer LD100 made by OMRON company. Test cycle consisting of 50 measurements allows to prepare report with graph shown in

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Kontroler	: ???	Uwagi	: ???
Data badania	: 2016-12-30 12:57:13	Wyrób	: ???
Odbiorca	: ???		
Typ maszyny	: ???		
Czujnik siły	: ???		
Prędkość testu	: ???		

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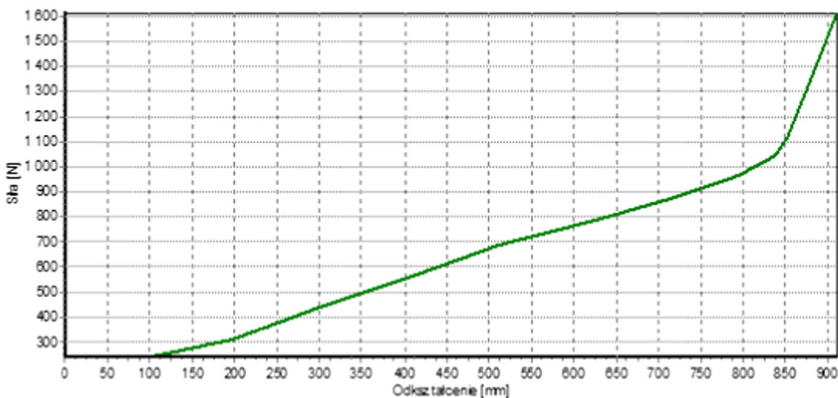


Fig. 2. Chart showing characteristic of distortion for correct coupler (force N/2, distortion mm  $\times$  100).

Fig. 2. The limit value for the compliant coupler is set depending on the type of rubber. The result of the measurement is presented by the terminal placed next to the operator table [3]. For the incorrect coupler, PLC controller starts procedure for rejecting wrong item by the activating actuator placed behind inspection door E3 (Fig. 3).

The next metrological task is detection of weld placed on the surface of the coupler. It is realized by the device placed behind inspection door E3 (Fig. 3). Coupler is rotated among three laser transducer type LD100, two of them are placed in front of coupler and generates differential signal of fluctuations of coupler's longitudinal axis and the third is sending auxiliary signal to identification of welding seam.

ARM microcomputer system is filtering signals from transducers, signals are disrupted by vibrations and by changes of position of coupler. Based on comparison of this filtered signals system is detecting welding seam on the coupler [1]. Charts with graphic visualization of described signals are shown in Fig. 4.

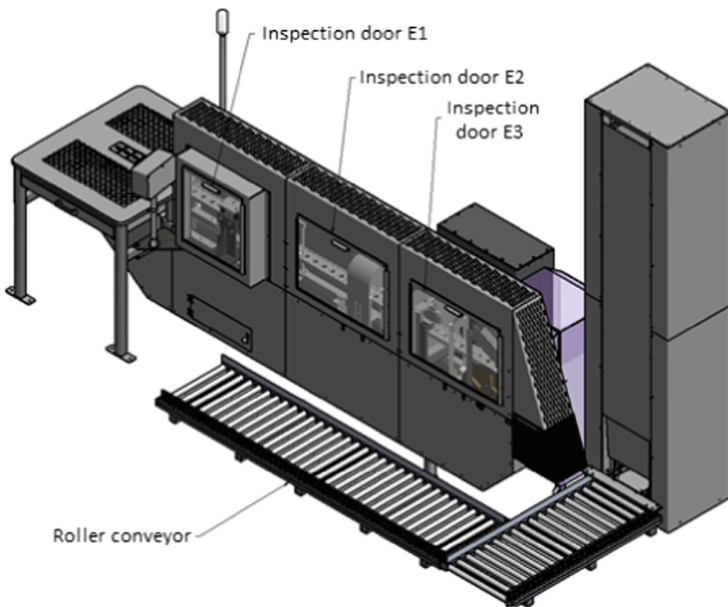
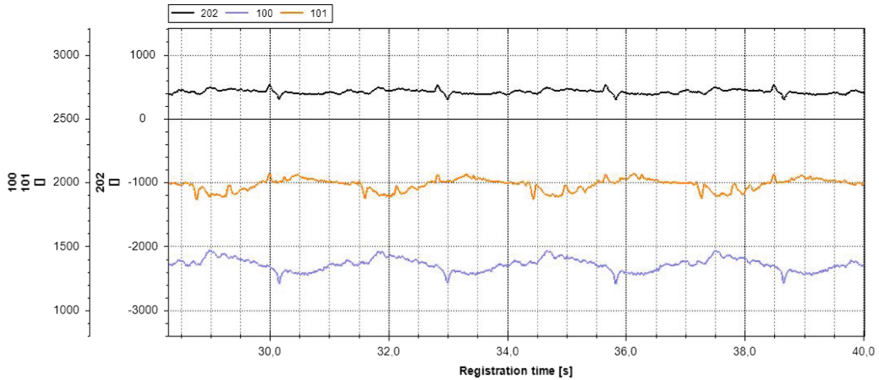


Fig. 3. Visualization of machine to 100% control of adhesion of car steering column couplers.

Disorder visible on the upper chart (Fig. 4) is used to comparison and stopping rotation of the coupler, moved to marking device placed behind inspection door E3. Burning of individual pictogram by the laser on the surface of each coupler is the end of the identification and marking process (Fig. 5). After that coupler is moved to box with correct items.



**Fig. 4.** Chart of filtered signals generated by the system detecting welding seam. 100, 101 – opposite transducers, 202 – received differential signal used to detection of welding seam.



**Fig. 5.** Car steering column couplers, left – item after test, dissection – negative result of test. Right – correct item with burned individual pictogram (QR code).

Figure 6 shown below presents machine with automatic device used to provide boxes for couplers.

Described machine is counting correct couplers. When amount of 64 pieces is reached, box with couplers is moved by the roller conveyor to prepared place into the box. At the same time, empty box is prepared for next batch of correct couplers.

## 4 Controlling Software

Controlling software consists of PLC driver software as well as industrial PC computer software. Display of operator's terminal is shown in Fig. 7.

Do avoid setting incorrect composition of rubber mixture, it is loaded direct based on scanned barcode. Controller software is supporting setting screen, which consists of tolerance and calibration factors. Connection with industrial computer provides



Fig. 6. Machine to 100% control of adhesion of car steering column couplers.

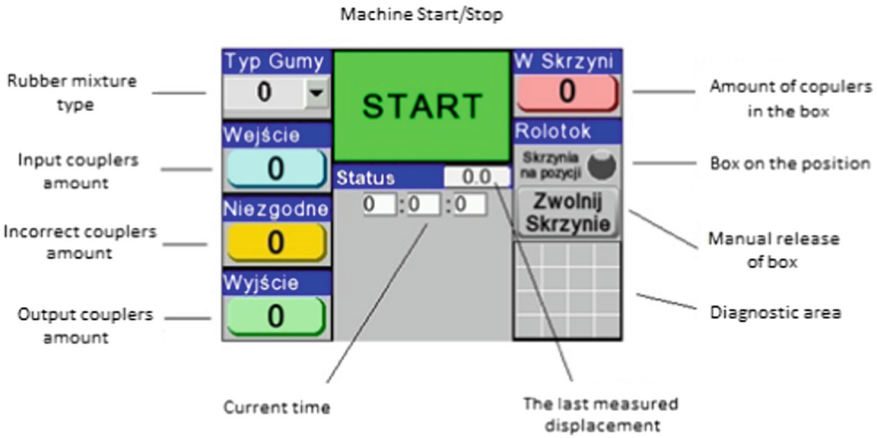


Fig. 7. Terminal display interface.

transmission of data from each measurement to further processing. Industrial computer software is converting data to text format, archiving on the local disc as well as sending data records to local workplace server (Fig. 8).

Subsequent component of the software is Quality Management System personnel PC computer software. It allows to access to workplace computer and real time preview of production as well as access to archive records.

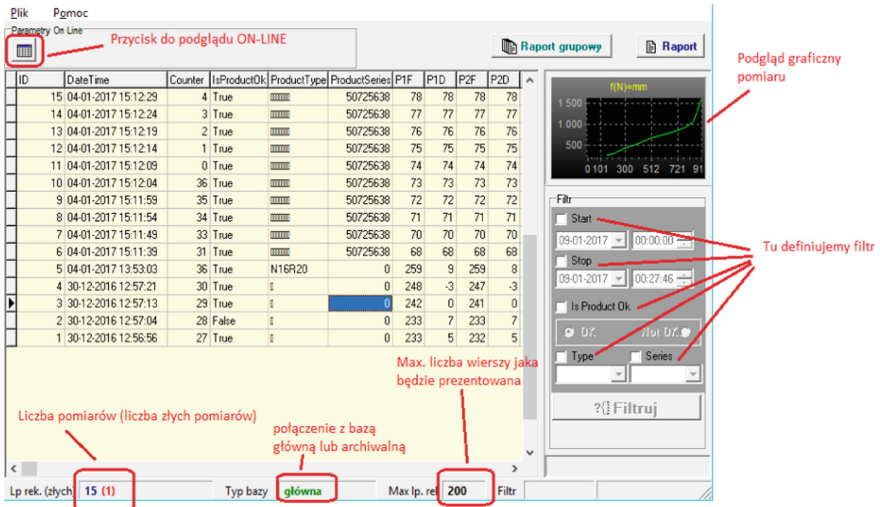


Fig. 8. Screen of PC computer with software for quality control.

## 5 Summary

On the primary stage of project, system based on visual method of detecting welding seam has identification errors level at 0,4%, however system based on the laser transducer doesn't show and identification errors. System works on the production line in the Sanok Rubber S.A. During one shift, machine is testing average more than 5 thousand couplers [2]. Currently device is operating with supervision to avoid contaminant of optical component by the vulcanization fumes. Laser transducers characterizes with high resistance to severe conditions of operating, optical parts of laser marking machine is susceptible to vulcanization fumes.

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