INVESTIGATION OF POSITIONING OF FLUIDIC MUSCLES UNDER DIFFERENT TEMPERATURES

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Abstract

Pneumatic Artificial Muscles (PAMs) have a wide range of use in industrial as well as medical fields. Their greatest disadvantage is said to be their nonlinear characteristics and due to this the difficulty of their positioning.

This paper presents our robust motion control of these muscle actuators under different temperatures using sliding-mode control.

Objective

Different solutions can be found for the control of Pneumatic Artificial Muscles during their use in [1], [2], [3], [4], [5] and [6]. The early control methods were based on classical linear controllers and then some modern control strategies have been developed (e. g. adaptive controller, fuzzy controller, neural network controller, sliding-mode controller and others).

The effect of temperature is scarcely mentioned at best in literature. This however is an important aspect since the muscles heat up considerably during use as well as cool down due to the temperature of their surroundings, for this reason we conducted our positioning experiments not only in room temperature but extreme temperatures as well.

Our goal was the design of robust control system that can guarantee accurate positioning up to 0.01 mm in room temperature as well as extreme high and low temperatures.

The layout of this paper is as follows. Section 2 (Methods and Materials) is devoted to display our positioning system and different LabVIEW programs. Section 3 (Result and discussion) presents several experimental results. Finally, section 4 (Conclusions and future work) gives the investigations we plan.

Fluidic Muscles DMSP-20-400N-RM-RM (with inner diameter of 20 mm and initial length of 400 mm) produced by Festo company were selected for our newest study. We have investigated type DMSP-20-200N-RM-RM (d_0 = 20 mm, l_0 = 200 mm) and type DMSP-10-250N-RM-RM (d0 = 1_0 mm, l_0 = 250 mm) in [7] and [8].

Methods and materials

A good description of our test-bed and experimental results for positioning can be found in [9].

The PAMs were installed horizontally and can be controlled by MPYE-5-M5-010-B type proportional valve made by Festo. Our robust position control method based on sliding-mode control. The linear displacement of the actuator was measured using a LINIMIK MSA 320 type linear incremental encoder with 0.01 mm resolution. To measure temperature inside and outside the muscle the test-bed was completed four thermocouples type K. Fig. 1 shows the block diagram of this positioning system with proportional valve.

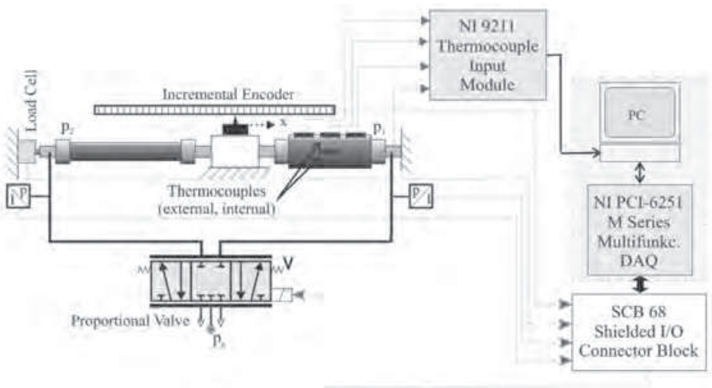

Figure 1. Block diagram of positioning system with proportional valve

For the data acquisition of temperature and positioning readings we used programs written in LabVIEW.

Front panel of LabVIEW program for positioning is shown in Fig. 2. Aside from the desired position the number of samples and the sampling time can also be set. The data can be saved into a text file.

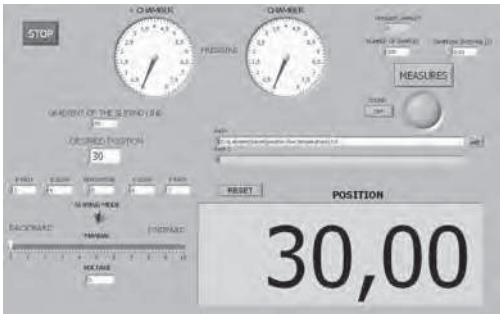

Figure 2. Front panel of LabVIEW program for positioning

The Figure 3 shows the front panel of the LabVIEW program created for temperature measurement. Here the number of samples and sampling time can also be set. During the periodic and automatic working of the muscles the contraction and rate of release can be adjusted with the frequency of the sine wave. The temperature inside and on the surface of the muscle can be read on the indicators on the screen also it is shown as a number. The measured results are saved in a text file for later processing.

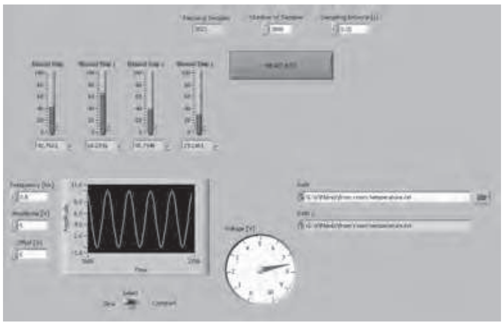

Figure 3. Front panel of LabVIEW program for measuring temperature

Result and discussion

Positioning was first done in room temperature on the pressure of 6 bars. The desired positioning was set to 40 mm, the number of samples was set to 300, while the sampling rate was set to 10 ms, thus the measurement took 3 s. Fig. 4 shows the positioning as a function of time. It took about 0.8 s for the position to reach the set value. To show the accuracy of positioning the area around the desired position has been magnified (Fig. 5). This Figure shows the accuracy of positioning is within 0.01 mm.

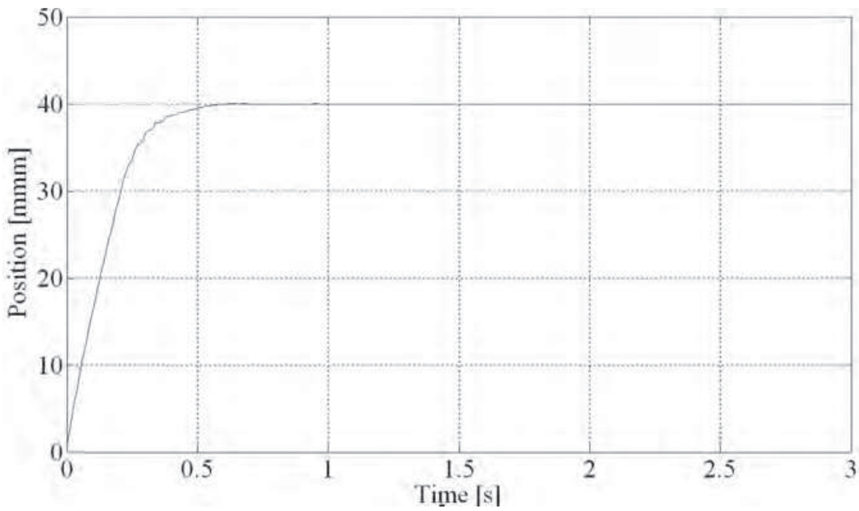

Figure 4. Positioning as a function of time

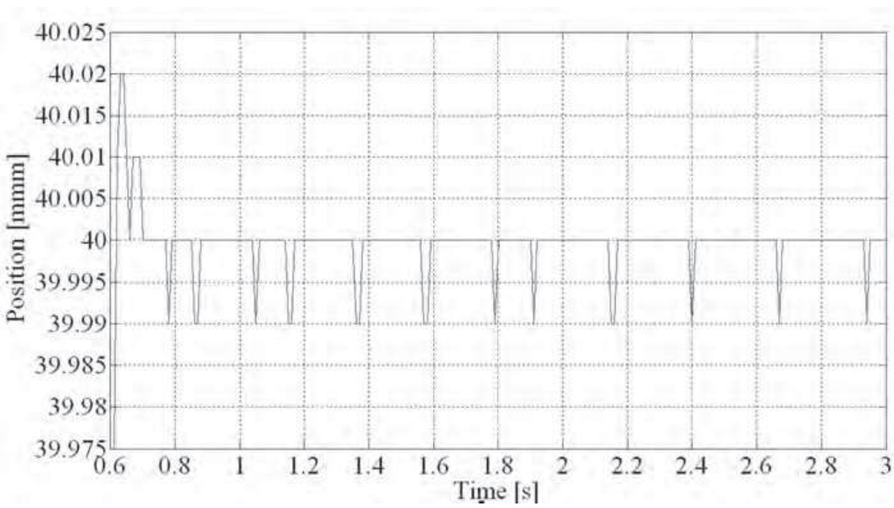

Figure 5. Positioning as a function of time (enlarged)

The periodic working of the muscles was achieved with a 0.5 Hz frequency sine wave. The measurement took 900 s during which the sampling time was 0.25 s, the acquired data is shown in Figure 6. While the external temperatures of the surface settle the internal temperature is changing because of the exchange of air.

After a constant temperature was reached positioning was measured on the pressure of 6 bars, too. The result of it is shown in Fig. 7. It shows the desired position was reached within 0.6 s. To show the accuracy of positioning the area around the desired position has been magnified (Fig. 8). The accuracy of positioning remained within 0.01 mm.

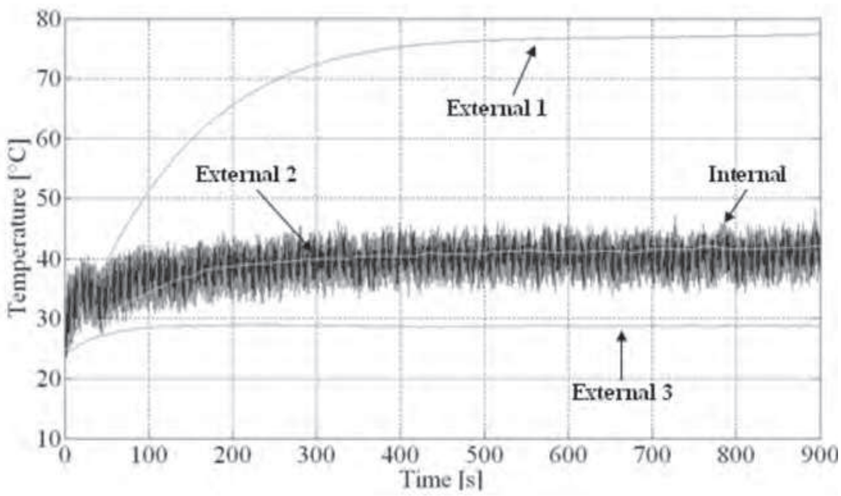

Figure 6. Temperature as a function of time

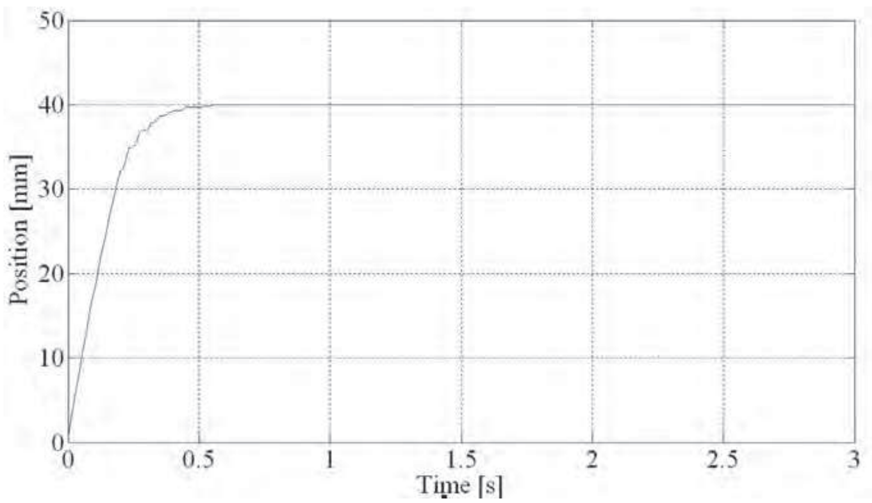

Figure 7. Position as a function of time after work cycle

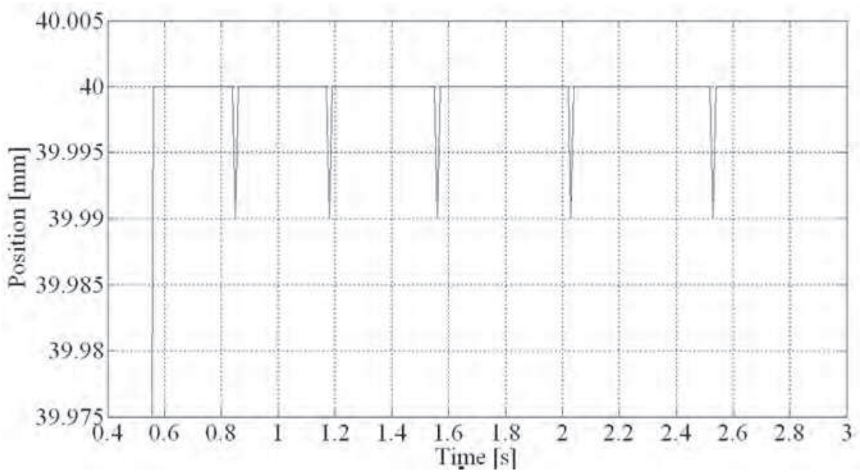

Figure 8. Position as a function of time after work cycle (enlarged)

Conclusions and future work

With the results of the experiments conducted with muscles of varying geometric parameters we can conclude that the accurate poisoning up to 0.01 mm is still possible on extreme temperatures and in the case of greater than room temperature positioning time is reduced. Our future will include experiments in temperatures lower than room temperature as well as the use of a 0.001 mm resolution encoder in the experiments with positioning.

References

1. Caldwell D. G., Medrano-Cerda G. A. and Goodwin M. (1995), Control of Pneumatic Muscle Actuators, IEEE Control System Magazine, Volume 15 (1), pp. 40-48.

2. Tondu B. and Lopez P. (2000), Modelling and Control of McKibben Artificial Muscle Robot Actuator, IEEE Control System Magazine, Volume 20, pp. 15-38.

3. Sheping T., Guoqing D., Detian Y., Liangming L. and Meng S. (2004), Nonlinear Controlling of Artificial Muscles System with Neural Networks, International Conference on robotics and Biomitics, Shenyang, China, 22-26 August, 2004, pp. 56-59.

4. Lilly J. H. and Yang L. (2005), Sliding-mode Tracking for Pneumatic Muscle Actuators in Opposing Pair Configuration, IEEE Transaction on Control System Technology, Volume 13 (4), pp. 550-558.

5. Situm Z. and Herceg Z. (2008), Design and Control of a Manipulator Arm Driven by Pneumatic Muscle Actuators, 16th Mediterranean Conference on Control and Automation, Ajaccio, France, 25-27 June, 2008, pp. 926-931.

6. Xiaocong Z., Guoliang T., Bin Y. and Jian C (2008), Adaptive Robust Control of a Parallel Manipulator Driven by Pneumatic Muscles, Automatica, Volume 44, pp. 2248-2257.

7. Sárosi J. and Csikós S. (2010), Positioning of Pneumatic Artificial Muscle Under Different Temperatures, Analecta Technica Szegedinensia, Review of Faculty of Engineering, Volume 2010/2-3, pp. 216-221.

8. Sárosi J. (2010), Investigation of Positioning of Fluid Muscle Actuator Under Variable Temperature, International Symposium on Advanced Engineering & Applied Management - 40th Anniversary in Higher Education (1970-2010), Hunedoara, Romania, 4-5 November, 2010, pp. 129-133.

9. Sárosi J., Gyeviki J., Véha A., Toman P. (2009), Accurate Position Control of PAM Actuator in LabVIEW Environment, IEEE 7th International Symposium on Intelligent Systems and Informatics, Subotica, Serbia, 25-26 September, pp. 301-305.