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A METHOD FOR THE CONSTRUCTION OF SOFTWARE AND A CONTROL SYSTEM FOR TESTING AND CERTIFICATION DEVICES IN THE FURNITURE INDUSTRY

Key words

Certification, test, device, furniture, PLC, HMI, impact hammer test.

Abstract

The article presents the problem of designing test equipment for testing and certification of furniture and materials used in the furniture industry. One of the main issues is the modularization of equipment and the automation of the tests. A natural consequence of the application of the modular structure of the hardware devices is the modularization of software to provide the synchronization of the operation of individual modules. This paper presents a software design methodology for the measuring and control of test equipment for the testing of furniture. The issues related to the diagnostics of the measurement and control system and the monitoring of the process of testing are discussed. A method was developed for the calibration of measurement circuits and the testing of the accuracy of positioning of products being tested. An example of process automation a functional device for impact test data of furniture is presented. The possibilities of applications of a developed solution for the impact testing of glassware are presented.

Introduction

Selected standards defining the proof tests and certification in the furniture industry [7] were analysed and the constructions of equipment from global manufacturers were reviewed 1–4. From the furniture industry, the standards for testing of chairs, tables, desks and bed frames were selected. The main tests of furniture are conducted for their stability, static strength, and fatigue and impact resistance. By analysing the standards, the construction blocks for testing equipment of furniture were identified. These are modules to exert vertical force and the horizontal force and the realisation of vertical and horizontal impacts.

A separate group constitutes speed control modules generally realised by means of an inverter for the AC motors or a PWM controller for the DC motors. The photographs (Fig. 1) show the completed test apparatus for furniture. The paper presents the following hardware and software modules that were found useful in the construction of the equipment for testing furniture:

- A module for the implementation of vertical and horizontal forces,
- A module for the implementation of the horizontal impacts, and
- A calibration module for measurement channels.

1. Control-measurement system for proof testing and certification equipment for the furniture industry

It was assumed that the control-measurement system would be implemented based on a modular controller PLC[1] with HMI touch operator panel, and a FC5A-type controller was selected with a built-in webserver D12S1E and operator's panel HG1F or HG2G from IDEC. The controller and panel connections to other devices were implemented through a local network and Modbus protocol (RTU TCP) [8], [9]. An example of the implementation of measurement and control system is shown in Fig. 2. Depending on the device, this scheme can be simplified. There are always preferred solutions with galvanic insulation.

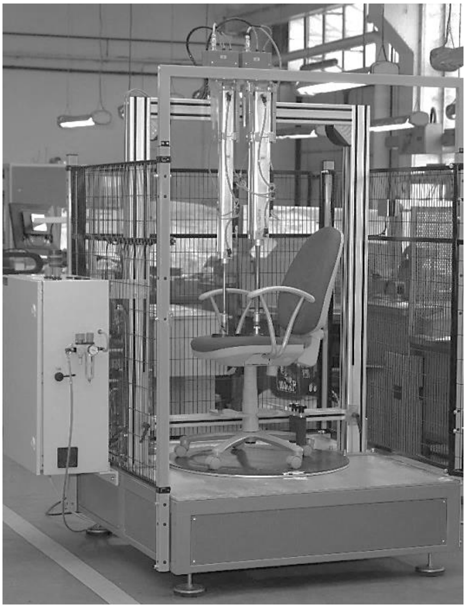
The diagnostics of the sensor data were provided by the relevant programming modules for analogue inputs and outputs of the PLC controller and allow easy conversion of measured analogue values into "engineering units" without the programming of special software.

The touch panel allows the operator to set the number of cycles, the duration of force exertion, cycle time or the force value, temperature value, etc. For example, the synchronization of force exerting modules may include (1) the start of the next cycle after returning to the retraction position of actuators, or (2) further exertion of force upon reaching by the all actuators the position of contact of stamp with the surface of the furniture. Software functions of the HMI

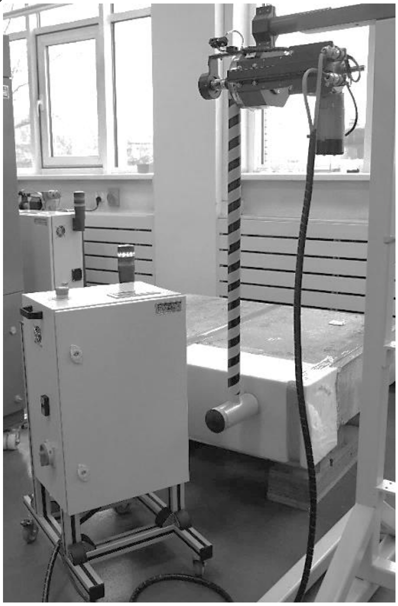
[1] FC5A-D12S1E controller from IDEC with built-in webserver.

operator panel and PLC controller make the software procedure (module) distributed.

a)



b)



c)

Fig. 1. a) Device for testing the rotary bases of office chairs and for rotation test of chair according to p. 7.3.3 and p. 7.3.5 of the PN-EN 1335-3:2099 standard, type **BK-EN 1335-3**, b) Device for impact testing the furniture, type **MU-M/D**, c) Device for testing the endurance and hardness of bed frames according to PN-EN 1957:2002 standard 5, 6

a) b)

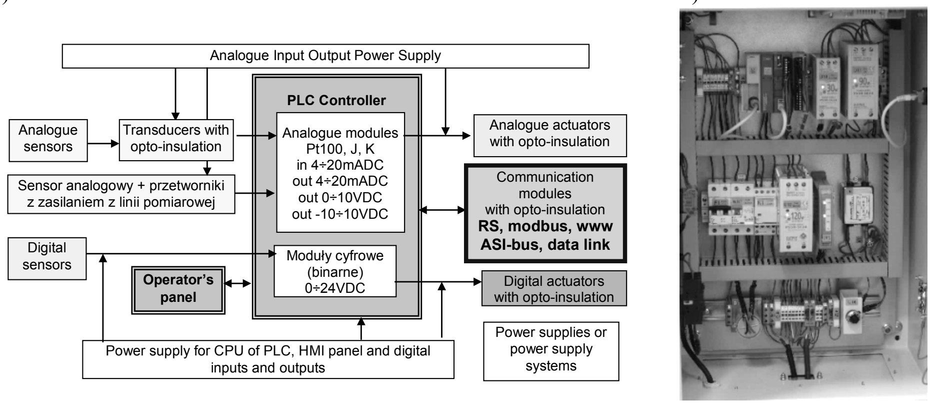


Fig. 2. a) Scheme of measurement circuit with two separate DC power supplies for analogue and for digital circuits, CPU and operator's panel; b) Realisation of control and measurement system for the device for testing the impact resistance of furniture (Fig. 1b)

RS232/485 output module supplied by the IDEC complete the communication protocol that provides the possibility for communication and programming the devices on a PC. The SCADA software module is implemented in Delphi and works in Windows 98 and Windows 8 environments without the installation of additional libraries and components.

In the controller used, all the software resources (inputs, outputs, registers, internal relays – also called flags, counters, Timers) are global. The controller is programmable in Ladder Logic Diagram Programming. The software has an expanded list of instructions for the ladder diagram. Due to the large reserves of flags, registers, timers, and counters, the "systematic programming rule" [10] was applied: All the flags and registers associated with the actuator are, e.g., in terms of numbers starting with 100–119, the next area is 120–139, etc. The application of regularity in the designation of registers defining the scope of analogue signals and in the designation of the current scope of measured (or computed) signal causes the following:

- Easy creation and modification of the control system software,
- Transparency of software, and
- Simplified commissioning of different software modules.

1.1. Technique for programming with flags

Since the controller programming is done using the LD, the technique of microprocessor systems programming and the creation of complex control software [11] was applied. Flags are understood here as a bit controlling the operation of sub-processes. The idea of programming techniques using the flags is shown in (Fig. 3a). The **FLGn** flag is set to the ON state and starts up the process. When the process (1) terminates or (2) meets the relevant conditions (e.g. an achieved position) or (3) generates alarm situations (the red line) or (4) has reached a preset control time, the **FLAGn** flag is set to the OFF state. Flag **FLAGn** at any moment can be reset from the main program of the PLC controller. Sometimes resetting makes it necessary to securely terminate the process. The **FLAGn** flag can be used to control the state of the process. This technique allows 'concurrent' operation of processes, where there can be several processes initiated simultaneously (Fig. 3b). Flags from some processes may condition the performance of other processes. The author uses and recommends the use of a separate synchronization process to control the process sequence, e.g. to control several actuators. Each process can run more processes (Fig. 3c). Concurrency is apparent here, since the program in the PLC is executed sequentially every few milliseconds, but from the point of view of the observer it appears to be performing concurrently and performing control tasks at maximum speed.

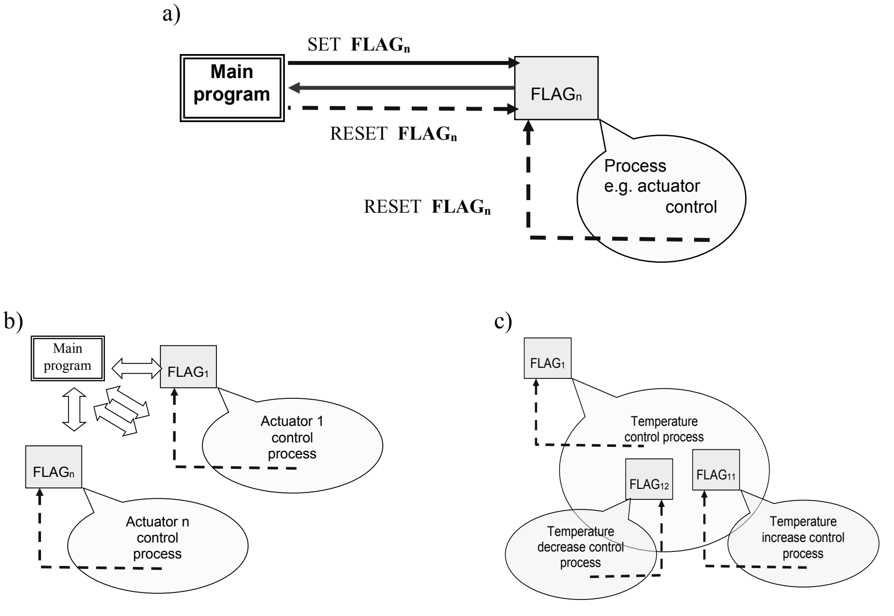


Fig. 3. Technique for programming with flags: a) The principle of control, b) Concurrency of processes, c) Controlling the sub-processes

The processes in Fig. 3 can be related to the operator's panel screens that define and initiate the processes. Then a switch and buttons on the operator panel initiate the beginning of the process.

2. Force exertion module

The method of exerting a vertical (horizontal) force is implemented by means of a pneumatic cylinder (Fig. 4). The air pressure corresponding to set force is supplied to the pneumatic cylinder. Piston position sensors are used for checking the control states. Pressure to force is converted automatically in the controller. The force exerted by pneumatic cylinders is specified by standards with an accuracy of 5% FS. The system shown in Fig. 4 ensures that accuracy.

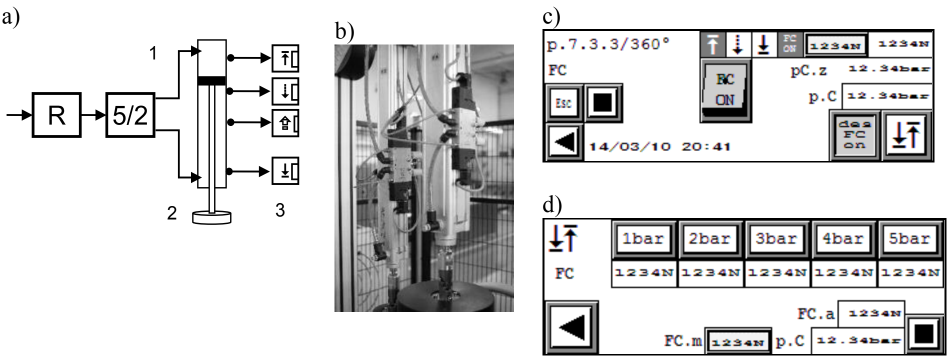


Fig. 4. The system for vertical or horizontal force exertion for the device (Fig. 1a): a) Block diagram, b) Valves fixed on the pneumatic cylinder, c) Manual actuator control screen d) Calibration screen for pressure-force tract for 40mm pneumatic cylinder; 1 – Double-acting pneumatic cylinder with valves, 2 – Holding plate, 3 – Piston position sensors, R – precise manual or electronic pressure regulator, 5/2 – electrical valve. Piston position: ⤒, ⤓ – at limit, ⇣ – working, ⇮ – element damage

Screens from Fig. 4c correspond to the sub-processes, where the FC/ON/OFF switch acts as a flag for cylinder action and the exertion of proper force.

The screen from Fig. 4d is used to calibrate the tract of the cylinder. The calibration results are automatically stored in the calibration macro. It is realised by the calibration software. The process is initiated by opening and stopped by closing the screen. Thanks to the software features of operator's panel, part of the operations performed by the controller is performed by the operator's panel.[2]

Emergency situations in the case of this module are defined as follows:

- In the case of setting the FC flag:
  1) A lack of a signal reaching the working position after a certain time,
  2) A lack of signal leaving the limit position after a certain time,
  3) A signal reaching the element damage position;
- In case of resetting the FC flag:
  1) A lack of signal reaching the limit position after a certain time.

[2] Mutual locking of buttons, the ranges of input values of forces, the signalling of faulty data, macros for the calculation of values, the handling of different language versions, etc.

Emergency situations are defined for all processes and are processed by a separate process – ERROR.

3. Horizontal impact module

The module for the implementation of the horizontal impacts is composed of (Fig. 5a) the following:

- A DC motor (4) operating in one direction and connected by an Oldham-flex[3] coupling to electrical clutch (3);
- The handle of a hammer (2) connected by bellows coupling[4] of potentiometric angle position transducer (1) is mounted to the armature of the electrical clutch; and,
- The entire structure is designed to be fixed to the frame structure built of ∅38 mm pipe.

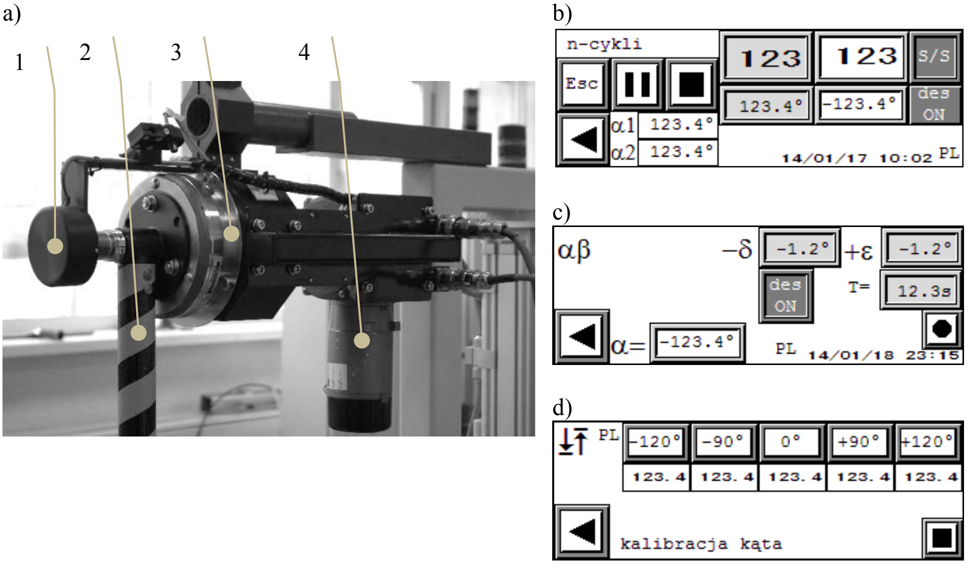


Fig. 5. System for vertical impacts for the device (Fig. 1b): a) Solution of the head for lifting the hammer, b) Screen for test performance, c) Screen for resetting and definition of angles, d) Screen for the calibration of angle transducer; 1 – Potentiometric angle transducer, 2 – hammer, 3 – electrical clutch, 4 – DC motor

The screen from Fig. 5d is used to calibrate the angle transducer tract. The calibration results are automatically stored in the calibration macro. It is realised

[3] Oldham coupling allows high absorption of radial displacement, produces no errors in kinematic transmission, and mechanical protection against excessive torque.

[4] Bellows coupling allows high absorption of shifts and high torsional stiffness.

by the calibration software. The process is initiated by opening and stopped by closing the screen. Thanks to the software features of operator's panel, part of the operations performed by the controller is performed by operator's panel.

The screen from Fig. 5c is used to reset and define angles. It is used before starting the process control screen. The screen from Fig. 5b is used to perform the testing procedure. The S/S[5] acts as a flag initiating the test.

Emergency situations in the case of this module are defined as follows:
- Operation of S/S when the hammer is not in the neutral position,
- When electrical clutch is not locked in the neutral position of the hammer.

Summary

Construction and software modules developed by the author of this article are intended for the construction of specialized equipment for testing and certification in the furniture industry. This concept has proven itself in practice.

The method for the construction of the software and the control system for testing and certification equipment in the furniture industry developed by the author of this article are intended for the construction of devices for testing of furniture. This concept of the design of devices from the modules has proven itself in practice.

The concept of measurement and control system in the form of an open distributed system allows flexible configuration of stands and their modifications in the future.

The prototype of the stand for horizontal impacts and the stand for the rotational chair testing was introduced in PUR Remodex Ltd. who specialises in quality and safety tests of furniture, and practical implementations for the furniture industry.

The prototype of the stand for testing bed hardness and wear resistance has been introduced at the Institute of Wood Technology in Poznan, which specialises in quality and safety tests and practical implementations for the furniture industry.

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[5] Start/Stop.

References

1. Website of CATAS company www.catas.it access on 20.01.2015.
2. Website of IDM company http://www.idminstruments.com.au/access on 20.01.2015.
3. Website of Texo Aplication AB company http://www.texoapplication.se/access on 20.01.2015.
4. Website of Hegewald & Peschke company http://www.hegewald-peschke.de/access on 20.01.2015.
5. Stand for testing sleeping surfaces http://katalog.itee.radom.pl/images/stories/karty/46.stanowisko_ang.pdf access on 20.02.2015.
6. Wojutyński J., Dobrodziej J., Matecki K., Gospodarczyk A., Rogoziński M.: Maszyna testowa do badania trwałości i twardości leżysk mebli, Problemy Eksploatacji, 2006.
7. Raport końcowy z realizacji zadania badawczego nr III.3.3/PS „Urządzenia do badań testowych i certyfikacyjnych w przemyśle meblarskim i materiałów budowlanych", Radom, lipiec 2013.
8. User's Manual. Web Server CPU Module. Dokumentacja FC9Y-1278.pdf firmy IDEC.
9. FC5A SERIES. Micro Programmable Logic Controller. User's Manual. Dokumentacja FC5A(B927).pdf firmy IDEC.
10. Wirth N.: Wstęp do programowania systematycznego. WNT, Warszawa 1987 (wyd. 2).
11. Wojutyński J.: Rodzina języków JSM. Problemy Eksploatacji 4'95, s. 17–32.

Metoda konstruowania oprogramowania i systemu sterowania urządzeń do badań testowych i certyfikacyjnych w przemyśle meblarskim

Słowa kluczowe

Certyfikacja, test, urządzenia, meble, PLC, HMI, impact hammer test.

Streszczenie

W artykule przedstawiono problematykę projektowania urządzeń do badań testowych i certyfikacyjnych dla mebli oraz materiałów stosowanych w przemyśle meblarskim. Jednym z podstawowych zagadnień jest modularyzacja urządzeń oraz automatyzacja prowadzonych testów. Naturalną konsekwencją zastosowania modułowej struktury sprzętowej urządzeń jest modularyzacja oprogramowania zapewniającego synchronizację działania poszczególnych modułów.

W artykule przedstawiono metodykę projektowania oprogramowania systemu pomiarowo-sterującego urządzeń testowych do badań mebli. Omówiono zagadnienia dotyczące diagnostyki systemu pomiarowo-sterującego oraz monitorowania procesu wykonywania testów. Zaprezentowano metodę kalibracji torów pomiarowych oraz kontroli dokładności pozycjonowania wyrobów poddawanych testom. Na przykładzie automatyzacji procesu badań udarnościowych mebli zaprezentowano funkcjonalne walory urządzenia. Przedstawiono możliwości zastosowań opracowanego rozwiązana w badaniach testowych udarności wyrobów szklanych.