Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
Annals of DAAAM International

STUDIES ON SIZING THE COIL SPRINGS GAS REGULATORS TO OPTIMIZE THE AMPLIFICATION COEFFICIENT

TUTA, A[delin] I[onel]; VELA, I[on] & TUFOI, M[arius]

Abstract: *This paper presents a method for sizing helically compression springs used in gas regulators using finite element method. The study aims to optimize the system dynamic operation of gas regulators. Using finite element method is very useful here, because starting from experimental data on a stand measurement and calibration, data are determined by series regulators, by using CAD techniques (Computer Aided Design) and CAE (Computer Aided Engineering) can optimize the coil springs of these regulators. To do this, use the laws of similarity and extrapolation methods. It made such significant savings in time, materials and experimental measurements for new prototypes of gas regulators. Optimizing the composition of helically springs gas regulators need to reduce vibration and noise occurring during operation and reducing the time constant of the actuator that are used in gas regulators. Also aims to increase the amplification factor controller.*
Key words: *regulators, CAD, CAE, simulation, FEM*

1. INTRODUCTION

Natural gas pressure regulators are devices of great importance in gas transport and distribution. Their main role is to monitor and maintain the optimum parameters, pressurized gas traveling over the transmission and distribution network. On entering the city, industrial or other beneficiaries and end users, regulators are those that serve to decrease the pressure of gas transport to the distribution conditions, specifically to the recruitment pressure distribution parameters. The figure 1 show constructive schemes for gas pressure regulators (Vintila et al., 1995.

A pressure regulator includes a number of basic components:
- A mechanism for charge entry;
- A sensory component type;
- A control mechanism.

All these components work as a whole in the controller, to obtain reduced pressure. Figure 2 presents a natural gas pressure regulator.

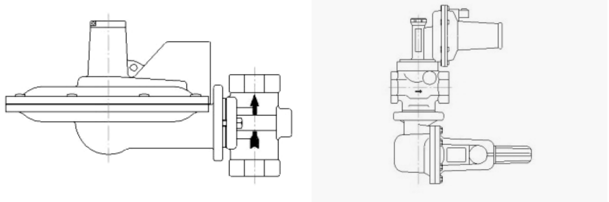

Fig. 1. Pressure regulators for natural gas

2. OPTIMIZING AMPLIFICATION FACTOR TO PRESSURE REGULATORS

Pressure regulators are part of the automatic pressure control in closed circuit, figure 3.

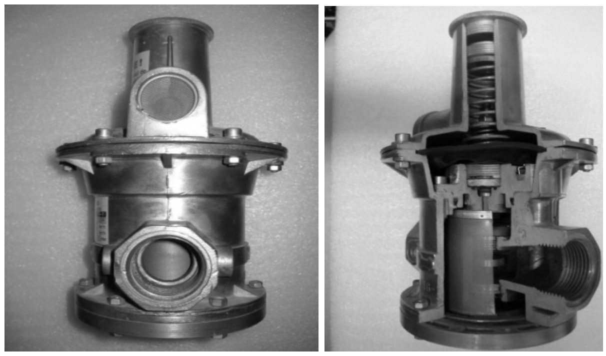

Fig. 2. Pressure regulator for natural gas

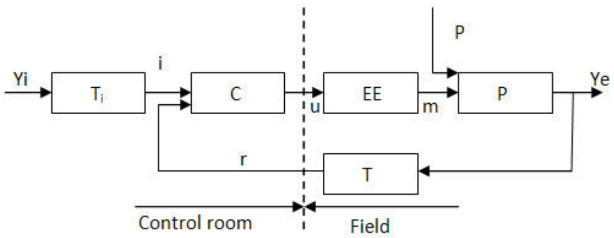

Fig. 3. Pressure control system

where: P is process; C- regulator; EE- actuator; T- transducer; T_i- input transducer;Y_e-size output; Yi-prescribed value for y r-size of the reaction; i - input size; u-control; m-size of execution; p-disturbance. Automatic pressure control system of figure 3 is aimed to maintain the value of output size, Y_e, of process, equal or closer to the desired value, prescribed $Y_e \pm \Delta Y_e$ under the action of disturbances "p". Random variations in time leading to differences Y_e-Y_i in system, through variables "i" and "r" respectively "i-r" violations are processed by the controller C, which generates command "u", on the actuator EE. Actuators under control action "u" change size of drive "m" until deviations are eliminated from the system.

3. AMPLIFICATION COEFFICIENT CALCULATION. APPLICATION NUMBER

For a helically spring actuator S300 in which Rm = 35mm, d = 14mm, n = 10, number of turns. Amplification coefficient b is calculated from equation (1)

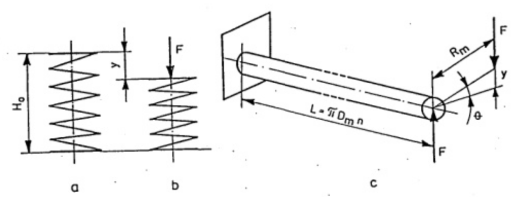

Fig. 4. Helically spring deflection

$$y = R_m \frac{M_t L}{G I_p} = \frac{R_m \cdot F R_m \cdot \pi D_m n}{G \cdot \left(\pi d^4\right)/32} = \frac{8 n D_m^3}{G d^4} \cdot F = bF \quad (1)$$

and then bow arrows, for different values of force developed on command membrane by control pressure P_c.

Solution: using for the transverse elasticity modulus the value G = 8.1 x10^5daN/cm^2= 0.81 x 10^{11}N/m^2 is calculated directly:

$$b = \frac{64 n R_m^3}{G d^4} = \frac{64 \times 10 \times 0{,}035^3}{0{,}81 \times 10^{11} \times 0{,}014^4} = 0{,}882 \times 10^{-5} \left[\frac{m}{N}\right] \quad (2)$$

The arc arrow under the action of force F=353daN

$$y = b \times F = 0{,}882 \times 10^{-5} \times 3530 = 0{,}0311m = 31{,}10mm \quad (3)$$

The arc arrows under the action of various values of developed force on the P_C control membrane, are:

$$Pc = 0{,}2bar\,; F_{PC} = 141\,daN \text{ (prestressed arc);}$$

$$H_1 = 0{,}882 \times 10^{-5} \times 1410 = 0{,}01244m = 12{,}44mm \quad (4)$$

$$Pc = 0{,}4bar\,; F_{PC} = 282\,daN$$

$$H_2 = 0{,}882 \times 10^{-5} \times 2820 = 0{,}02487\,m = 24{,}87\,mm$$

$$Pc = 1bar, F_{PC} = 706daN$$

$$H_3 = 0{,}882 \times 10^{-5} \times 7060 = 0{,}0623\,m = 62{,}3mm$$

Actual value (useful), of the servo-drive stroke is so:

$$H_{100} = H_3 - H_1 = 62{,}3 - 12{,}4 = 49{,}9mm \approx 50mm, \quad (5)$$

is current value for actuator S300.

4. COIL SPRINGS DESIGN AND SIMULATION USING CAD AND CAE

In order to optimize the coil spring pressure regulators, was designed by CAD methods, the controller of Chapter 3. Then, simulations were performed by applying the finite element method (Patrascu et al., 2009) determining the values of stress, elongations and travel arising to helically spring, under the action of forces caused by movement of elastic membranes. They compared the values obtained previously by experimental measurements with those obtained by simulation and found that these values are very close. This validates the simulated model that respects the values experimentally obtained, figure 5.

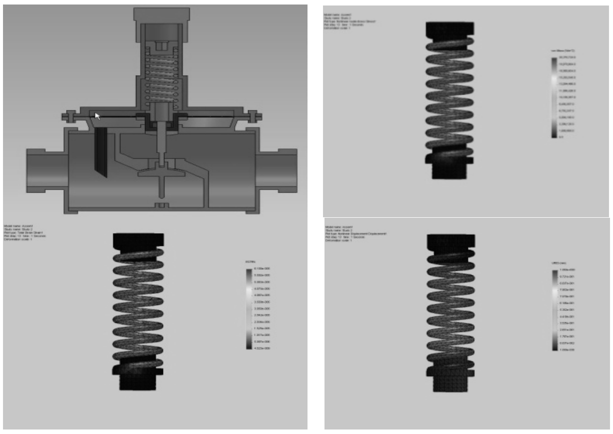

Fig. 5. Simulated model, stress, strain and displacement value for normal helically spring

To optimize the amplification factor of gas regulators by proper sizing of coil springs from their composition, proceed as follows: going from the simulated and validated model by experimental measurements (Berce et al., 2000), it change constructive shape and sizes of the spring design. Then, on these modified springs were applied for the same applications

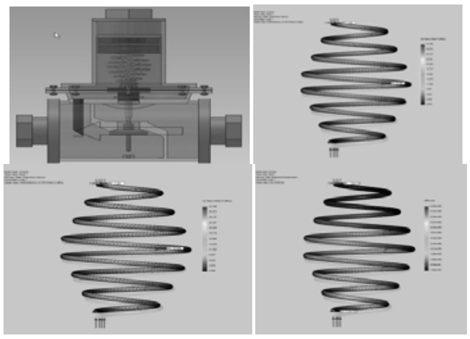

Fig. 6. Simulated model, stress, strain and displacement value for modified helically spring

as the original arc, unchanged. Stress values were determined, of strain and displacement and it is noted that in case of an arc diameter turns, ascending from the ends and has a maximum in the middle of the arc it is obtain a larger displacement of control rod. Thus the amplification factor grows without appearing critical values of stress or arc strain, figures 6.

5. CONCLUSIONS

Optimization of gas pressure regulators, is necessary to increase the pressure range of input / output and of the flows for the same type of controller. Studies done by the authors, lead to the following conclusions:

- Use of CAD and CAE techniques to optimize pressure regulators reduce design time, the number of experimental tests necessary to implement in industrial practice;
- Studies using finite element method (SolidWorks 2009 software) on sizing the helically springs gas regulators ensure a judicious design, offering the possibility of a complex static and dynamic analysis, of a spring operation at different pressures on the control membrane

Future research will focus on optimizing control membrane regulators to reduce their surface for the same controlled pressure by regulator.

6. ACKNOWLEDGEMENTS

The work has been funded by the Sectorial Operational Programme Human Resources Development 2007-2013 of the Romanian Ministry of Labour, Family and Social Protection through the Financial Agreement POSDRU/6/1.5/S/16.

7. REFERENCES

Berce P., Ancau M., Caizar C., Balc N., Comsa S., Jidav H. (2000). *Rapid prototyping manufacturing,* Technical Publishing House, Bucharest

Canau S. (2009). FEM analysis of spur gear systems with misalignment, *Proceedings of DAAAM 2009,* Katalinic, B. (Ed.), pp. 261-262, ISSN: 1726-9679, Austria, November 2009, Vienna

Patrascu G., Carutasu N.L., Dragomirescu C.G. (2009). 3D tool wear simulation for turning process, *Proceedings of DAAAM 2009,* Katalinic, B. (Ed.), pp. 663-664, ISSN: 1726-9679, Austria, November 2009, Vienna

Vintilă Șt., Cruceru T., Onciu L., *Plumbing and gas installations*, Didactic and Pedagogic Publishing House, Bucharest, 1995

*** (2010) http://www.solidworks.com/sw/support/808_ENU_HTML.htm, SolidWorks Simulation Professional *Accessed on: 2010-07-10*