Speed Control of Pneumatic Cylinder by a Microcontroller

György Györök, Margit Makó
Alba Regia University Center
Óbuda University
Budai Str. 45, H-8000 Székesfehérvár
{gyorok.gyorgy, mako.margit}@arek.uni-obuda.hu

***Abstract*—In engineering practice we often use pneumatic cylinders, motors, actuators. Popularity of these instruments is understandable, since fast and clean, isn't an electromagnetic compatibility trouble, and can be used in potentially explosive environments. A disadvantage of undetermined speed of movement can be mentioned, which is coming from the dynamic characteristics of the air is generally difficult to handles.**

In the present paper we present such a solution, which can be achieved by using an embedded micro-controller with a special pulse width modulation control (PWM) which the pneumatic actuators velocity is controllable.

I. Introduction

A conventional pneumatic actuator arrangement is shown in Fig. 1. If the electrically controlled (μ) valve (v) opens, the pressure air (P_{in}) enters the chamber of piston (c) and the plunger moves. Since the air (gas) is compressible so the movement of mechanic (s_t) is enough hectic.

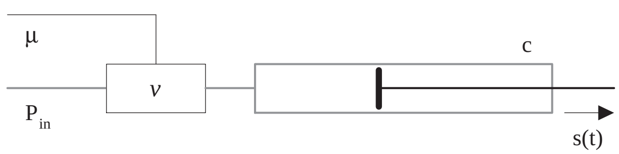

Fig. 1. Conventional pneumatic actuator arrangement.

As the applied gas behavior depends on several physical parameters (σ_g) such as the displacement under given unit time is difficult to determine. The moving of cylinder formally (1) depends on the turned on time of electronic valve (t_{cyl}) and the mechanical load (m_l).

$$s(t) = f(\sigma_g, t_{cyl}, m_l). \tag{1}$$

The motion, the velocity determining the real issue is that the value of (σ_g) also time dependent in such application.

So, if we put on that the gas internal state is constant and the pistons is fixed, we can write the change in pressure in work chamber of cylinder with buffer container (P_c) in equation (2);

$$P_c = P_{in}(1 - e^{-\frac{t}{V_c k_g}}), \tag{2}$$

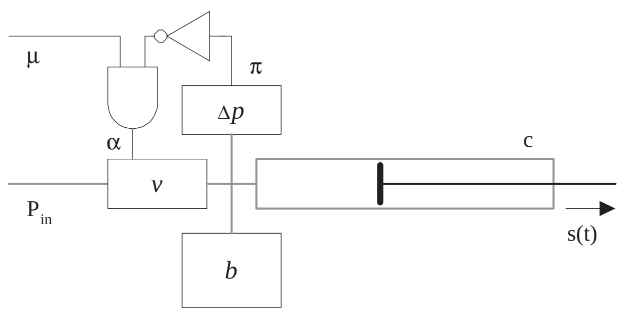

Fig. 2. Pulse width modulation (PWM) regulating with electro-pneumatic feedback.

where; V_c is the volume of work chamber of cylinder, k_g is moving resistance of gas. Solution for time (t) of this equation of course gives only a theoretical result. However, be sure that the piston's position depends on work-chamber's pressure or turned ON of valve.

From equal (1) and (2) follow the (3);

$$s(t) = g(P_c, t), \tag{3}$$

so the actual position of piston depends only the chamber pressure and the time of on operation of valve.

II. Pulse Width Modulation at Pneumatic Systems

Able to handle together the equal (3) P_c and t parameters in a self-regulating electro-pneumatic system (Fig. 2).

On Fig. seen a pneumatic buffer (b), and a pressure sensor (Δp).

Figure 2 arrangement capable of achieving a specific electro-pneumatic feedback method. Electronic turned on the start signal (μ). Cause in the work chamber of cylinder the pressure not enough high so the pressure sensor (Δp) get out LOW binary value (π). Therefore the output of AND gate (α) will HIGHT, because; ($\alpha = \mu \bigwedge \overline{\pi}$), so the valve stayed in OPEN state. When the pressure is enough high value of π will change, and valve will close. The function of b buffer is important, especially when the work camber isn't enough

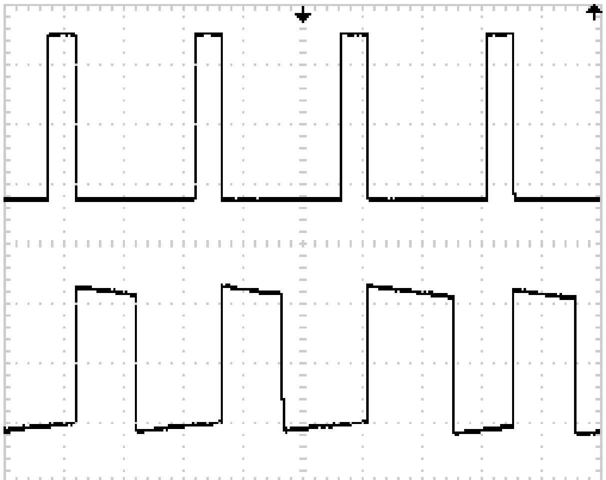

Fig. 3. Time functions of traditional electro-pneumatic PWM system at slow mowing piston, with great load.

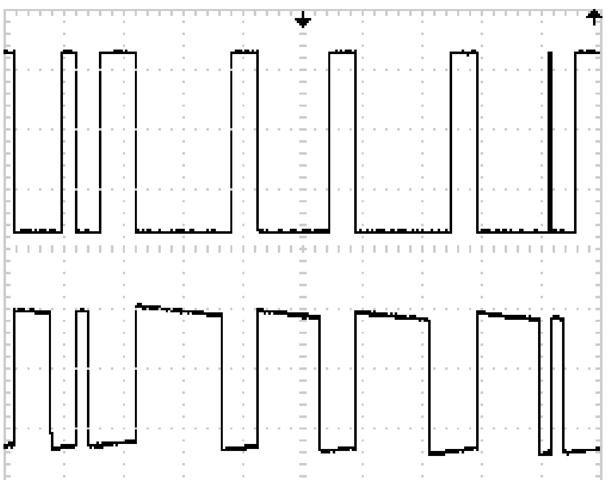

Fig. 4. Time functions of traditional electro-pneumatic PWM system at fast mowing piston, with small load.

big [15] [5]. Actually we make a low pass (LP) filter with pneumatic devices, actually speed of feedback [7] [3].

At using of this solution we get such a pulse with modulation (PWM) system by there repeat frequency depends of frequency of μ, and the duty cycle of α depends of pneumatic-, and other physically environmental parameters. Fig. 3 shows time functions of traditional electro-pneumatic PWM system. On Fig. upper seen the electronic repeat frequency signal (μ), and bottom the valve operation (α) at slow mowing piston [2] [8].

Fig. 4 shows the upper defined down both signals at fast mowing piston, with small load.

III. Pneumatic Speed Control Realization in Microcontroller Environment

The above described system great disadvantage the inflexibility [11] [12]. We can operate only the repeat frequency, volume of buffer, and the manually setting of pressure sensor.

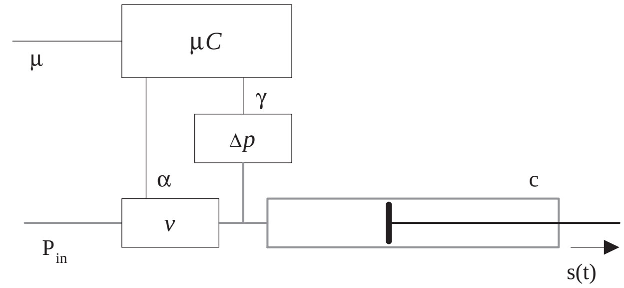

Fig. 5. Pneumatic speed control in microcontroller environment.

Last one means with a screwdriver before the using passible the setting of the pressure value of the sensor switch, or in luckier case with a pre configuration procedure [17] [18] [20] [19].

On Fig. 5 we suggest a new flexibility arrangement for realization of PWM at pneumatic system [4] [6] [16].

In this case pressure sensor (Δp) a such a type so where the output voltage (U_γ) depends the current pressure (P_c) as describes in equal (4);

$$U_\gamma = U_0 + kP_c, \tag{4}$$

where; U_0 a constant voltage, k is a transfer function of pressure sensor.

U_γ connect to analog-digital converter type, even a comparator input of microcontroller [9] [10]. At this arrangenment we have a ability to change the buffer function (b) of Fig. 2 an algorithmic denouement. So we can modify the necessaries software parameters of pulse width modulation's; repeat frequency (f_{PWM}) and the fastness of feedback (t_{FB}) according equal (5);

$$t_{FB} = \mathscr{A}_2, \tag{5}$$

depends of $\mathscr{A}_1$ algorithmically parameter.

So formally describe (6);

$$\alpha = g(\mathscr{A}_1(U_\gamma), \mathscr{A}_2, \mathscr{A}_3) \tag{6}$$

the valve control depends only one physical parameter, the output of pressure sensor (U_γ), and three algorithmically variables; $\mathscr{A}_1, \mathscr{A}_2, \mathscr{A}_3$. The $\mathscr{A}_1$ parameter is value of pressure depends voltage output (U_γ) of sensor.

Very easy to change the appropriate level setting for the necessaries characteristic to setting [13] [14] [1] .

From equal (6) we get (7) for average valve operation voltage;

$$v_a(t) = f_{PWM} \int_0^t ((\mathscr{A}_1(U_\gamma(t)), \mathscr{A}_2, \mathscr{A}_3))dt, \tag{7}$$

where upper integral limit t is (8);

$$t = \frac{1}{f_{PWM}}. \quad (8)$$

The proposed flowchart of algorithm is seen on Fig. 6.

Of course, the microprocessor is not use to its full possibilities of to implement the proposed algorithm. So that the above mentioned three parameters even a procedures calculated, or read a look up table (LOT) as well [21] [23] [22] .

On Figures 7-9 are seen the three different behavior of pneumatic cylinder according of figures upper μ signal, and valve driving function (α) bottom in figures.

IV. Conclusions

The proposed process control scheme is reached at which the piston travel speed range can be large.

To do this we need to change the three parameters, depending on the physical characteristics.

Further work is an autonomous, predictive-like load measurement on proposed arrangement by the dynamically behavior of moving parts, the function of the velocity can be immediately intervene.

The experimental devices are shown in Fig. 10.

References

[1] N. Ádám. Single input operators of the df kpi system. *Acta Polytechnica Hungarica*, 7(1):73–86, 2010.

[2] Gy. Györök, M. Makó. Configuration of EEG input-unit by electric circuit evolution. pages 1–7, September 2005.

[3] Gy. Györök, M. Makó, J. Lakner. Combinatorics at electronic circuit realization in FPAA. *Acta Polytechnica Hungarica, Journal of Applied Sciences*, 6(1):151–160, 2009.

[4] Gy. Györök. The function-controlled input for the IN CIRCUIT equipment. pages 443–446, September 2006.

[5] Gy. Györök. Self configuration analog circuit by FPAA. pages 34–37, January 2006.

[6] Gy. Györök. Self organizing analogue circuit by monte carlo method. pages 34–37, September 2007.

[7] Gy. Györök. A-class amplifier with FPAA as a predictive supply voltage control. pages 361–368, November 2008.

[8] Gy. Györök. The FPAA realization of analog robust electronic circuit. pages 1–5, November 2009.

[9] J. Kopják. Dynamic analysis of distributed control network based on event driven software gates. *IEEE 11th International Symposium on Intelligent Systems and Informatics, Subotica, Serbia*, ISBN: 978-1-4673-4751-8:p. 293–297, 2013.

[10] J. Kopják and J. Kovács. Implementation of event driven software gates for combinational logic networks. *IEEE 10th Jubilee International Symposium on Intelligent Systems and Informatics, Subotica, Serbia*, ISBN: 978-1-4673-4751-8:p. 299–304, 2012.

[11] K. Lamár. A világ leggyorsabb mikrovezérlöje. *ChipCAD Kft.*, page 96, January 1999.

[12] K. Lamár and Veszprémi K. A mikroszámítógépek térnyerése a villamos hajtások szabályozásában. *Proceedings of the Kandó Conference 2002, Budapest, Hungary*, pages 1–7, January 2002.

[13] L. Madarász and Zivcak J. Aspects of computational intelligence: Theory and applications. *Revised and Selected Papers of the 15th IEEE International Conference on Intelligent Engineering Systems 2011, Springer-Verlag , Berlin Heidelberg*, ISBN 978-3-642-30667-9:p. 436, 2011.

[14] L. Madarász and Fözö R. Intelligent technologies in modelling and control of turbojet engines. *New Trends in Technologies : Control, Management, Computational Intellingence and Network Systems, Rijeka, Croatia*, ISBN 978-953-307-213-5:p. 17–38, 2011.

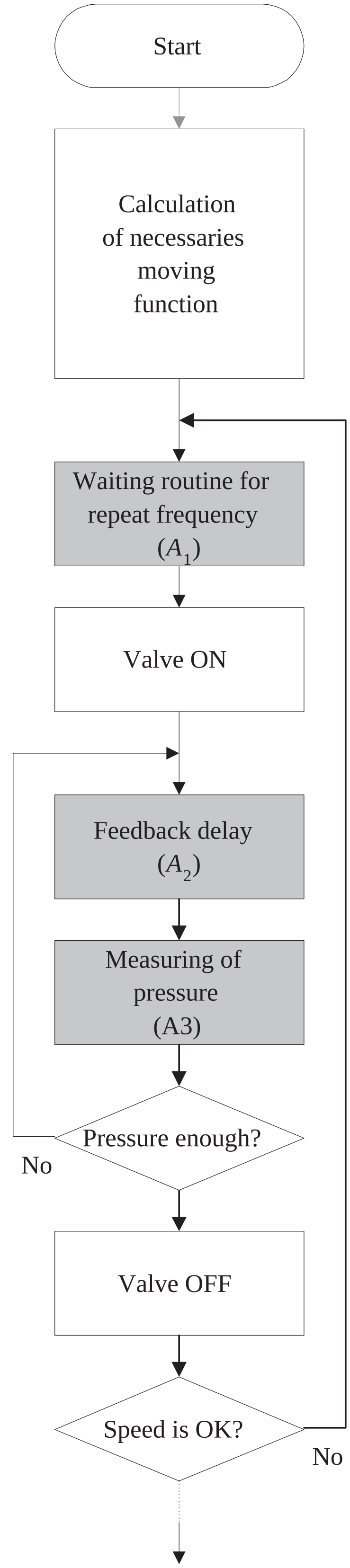

Fig. 6. Flowchart of microcontroller's PWM programm.

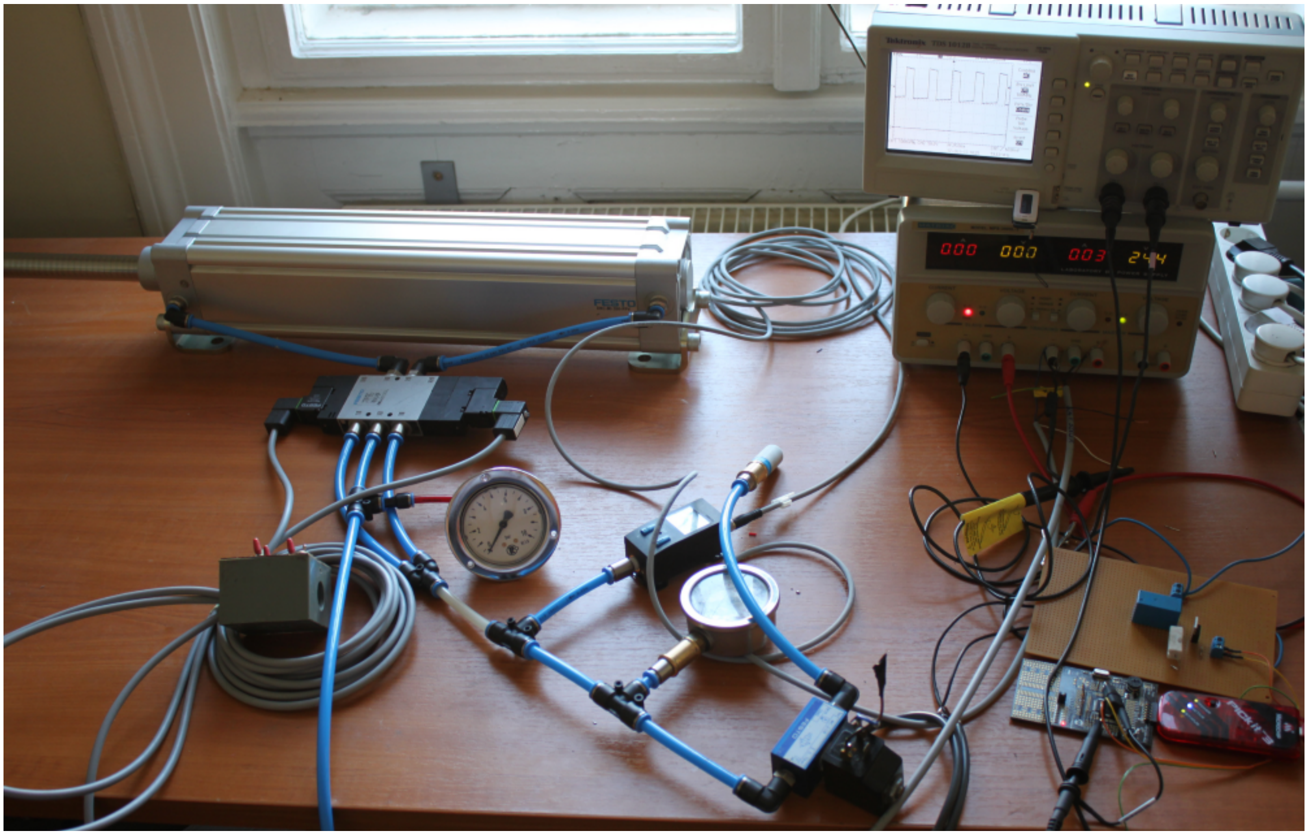

Fig. 10. Experimental arrangement of pneumatic cylinder on a desk.

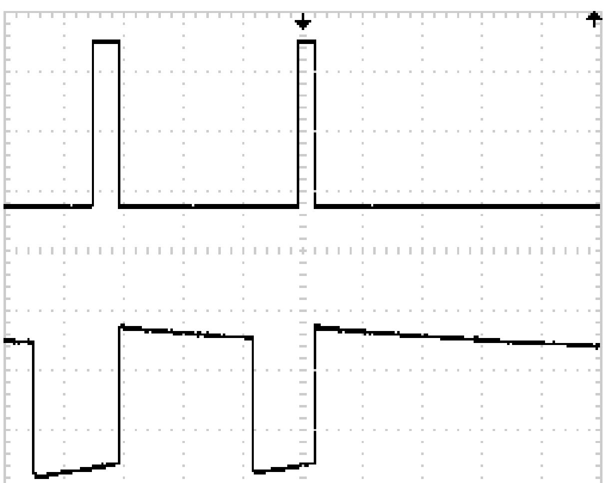

Fig. 7. Slow moving piston at small lasting.

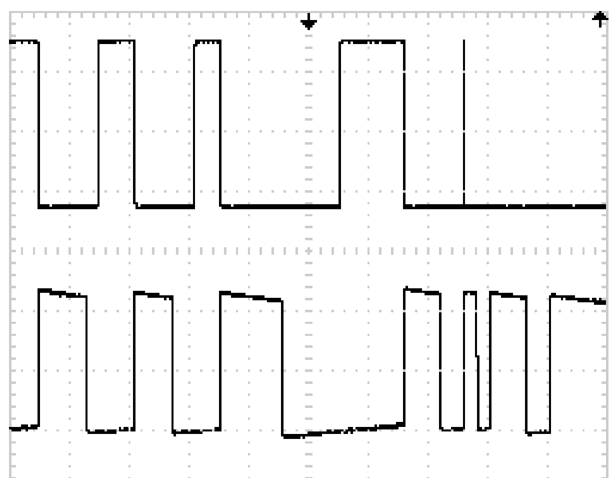

Fig. 8. Slow moving piston at big lasting.

[15] A. Pilat and J. Klocek. Programmable analog hard real-time controller [programowalny sterownik analogowy]. *Przeglad Elektrotechniczny*, 89(3 A):38–46, 2013. cited By (since 1996) 0.

[16] Adam Pilat. Control toolbox for industrial programmable analog controllerembedding state feedback controller. pages 1–4, 2012.

[17] S. Sergyán. Edge detection techniques of thermal images. *2012 IEEE 10th Jubilee International Symposium on Intelligent Systems and Informatics, SISY 2012*, pages 227–231, 2012.

[18] S. Sergyán. Useful and effective feature descriptors in content-based image retrieval of thermal images. *LINDI 2012 - 4th IEEE International Symposium on Logistics and Industrial Informatics, Proceedings*, pages 55–58, 2012.

[19] J. Tick. User interface redesign based on user behavior analyses. pages 29–31, October 2003.

[20] J. Tick. *Potential Application of P-Graph-Based Workflow in Logistics*. Aspects of Computational Intelligence: Theory and Applications: Revised and Selected Papers of the 15th IEEE International Conference on Intelligent Engineering Systems 2011, pp. 293-303, Springer Verlag, 2012, Heidelberg; London; New York, 2012.

[21] J. Tick. Business process-based initial modeling at software develop-

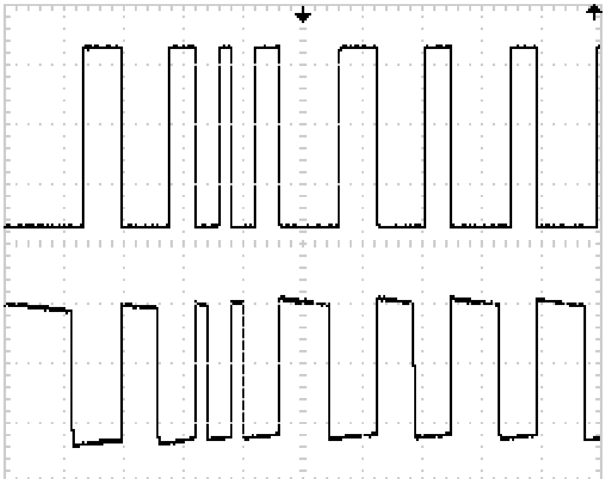

Fig. 9. Quick moving piston at small lasting.

ment. pages 141–144, January 2013.

[22] Z. Vámossy. Thermal image fusion. *2012 IEEE 10th Jubilee International Symposium on Intelligent Systems and Informatics, SISY 2012*, pages 385–388, 2012.

[23] L. Vokorokos, N. Ádám, and B. Madol. The process control for p-single operators. *19th International Workshop on Robotics in Alpe-Adria-Danube Region, RAAD 2010 - Proceedings*, pages 119–123, 2010.