EXPERIMENTAL DETERMINATION OF CONNECTING PIPE LENGTH INFLUENCE TO THE DATA ACQUIRED

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Abstract. The utilization of pneumatic muscles in industrial applications is still in a premature stage, due to the relative freshness of these components. The paper presents some of the results of research carried out in the Fluidtronics Laboratory of Department of Economical Engineering and Manufacturing Systems of the Transilvania University of Brasov.

Keywords: pneumatic muscle, connecting pipe length, pressure, force

1. Introduction

A pneumatic artificial muscle is essentially a volume, enclosed by a reinforced membrane, that expands radially and contracts axially when inflated with pressurized air. Hereby the muscle generates a unidirectional pulling force along the longitudinal axis. [1, 5, 6]. The paper presents some experiments concerning pneumatic muscle performances by establishing the influence of pneumatic components connecting pipe length on the dynamic behaviour of the system.

2. Experimental stand

Experimental researches were conducted in the Fluidtronics Laboratory of the Transilvania University of Brasov. Experimental facility, shown in fig.1 contains: a pneumatic muscle MAS-10-N-100-AA-MCFK; a force transducer RDP LOAD CELL MCL/1kN; a flow transducer SFE3-F500-W18-L-2PB-K and a pressure transducer SDE-1- D10 (manufactured by FESTO Co. of Germany). The experimental stand circuit, used for completely or partially experiments, contains a FESTO application named FluidLab which allows the data input acquisition and their graphical representation. The application offers different types of windows particularised on the chosen pneumatic element. Also, it is necessary to use FESTO acquisition system that includes communication protocol RS232, which connects the data acquisition board and the FESTO application. Because the FESTO application does not allow viewing negative values, it was necessary to utilize an offset compensation circuit. The circuit involves an independent voltage source (a battery of 1.5 V) and a semi-adjustable potentiometer. For the full set of experiments presented in this paper it was used the RDP LOAD CELL MCL/1 kN force transducer. This, according to the catalogue pages, has a field of forces between –1 and 1 kN, while the field of differential output voltage between -10 V and 10 V, as the characteristic force - voltage is approximately linear (maximum error is 0.2% for an electromagnetic disturbance of 3 V/m, and 2% for an electromagnetic disturbance of 10 V/m).

Under these conditions, experiments allowed us to obtain the voltage output of the force sensor, which should be transformed in force. In order to determine the force generated by muscle it must be taken into account the ratio voltage - force of the sensor used, which is 1V/100 N. [2, 3, 4].

3. Experimental Data Registration

In order to obtain the connecting pipe length influence to the data acquired there have been carrying out four sets of measurements, two for each of the following pressures: 3 bar, respectively 5.3 bar. For each pressure it was positioned the point of pneumatic ramification between the pressure source and muscle towards pneumatic transducer, at 5 mm (namely “near” the muscle) and respectively at 600 mm of the muscle (namely “away” from the muscle). In addition, measurements were made for a length of pneumatic artificial muscle of 98 mm.

3.1. Connecting pipe length influence for a 3 bar pressure

The first experiments were carried out for a 3 bar pressure and the experimental results are shown in figures 2 and 3. In order to do a comparative analysis of the system reaction, the sets of experimental data

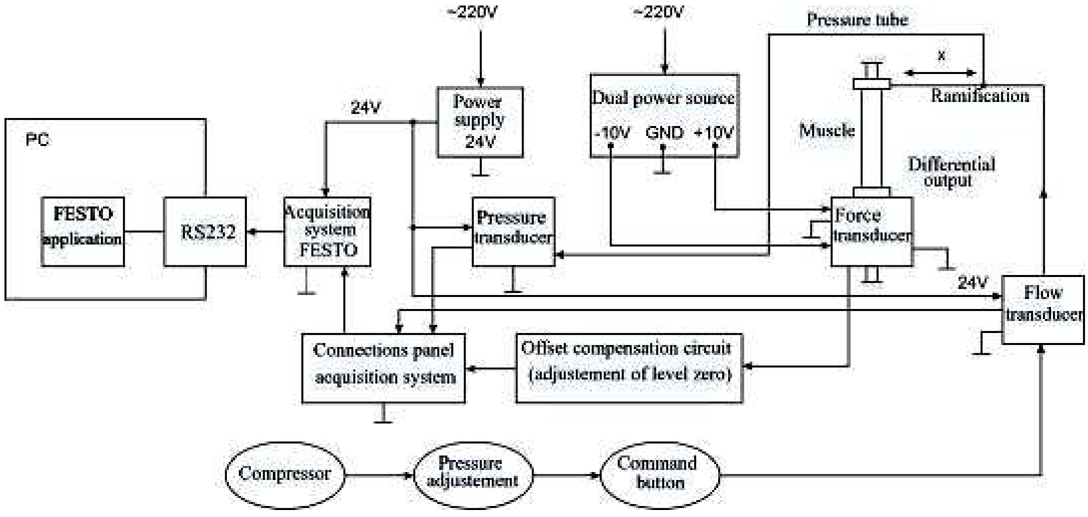

Figure 1. Experimental stand

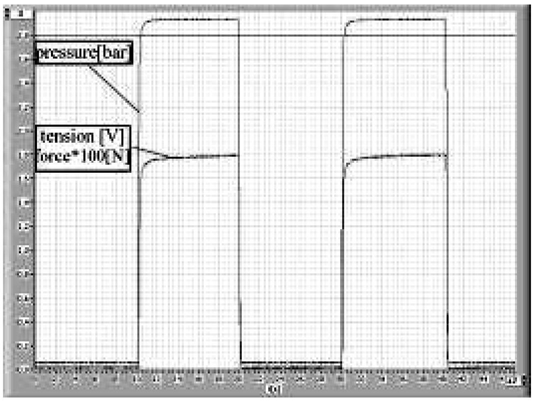

Figure 2. System Reaction when the pressure transducer is mounted at 5 mm

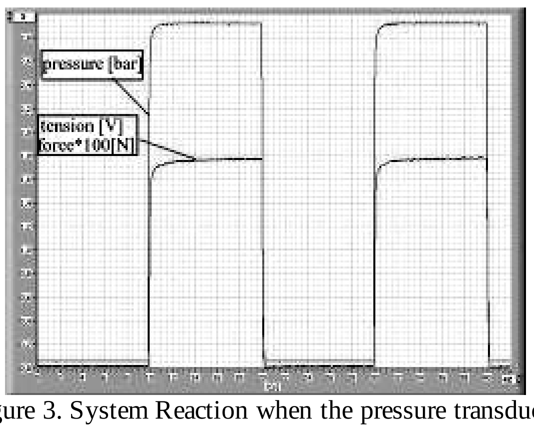

Figure 3. System Reaction when the pressure transducer is mounted at 600 mm

previously obtained have been incorporated in a Matlab simulation program.

The overlap of the two voltages, respectively forces, allowed us to obtain the diagram from figure 4. The data processing showed that for a near assembling of the pressure transducer to the muscle, maximum force developed (the value at which the signal is stabilized) was 178.7 N, and for an away assembling force was 177.7 N. Thus, the difference between the two stabilized values is 1 N, but analysing the acquired data files results, despite of cancelling offset circuit, that at out of the force transducer, at zero pressure, appears an offset value of 0.01 V, that is about 1 N. In these conditions results the fact that the difference between the force in near and away assembly is 0 N.

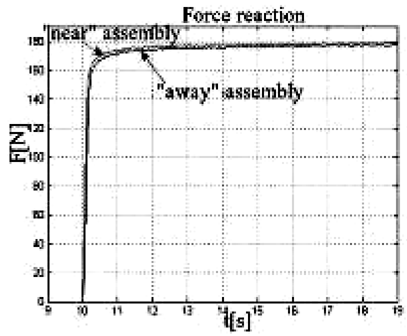

Figure 4. Forces developed at p = 3 bar, in transducer assembly "near" and "away" from the muscle

The steady-state time (considering it the moment when the system reaches for the first time the steady-state value) for “near” assembly is 0.865 s and for “away” assembly is 0.973 s, resulting a difference of 0.108 s. The time of growth (the range time in which the force values are between 10% and respectively 90% of the steady-state value) is the same in both cases: 0.21 s (figures 5, 6). In terms of pressure reaction, by processing experimental data and their representation, it has been obtained the characteristic shown in figure 7. In both cases, the attained pressure is 2.93 bar. The difference between the pressure shown on the electronic display of the transducer and the value attained by the computer from the same transducer is 0.07 bar and is justified by analog-digital conversion error.

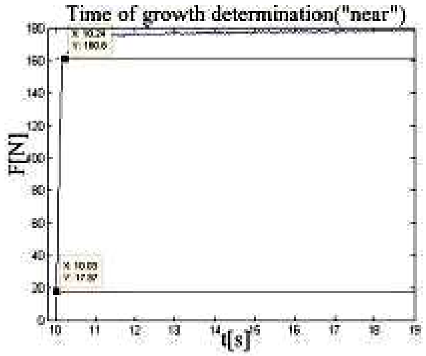

Figure 5. Time of growth for the both assembly

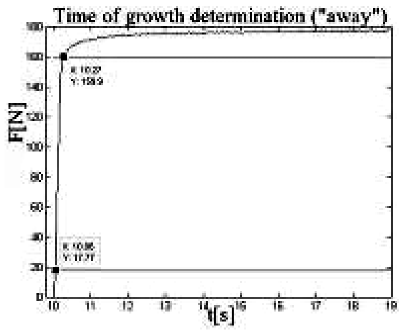

Figure 6. Time of growth for the both assembly

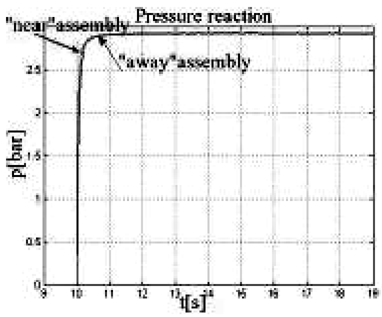

Figure 7. Recorded pressure in transducer assembly "near" and "away" from the muscle

3.2. Connecting pipe length influence for a 5.3 bar pressure

The second set of experiments was done for a supply pressure of 5.3 bar and obtained characteristics are shown in figures 8 and 9. Similar to the case of 3 bar supply pressure, in order to do a comparative analysis of the system reaction, the sets of experimental data previously obtained have been incorporated in a Matlab simulation program. Analogous to the situation where supply pressure was 3 bar, the overlap of the two voltages, respectively forces, allowed us to obtain the characteristic shown in figure 10. The data processing showed that for the near assembly of the pressure transducer, maximum force developed (the value at which the signal is stabilized) was 341.6 N, and for the away assembly the force was 349.6 N. Thus, the difference between the two stabilized values is 8 N, but analysing the acquired data files it can be seen that, despite of an off offset circuit, at out of the force transducer, at zero pressure, appears an offset value of 0.08 V, that is equivalent to approximately 8 N.

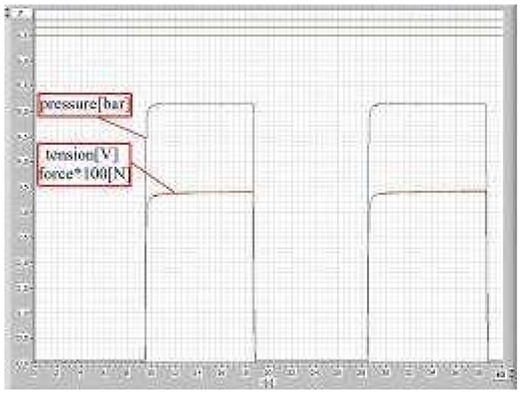

Figure 8. System reaction when pressure transducer is mounted "near" (5 mm) from the muscle

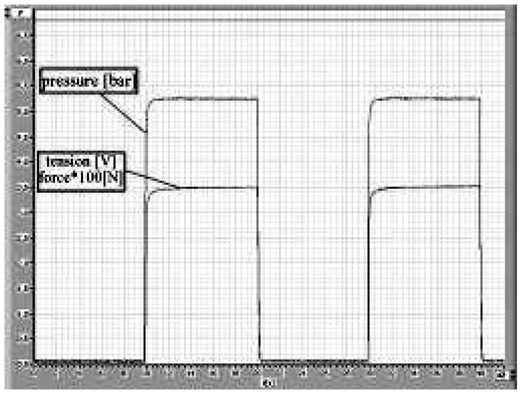

Figure 9. System reaction when pressure transducer is mounted "away" (600 mm) from the muscle

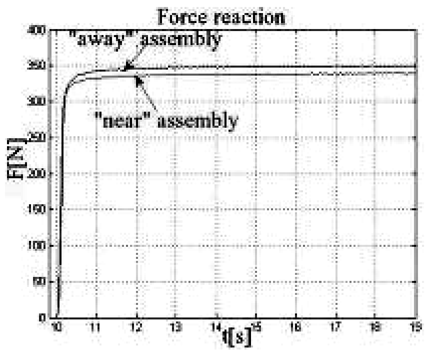

Figure 10. Developed forces at p = 5.3 bar, in "near" and " away" transducer assembly

In these conditions results the fact that the difference between the force in near and away assembly from the muscle is 0 N. The steady-state time (considering it the moment when the system reaches for the first time the stabilized value) for "near" assembly is 0.960 s and for "away" assembly is 0.695 s, resulting a difference of 0.265 s. The time of growth (the range time in which the force values are between 10% and respectively 90% of the steady-state value) is the same in both cases: 0.18 s (figures 11 and 12).

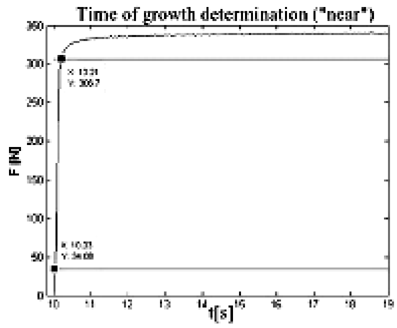

Figure 11. Time of growth for " near" assembly

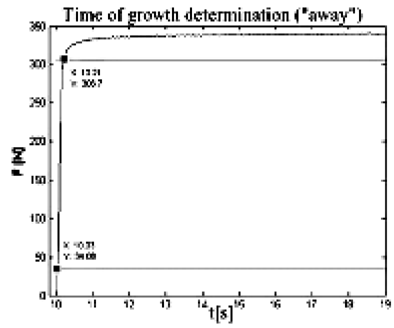

Figure 12. Time of growth for " away" assembly

Analogous to the situation where supply pressure was 3 bar, in terms of pressure reaction, by processing experimental data and their representation, it has been obtained the characteristic shown in fig.13.

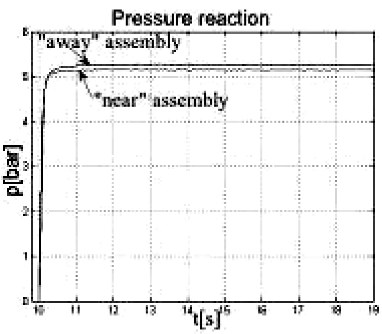

Figure 13. Recorded pressure in " near" and " away" transducer assembly

The attained pressure maximum values were 5.16 bar, for "near" assembly, respectively 5.26 bar, for "away" assembly. The difference between the pressure shown on the electronic display of the transducer and the value recorded by the computer from the same transducer is 0.14 bar and 0.04 bar, respectively, and is justified by analogue-digital conversion error.

4. Conclusions

Experimental determinations performed have concerned the influence of pneumatic components connecting pipe length on the dynamic behaviour of the system. Thus, they were experimentally determined the force and pressure characteristics for a muscle with a length of 98 mm at two different pressures, 3bar and 5.3 bar and for two different positions of the pressure transducer connection: 5 mm ("near") and 600 mm ("away") from the muscle.

According to experiments, data characteristics raised and processed it appeared that: dynamic parameter stabilized force value is not influenced by the position of transducer connection; dynamic parameter steady-state time is different for the two positions, but this difference is 0.108 s for a pressure of 3 bar, respectively, 0.265 s for a pressure of 5.3 bar; dynamic parameter time of growth is the same in both positions of the transducer and for both pressures. In conclusion, in terms of the force characteristics, pressure transducer positioning does not affect the steady-state value of the force and therefore the "near" or " away" assembly of the transducer from the muscle is a one user choice.

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References

1. Daerden, F.: *Conception and Realization of Pleated Pneumatic Artificial Muscles and their Use as Compliant Actuation Elements*. PhD thesis, Vrije Universiteit, Brussels, 1999
2. Deaconescu, T.: *Studies regarding the performance of pneumatic Muscles*. **RECENT** Journal, Vol. 8, Nr. 3a (21a), July, 2007, p. 271 - 276, ISSN 1582-0246, Brasov, Romania
3. Deaconescu, A., Deaconescu, T.: *Pneumatic Muscle Actuated Rotation Module for Rehabilitation Robot*. Proceedings of the 19th International DAAAM Symposium, Trnava, Slovakia, October 2008, ISBN 978-3-901509-68-1, Published by DAAAM International, Vienna, Austria
4. Deaconescu, T., Deaconescu, A.: *Study of a Non-Anthropomorphic Pneumatic Muscle Actuated Gripper*. Proceedings of the 6th International Fluid Power Conference, April, 2008, Dresden, Shaker Verlag
5. Hesse, S.: *The Fluidic Muscle in Application*. Blue Digest on Automation, Available at: http://ortegaalfredo.googlepages.com/BD_MAS_en_150.pdf. Accessed: 2008-10-15
6. Ichim, I.: *Pneumatic Applied To Logistic Systems*. Annals of the Oradea University, Fascicle of Management and Technological Engineering, Volume VI (XVI), May 2007, p. 2282-2289, ISSN 1583-0691, Oradea, Romania