MECHATRONIC SYSTEM FOR PNEUMATIC ACTUATION, USING AS EXECUTION ELEMENT, AN ARTIFICIAL MUSCLE AND FOR CONTROL LOOP, USING A CAMERA

Ardeleanu M.[1], Cîrstoiu A. [1], Mihai S.[1];

[1]Valahia University of Targoviste, Romania; miniarde@yahoo.com , adriana_cirstoiu@yahoo.com, mihai.simona@yahoo.com

***Abstract:** In this paper it was conceived a system to control supplementary the accidental situations that may occur during operation of the mechatronic device with pneumatic muscles, for precise actuation loads. The system developed includes the technical work with image processing, in the static case. An interactive program is designed bellows gauge functional check for artificial muscle, checking frame by frame the pixel's attributes arrays of compared, in comparison with the maximal state matrix. The system has the capacity to respond by sending a digital message encoded by a superior computer system.*

***Keywords:** pneumatic muscles, pressure match, software variables, process variables, the maximum distance.*

1. INTRODUCTION

Pneumatic actuators elements studies led to the design of a membrane in the year 1950 - 1960 and finally the pneumatic artificial muscles (Figure 1) to simulate human muscles. Pneumatic muscles were sold by the Bridgestone Rubber Company of Japan since 1980 and more recently by the Shadow Robot Company in the U.S. and Germany FESTO Corporation (2001).

Figure 1 Pneumatic Muscle

Pneumatic muscles are actuators that convert pneumatic energy into mechanical energy, transferring the pressure applied to the internal surface of a membrane tension leads to a change in longitudinal dimensional [2].

Pneumatic muscles are extremely easy because the main element, a membrane that can transfer the same energy as a cylinder, because they operate the same values of pressure and volume. Can thus be used increasingly as a source drive over to robots, with advantages such as direct connection, replacement easy and safe operation [1].

When compressed air is applied, pneumatic muscle membrane type contract expands in circumference, so a traction device, such as a contracting motion in the longitudinal direction. Acting independently. The movement is transferred to the workload with connecting elements.

The amount of motion in a thermal system introduced by a pneumatic muscle, must wrapping, progress measured and controlled by feedback information.

This feedback should be provided in real time to determine the overall dynamics technically adequate.

Image processing has evolved in terms of speed and quantity of information processed per unit time. This already known today, was a imblod to design a control system in a motion introduced by a system of artificial muscles. This paper will presents the basic concept that will be used for designing and implementation of a feedback system with image processing for closed-loop control of movements into longitudinal pneumatic muscles case.

2. MAIN ELEMENTS TECHNICAL PRESENTATION

The schematization system concept, involves the main elements that will be integrated systemic and mechatronic.

Being a pneumatic artificial muscles, pressure is an important technical parameter, through will be apply the displacement command into entire ensemble.

The approach paper is a presentation of invoice static pressure-displacement correlation, being most important.

The main technical elements are:
1. Pressure Regulator
2. Mechanical Distributor 3/2-way
3. Pneumatic muscle
4. Web cam

1.Regulatorul pressure air supply to maintain operating pressure and compensates for pressure fluctuations determined. Flow direction is identified by arrows on the housing. Pressure gauge indicates the set [3].

2. Mechanical distributor 3/2-way, the valve is actuated by turning the dial. Rotating the selector valve to restore the settings to the starting position by a return spring.
Pressure Range: -90 – 800 kPa (-0.9 – 8 bar)
Standard nominal flow 1 ... 2 =60 l/min
Driving force in 600 kPa (6 bar) = 6 N

Connection: Accessories QSM-4 plastic tubes put 4 x 0.75 [4].

3. Pneumatic muscle
Contractible membrane diameter =10mm
Contraction maximum allowed: 25% of the nominal length (= visible membrane contractible unstressed)
Membrane contracting reinforced Neoprene [5].

4. Web cam
You can use any kind of camera, in this case will use a system with a webcam with a refresh at least 15 frames / s.

3. DESIGN SYSTEM. OPERATION PRINCIPLE

The bavic idea of system design, persist into fact that the technique reality can be captured by photographic frames that can be interpreted quantitatively and qualitative.

In this case, the picture will be the package of information whose interception generates with a certain precision, relative longitudinal displacement of the artificial muscle. Into Figure 2a) is shown the principle diagram.

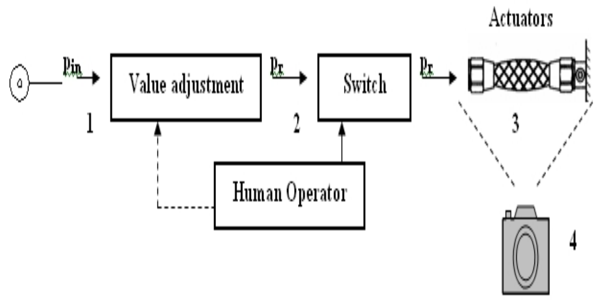


Figure 2, a) Scheme of principle

Legend
1. Pressure Regulator
2. 3/2-way valve with selector switch, normally closed
3. Pneumatic muscle
4. Web cam

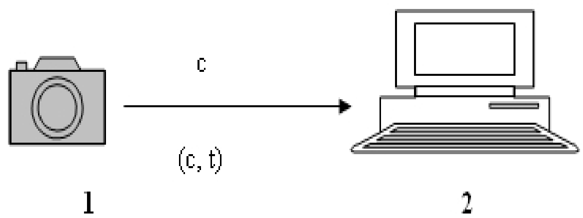


Figure 2, b) image processing

Legend
1. Web cam (fixed)
2. PC

Actions
c. capture frame (static)
(c, t). Capture frame (dynamic)

Process Variable = pressure and / or flow
pressure → static deviation
flow → dynamic deviation
In the next part of the paper, it will treat the technical detail that will expose the principle of operation summarized above.

4. TECHNICAL DETAILS OF THE SYSTEM DEVELOPED

Searching for obtaining a correspondence between the variables that evolve in a software image processing applications and process variables (p in this case air)
Software variable is the maximum distance between contour lines of marginal attributes matrix definition of an image captured or travel distance of a line and / or columns relative to a part of the mathematical entity.

Matrix definition with attributes of an captured frame.

$$\begin{vmatrix} a_{11} \; a_{12}.........a_{1n} \\ a_{21} \; a_{22}.........a_{2n} \\ \vdots \\ a_{i1} \; a_{i2}....a_{ij}....a_{in} \\ \vdots \\ a_{m1} \; a_{m2}........a_{mn} \end{vmatrix}$$

In the following, are given correspondences between real variable (pressure) and virtual variables, for matrices of explicit definition below.

Association [Variable. Softaware + variable. Process]

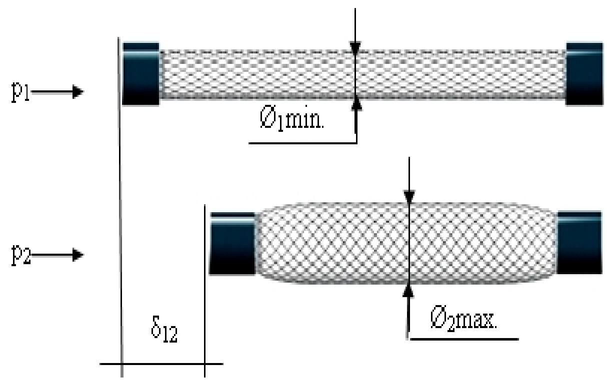


Figure 3 Parameter muscle movement

$$p_1 \leftrightarrow \begin{vmatrix} a_{150,1} & a_{150,2} \cdot\cdot\cdot\cdot\cdot\cdot \\ a_{720,1} & a_{720,2} \cdot\cdot\cdot\cdot\cdot\cdot \end{vmatrix}$$

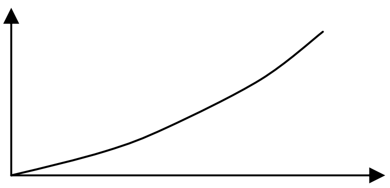
$$p_2 \leftrightarrow \begin{vmatrix} a_{100,1} & a_{100,2} \cdot\cdot\cdot\cdot\cdot\cdot \end{vmatrix}$$

$a_{900,1}$ $a_{900,2}$ . . . . . .

$Ø_1$ → defined by the matrix variable function software.
$p_1 > p_2$
δ_{12} – relative displacement between the p_1 and p_2 states pressure.
It can be built the function δ12 = f (Ø), so you can control the displacement on the horizontal axis through the image processing.

Calibration model is necessary to correlate the real driving mechanics, as an expression of the existence of a unique pressures associated matrices resulting definition image processing.
Calibration is obtained through maintaining the constant conditions for image capture, respectively, light, reflection, etc.
It will join the virtual dimension - values measured with precision of 0.01 mm.

Stage: I
δ=δ (p)



Stage: II
D^{max}_{matrix} [Variable software]=f(δ)=f($\delta_{(p)}$)

Detailed scheme for capturing images

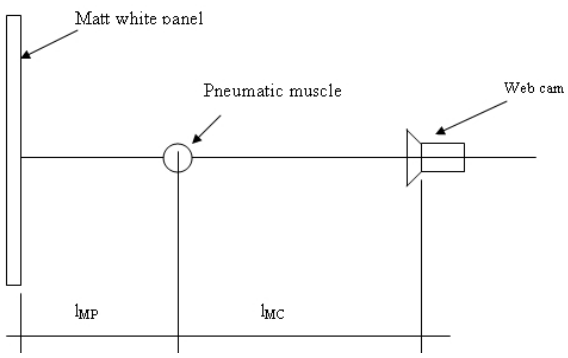


Figure 4 Scheme of location of the camera relative to actuator

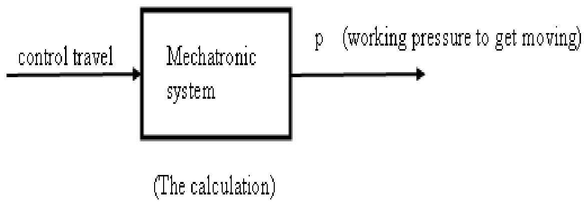
5. WORKING PROCEDURES

Algorithm of determinations is described below.
Step 1. Ensure the air intake pressure 7at
Step 2. Adjust the regulator on the p-value = 1at
Step 3. Switch on the condition ON distributor
Step 4. Wait 10 seconds
Step 5. Capture frame
Step 6.The trigger processing procedure (program resumed).

Note: Recording d^{max}
Step 7. The distributor switches OFF
Step 8. Return to step 2 and change the value of p
After a session of measurements, will get a set of values (p-d^{max})

Following experimental data it determined δ=δ(p).
Then it will up-date software for the calculation of indirect δ=δ[d^{max}(p)]

Mechatronic system, after calibration it will generate the following scheme.



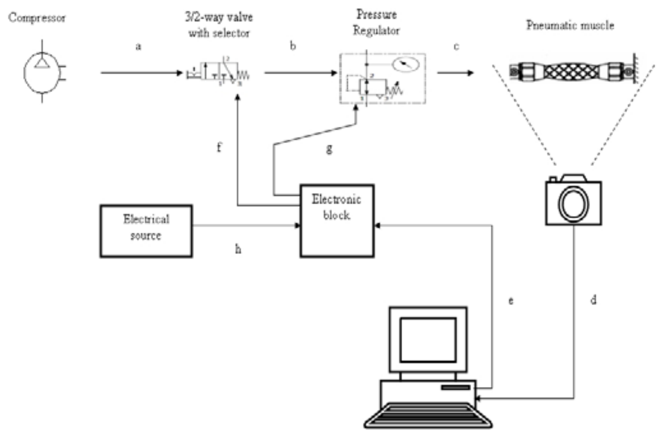


Figure 5 Scheme mechatronic system with image processing

Definition signals:
a – pressure p=7bar
b = {a- state ON; o- state OFF}
c – pressure p_R Є [o,6]bar
d – image code (digital)
e – digital control code
f – digital control
g – analog control
h – power

6. CONCLUSIONS

Technical system following to be designed and achieved, brings innovation in automated closed-loop controls, introducing image processing as a means to develop feed-back information.
With high processing speed, the paper opens a series of concepts system, through control the movement of image capture and processing, will expand the dynamic aspects, respectively, speeds displacement.

The work covered by the proposed topic, a current trend in development, namely, optical control.

7. REFERENCES

[1]Andrea Deaconescu, Tudor Deaconescu - Performance of a Pneumatic Muscle Actuated Rotation Module

[2] Fluidic Muscle DMSP, with press-fitted connections, Fluidic Muscle MAS, with screwed connections www.festo.com

[3] www.festo-didactic.com - “Search” code “152894”

[4] www.festo-didactic.com - “Search” code “152863”

[5] www.festo-didactic.com - “Search” code “544311”