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The laboratory stand for didactic and research of a Fluidic Muscle

G. Wszołek [a,*], G. Stawarz [b], P. Zub [a]
[a] Institute of Engineering Processes Automation and Integrated Manufacturing Systems, Silesian University of Technology, ul. Konarskiego 18a, 44-100 Gliwice, Poland
[b] VIX Automation sp. z o.o., Al. Roździeńskiego 188, 40-203 Katowice, Poland
* Corresponding author: E-mail address: grzegorz.wszolek@polsl.pl

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ABSTRACT

Purpose: The aim of this work was to design and build a laboratory stand dedicated for didactic and research purposes connected with a Fluidic Muscle. The stand is placed at the Electropneumatic and PLC controllers Laboratory [10,11,12] of the Institute of Engineering Processes Automation and Integrated Manufacturing Systems of the Faculty of Mechanical Engineering of the Silesian University of Technology, Gliwice, Poland.

Design/methodology/approach: The stand was designed and visualised by utilisation of professional CAD software – CATIA and a fluidic muscle was chosen according to a MuscleSIM programme of FESTO company.

Findings: The device integrates the elements which are indispensable determinant of contemporary industry and the main aim of its construction was to bring closer conceptions and ideas connected with the construction and the outworking of the fluidic muscle, problems of proportional pressure control, visualisation and control of the industrial processes as well as making possible of carrying out the investigations and experiments on these elements.

Research limitations/implications: The module structure of the research stand gives possibility to make its further development by adding extra modules that can be easily mounted on plates, which will make possible the implementation of series of individual positions controlled by one PLC. Thanks to the applied system of visualisation, switching among synoptic screens is possible. The visualisation represents every separate module of the stand and so, with the help of one operator position, gives possibility to control every chosen module of the whole device.

Originality/value: The mechatronic didactic and research device introduced in the paper represents the new approach to the problem of visualisation and control of the fluidic muscle and constitutes the perfect tool of the aided didactic process in the Institute's laboratory.

Keywords: Manufacturing and mechanical engineering; Automation engineering processes; Visualisation of engineering processes; PLC control; Fluid Muscle

1. Introduction

A Fluidic Muscle [16,17], Type MAS constitutes a great competition to traditional pneumatic linear actuators and gives possibility to achieve precise and repeatable linear displacement, that is realised because of material deformation and flexure. It gives designers the possibility to choose an efficient actuator in size and at the same time in weight.

The Fluidic Muscle has a membrane-contraction system, that is alike a human muscle in its construction [Fig. 1].

The large initial strength of a muscle as well as its big acceleration makes it suitable to processes where quick cycles as well as a high level of dynamics are required. A muscle produces strength ten times greater than the strength of a conventional pneumatic actuator, taking about 40% less energy necessary to produce equivalent strength. Simultaneously, to produce such force a muscle uses only one third of cross-sectional area, which a conventional pneumatic cylinder needs to the same task. Those advantages are important in many applications, giving simultaneously completely new areas of the application of pneumatic elements.

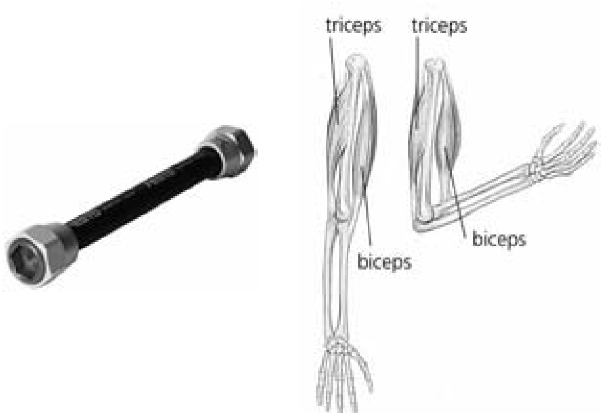

Fig. 1. A Fluidic Muscle and a human muscle corresponding with it

The construction of the laboratory stand (Fig. 2) based on the use of a pneumatic muscle, gave possibility to perform detailed investigations of this element in order to seek new industrial uses as well as ones contributed to widening a didactic offer of the Institute's Laboratories [1,…, 12, 14].

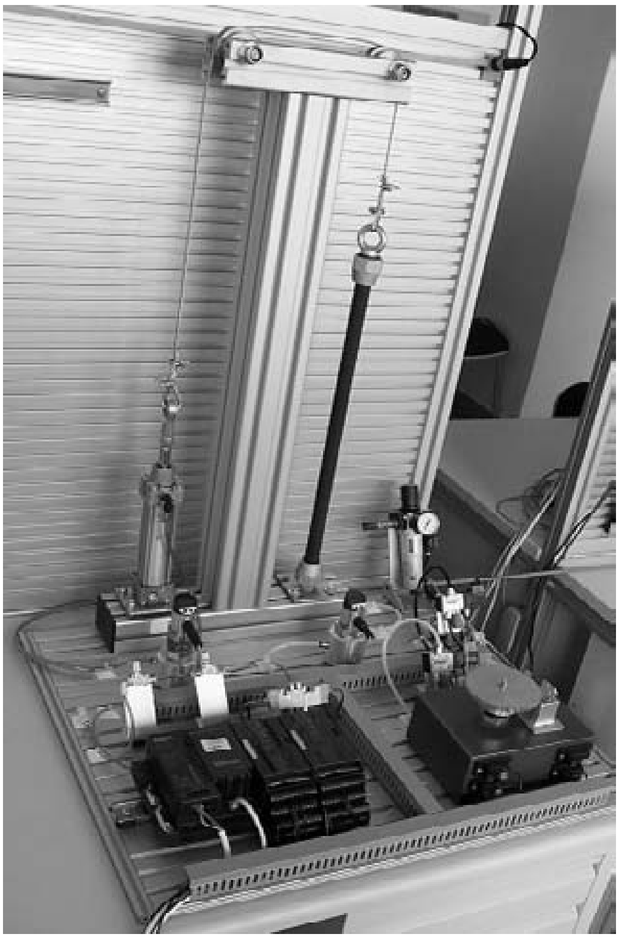

Fig. 2. The view of the stand for Fluidic Muscle investigations

2. Project assumptions

The research of properties of a Fluidic Muscle required to design a suitable stand that had to fulfil following conditions:

- The stand had to be equipped with a Fluidic Muscle of FESTO company,
- every elements of the stand taking an active or a passive part of a research process, had to be electronically controlled (digitally or analogically).
- The data received as a result of the research process had to be saved and archived, and easily accessible for different stands (computers) in order to make an accurate and precise analysis to find suitable conclusions.
- The stand should give possibility to control in a superior way (that is with the help of a computer, all functions are accessible from the operator's level),
- The stand should have the possibility of monitoring its state on the computer screen (visualisation).

The following foundations were accepted:

- a device to control the stand is a PC computer connected with a PLC controller,
- the control task will be realised through a programmable logical controller PLC,
- a computer will be equipped in visualisation software which will assure the possibility of following on a monitor screen the course of investigation process, and will make possible the control from the level of a computer as well. With the help of the visualisation the following things will be possible:
    - putting the value of muscle load,
    - setting the needed pressure of a fluidic muscle,
    - reading states of valves (on / off),
    - reading the current pressure from manometers,
    - controlling electropneumatic valves and proportional pressure valves,
- a position will be equipped with two kinds of proportional valves of pressure:
    - a proportional pressure valve built in support of a reductive valve and a step engine,
    - proportional pressure valve built in support of a 5/3 electropneumatic valve,
    - a pneumatic fluidic muscle loaded by a pneumatic cylinder

A pneumatic muscle was chosen with the help of the MuscleSIM programme of FESTO company [16] with assumption of pressure supply from 0 to 0.6 MPa, the linear load from 0 to 700 N as well as the maximum 60 mm change of length.

In the process of muscle selection external temperature was taken into account as well as its working conditions. The stand permits to lead among others: the investigations of influence of load and pressure changes on its extension.

3. Description of the stand to investigation of a Fluidic Muscle

The project of the investigative stand was designed in CATIA software environment (fig. 3) and then executed, on the basis of chosen elements and systems, according to certain criteria.

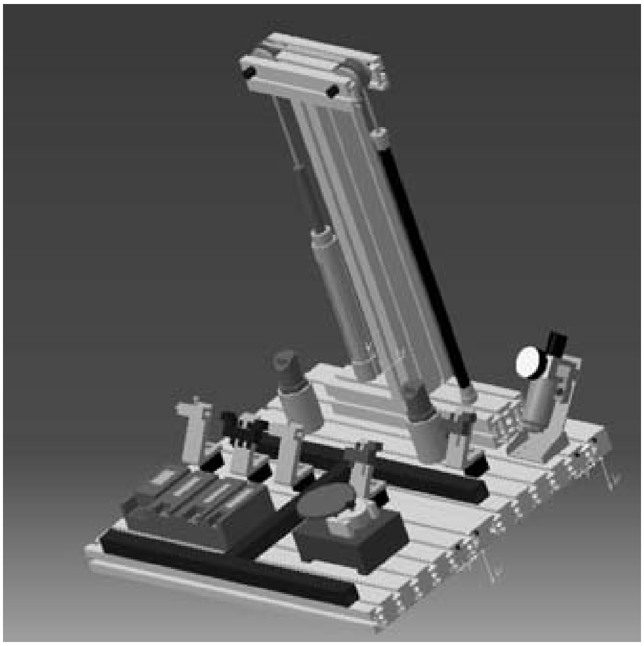

Fig. 3. The view of the stand designer in CATIA software

The position is supplied with the voltage of 24V DC. Fig. 4 shows the diagram of electric connections of the stand.

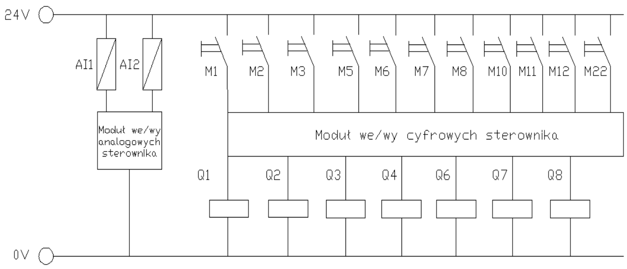

Fig. 4. The diagram of electric connections of the stand

Where: AI1 – a pressure sensor 1, AI2 – a pressure sensor 2, M1 – M22 – internal markers, Q1 – a solenoid of a 5/3 valve, Q2 – a solenoid of a 5/3 valve, Q3 – right rotation of a step motor, Q4 – left rotation of a step motor, Q6 – contact of a proportional valve (power supply of a step motor), Q7 – a solenoid of a 3/2 valve at the entrance, Q8 – a solenoid of a 3/2 valve before a proportional valve.

The pneumatic diagram of the stand represents fig. 5.

3.1. Visualisation and process of control

In the framework of established foundations the visualisation software named Proficy HMI / SCADA iFix 4.0. of GE Fanuc company was applied to management reasons. The VersaMax controller of the same company was used as an individual central controller. The work required designing and building two proportional pressures valves, the first one based on a step motor and a reductive pressure valve and the second one built on the basis of an electropneumatic valve.

The process of control, because of the safety reasons is taking place from the level of the synoptic operator's screen. Thanks to the applied solution (Ethernet) the stand can be placed in a distance from an operator. The operator approaching to investigations of the muscle has to start the computer with installed iFix system. After logging in, with the help of a synoptic screen the operator can monitor all parameters of the system as well as to control them (fig. 6).

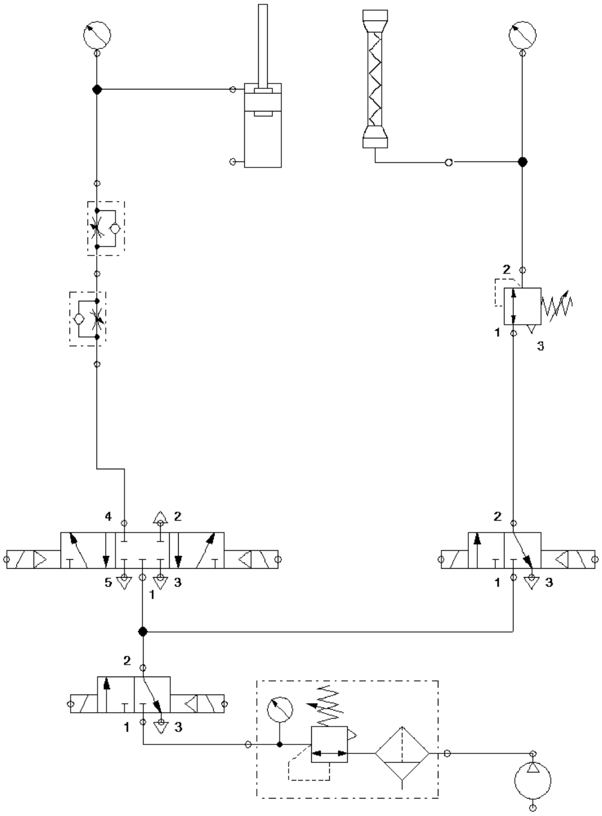

Fig. 5. Diagram of pneumatic connections of the stand

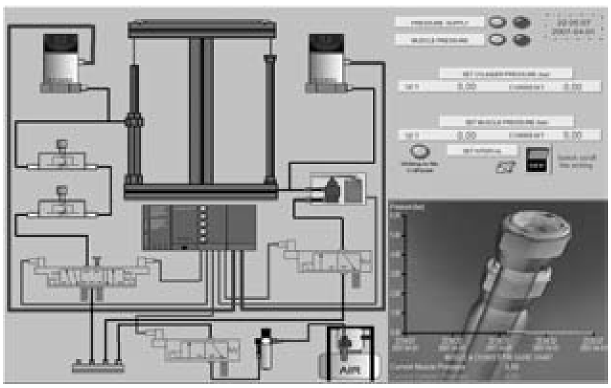

Fig. 6. The view of the synoptic operator's screen

Fig. 7 presents one of the possible work characteristics of the stand which enables the basic calculation of the pneumatic muscle force.

Fig. 7.The example of Fluidic Muscle characteristics

4. Conclusions

The stand described in this paper is a didactic laboratory stand, which task is to enable investigations and gather knowledge of construction and the way of working such elements as: a Fluidic Muscle, a PLC controller [13], HMI SCADA systems as well as proportional pressure control techniques.

It offers many didactic and investigative possibilities [15] and thanks to applied solutions its development is easily available.

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