ACTA TECHNICA CORVINIENSIS
– Bulletin of Engineering
Tome IX [2016], Fascicule 4 [October – December]
ISSN: 2067 – 3809

[1.]Gheorghe NEGRU

RESEARCH ON NUMERICAL SIMULATION APLICABLE TO THE PRESSURE RELIEF VALVE ON THE BORE GAS EVACUATION DEVICE

[1.] Military Equipment and Technologies Research Agency, Bucharest, ROMANIA

Abstract: The paper presents the research approach on the numerical simulation applicable to pressure relief valve on the bore gas evacuation device embedded on the high pressure barrels with special destinations. The numerical simulations were conducted in order to asses the behavior of the components elements of the pressure relief valve belonging to bore gas evacuation device. Consequently the present research could contribute at the problem of solving of an increased number of requirements with reduced resources in terms of functioning assessment of high pressure barrels with special destinations.
Keywords: High pressure barrels, bore gas evacuation and pressure relief valve

INTRODUCTION

The bore gas evacuation device enables the evacuation of the gas from the high pressure barrel channel in the bore gas reservoir. After a short period of time the gas stocked in the reservoir will be ejected in the atmosphere in the direction of the muzzle barrel. [6]

Consequently the quantity of the burned gas from the interior of the special destination vehicles will be decreased.

The interior of the bore gas evacuation communicate with the high pressure barrel channel through different dedicated holes drilled in the barrel. [7].

A salient factor in the bore gas evacuation device functioning is represented by the pressure relief valve. The pressure relief valve controls the gas admission from the barrel channel within the bore gas reservoir.

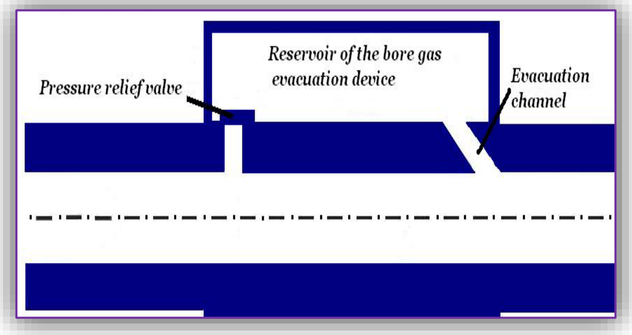

Figure 1. A schematic view of an bore gas evacuation device

EXPERIMENTAL AND NUMERICAL MODEL

The functioning of the bore gas evacuator depends on the proper functioning of the pressure relief valve. The pressure relief valve could have different technical constructive solutions.

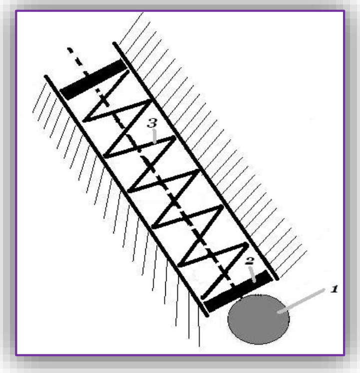

Figure 2. A schematic view of the pressure relief valve

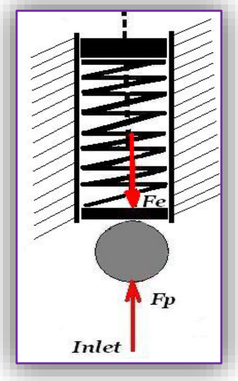

Figure 3. A schematic view of the pressure relief valve dynamic

For the current research the main components of the pressure relief valve, taken into consideration, are presented in Figure 2. Thus was taken into consideration a pressure relief valve which consists in 1-ball, 2-plunger rod, 3-elastic damping elements.

The equation of the motion of the pressure relief valve mobile mass according to the D'Alambert principle is:

$$F_p = F_e + m\ddot{y} + F_d + mg \qquad (1)$$

The mobile mass of the pressure relief valve include the mass of the ball, plunger rod and of the elastic damping elements.

The force induced by the gas pressure at the admission of the gas inside the reservoir of the bore gas evacuation device is computed with

$$F_p = Ap(t) \qquad (2)$$

where *A* represent the area of the admission gas hole and p(t) represent the variation of the pressure inside of the channel barrel. The variation of the pressure p(t) is computed according to the provisions of the dedicated technical literature books. [3]

The force which is opposed at the movement depends on the velocity the plunger rod and is computed with

$$F_p = k_d \dot{y} \qquad (3)$$

The critical damping coefficient [4] is computed with

$$k_{dc} = \sqrt{4mk_e} \qquad (4)$$

The damping ratio [4] is computed with

$$\delta = \frac{k_d}{k_{dc}} \qquad (5)$$

The restoring force of the elastic damping elements is computed with

$$F_p = k_e y \qquad (6)$$

In order to asses the functioning of the pressure relif valve of the bore gas evacuation device was computed a dynamic simulation within the SYMULINK dedicated software.

CASE STUDY

Input data

The integration scheme of the functioning ecuation of the pressure relief valve according to the SYMULINK notations is presented in Figure 4.

The simulation of the functioning of the pressure relief valve was conducted with the inlet force depicted in Figure 5. The signal of the inlet force is applied for a extermely short period of time up to 0.1 seconds. In this manner is emphasised the particular behavior of the gazodinamic phenomenon in the admission area of the gas within the bore gas evacuation device. Input data are: inlet force, mass of the ball, plunger rod and of the elastic damping elements, elastic coefficient k_e.

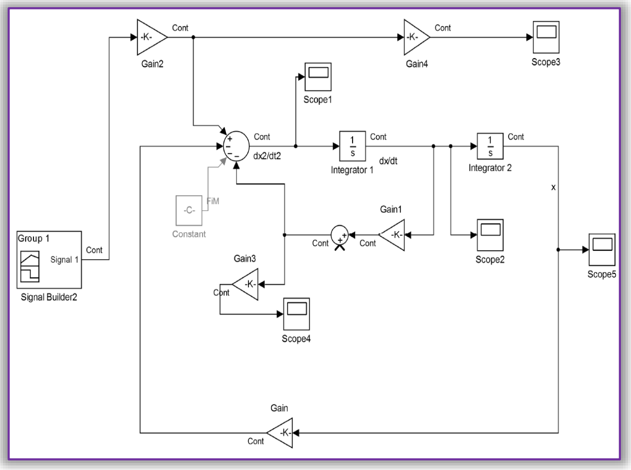

Figure 4. SYMULINK diagram

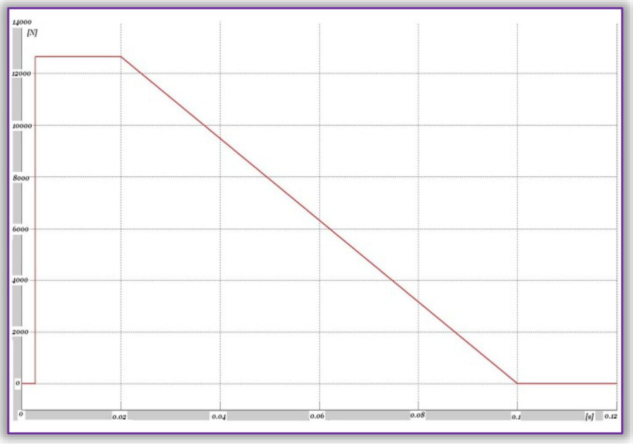
Figure 5. The force applied on the ball of the bore gas evacuation device

Output data

Based on the input data was computed the critical damping coefficient k_{dc} and where plotted the diagrams of movement, velocity and acceleration of the ball-plunger rod assembly. (Figure 6, Figure 7 and Figure 8)

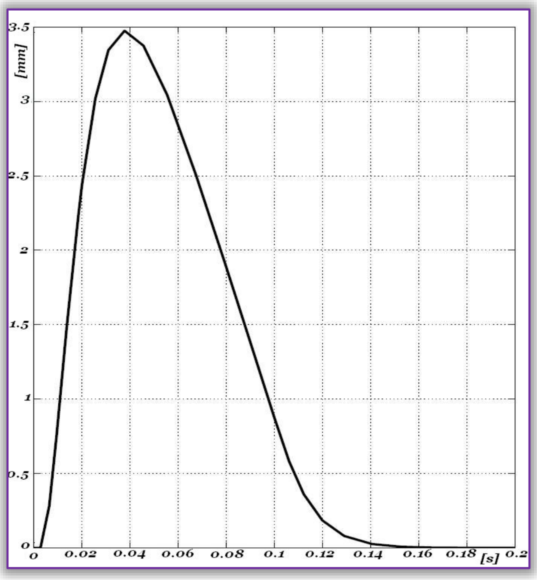

Figure 6. Ball-Plunger rod movement

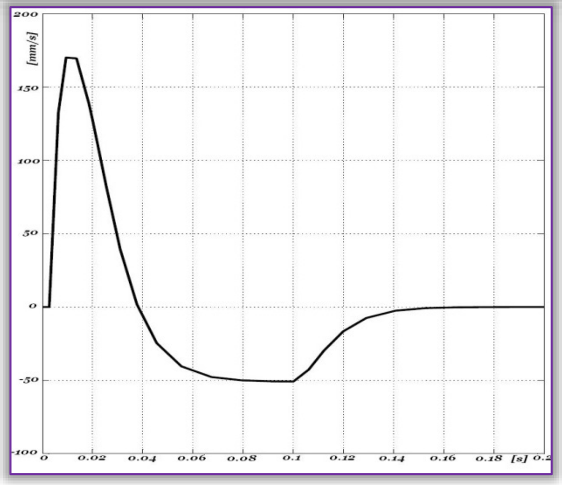

Figure 7. Ball-Plunger rod-velocity

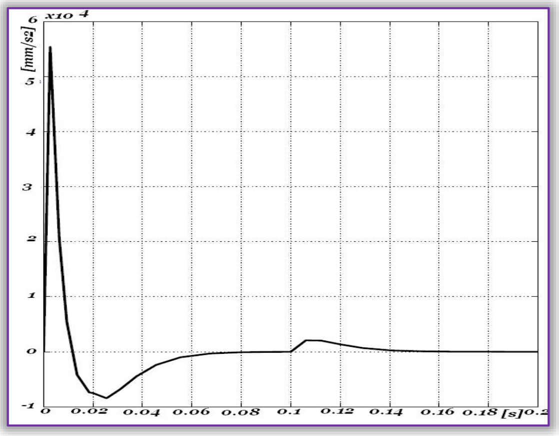

Figure 8. Ball-Plunger rod acceleration

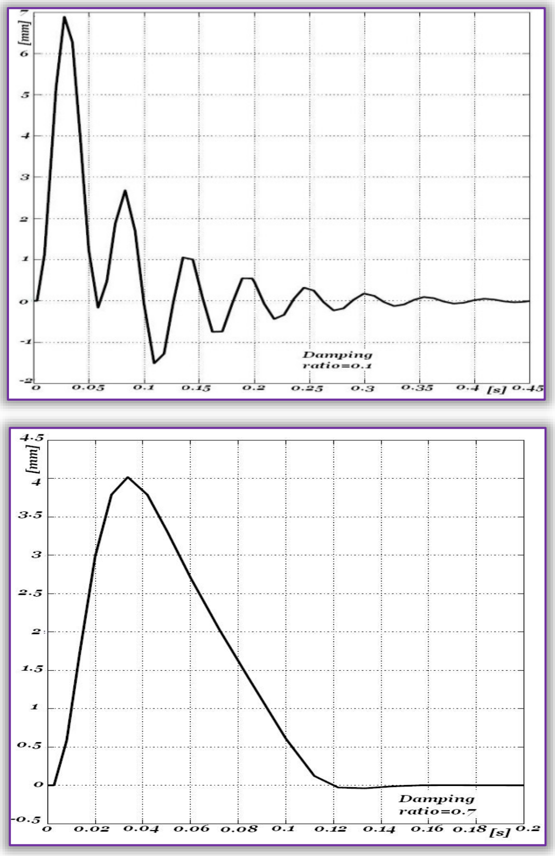

Figure 9. Ball-Plunger rod movement

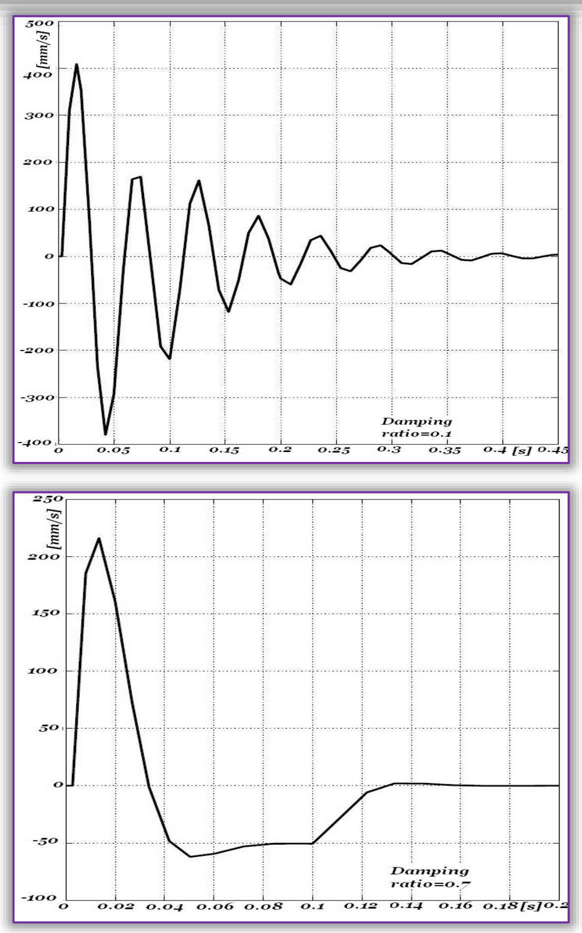

Figure 10. Ball-Plunger rod-velocity

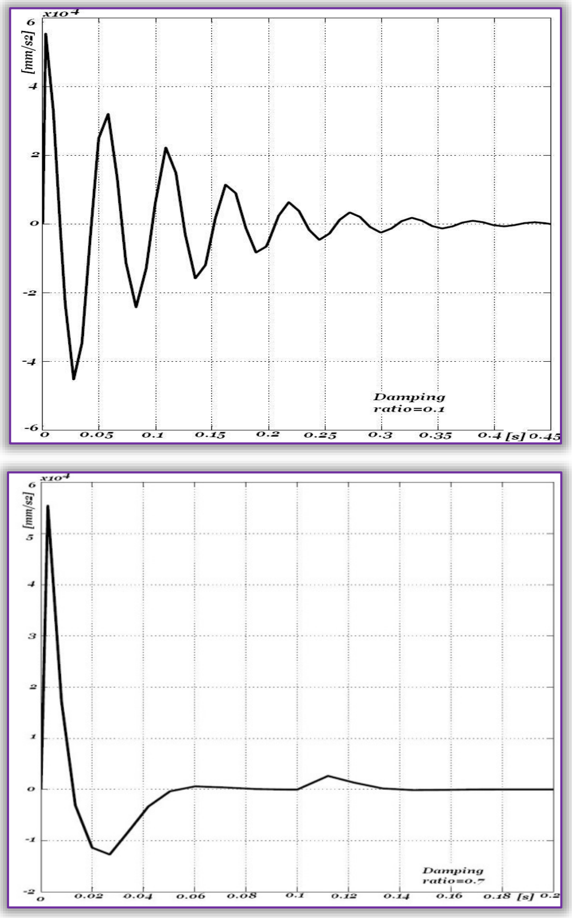

Figure 11. Ball-Plunger rod acceleration

To assess the behavior of the ball-plunger rod assembly where conducted numerical simulations in the variants with damping ratio values 0.1 and 0.7. For the before mentioned values of the damping ratio where computed the corresponding values of the actual damping coefficient. With these values as input data for the SYMULINK calculus where plotted the diagrams of the movement, velocity and acceleration (Figure 9, Figure 10, Figure 11).

The obtained diagrams present the possible options for the functioning of the components elements of the pressure relief valve. Thus in principle could be defined the followings approaches:

» mechanical elements with damped movement in a period of time up to 0.45 seconds
» mechanical elements with fast damped movement in a period of time up to 0.14 seconds
» In the context of the high pressure barrels with special destination the numerical dynamic simulation has a couple of advantages:
» the costs to identify a proper technical solution for the pressure relief valve are decreased. In this context is to emphasize that a real test for a bore gas evacuation device is expensive.
» the behavior of the components elements of the pressure relief valve is assessed also in the case with a high value of the friction coefficient. This is equivalent with the dissipation of enhanced quantity of heat due the functioning of the pressure relief valve. At this phenomenon is added also the heat induced by the intense thermodynamic regime within the inlet zone of the bore evacuation device.
» assessment of the behavior of the components of the pressure relief valve enable the establishment of their optimal technical solution.
» the value of the ball-plunger rod movement enable the design of the pressure relief valve in term of its size.

CONCLUSIONS

The proposed model can contribute at the assessment of the functioning behavior of the bore gas evacuation device embedded on the high pressure barrels.

The results of the numerical simulation emphasizes the achievements of the presented method as follows:

» the depiction, through the mechanical theory equations, of the behavior of the pressure relief valve belonging to the bore gas evacuation device is a genuine approach in the field of the high pressure barrels with special destination;
» the method enable to be established a data base in terms of assessment of the dynamic behavior of the elements components belonging to the bore gas evacuation device;
» the method contribute to a proper design of the bore gas evacuation device through parameters like movement, velocity or acceleration of the ball-plunger rod assembly;
» the future research work can be focused on a thorough evaluation of the thermal effect on the reliability and dynamic behavior of the pressure relief valve.

References

[1.] Control valve handbook, Fourth Edition, Fisher Controls International LLC, 2005
[2.] Crosby Pressure Relief Valve Engineering Handbook, Technical Document No. TP-V300 Effective: May 1997
[3.] Petrisor E, Titica V, Interior ballistic, Military Publishing House, Bucuresti, 1975
[4.] Graham s. K, PhD, Schaum's outline of Theory and problems of Mechanical vibrations, McGraw Hill, ISBN 0-07-034041-2, 1996
[5.] Xue G. S., Ji H. J., Hyeong S. L., Dong K.K., Young C. P., 2 D Dynamic analysis of a pressure relief valve by CFD, Proceedings of the 9th WSEAS International Conference on Applied Computer and Applied Computational Science
[6.] SMT 40035/1991, Specialised standard
[7.] Carlucci D.E, Jacobson S., Ballistics: Theory and Design of Guns and Ammunition, Second Edition, CRC Press, August 26, 2013
[8.] Stefanski F., Nowak A., Minorowicz B., Pneumatic single flapper nozzle valve driven by piezoelectric tube, Poznan University of Technology, Division of mechatronics devices, 2015
[9.] Adadande A.S, Naniwadekar A.M, Patil R.B, Reliability Analysis of Pressure Relief Valve Manufacturing System, International Journal of Emerging Engineering Research and Technology Volume. 2, Issue 2, PP 64-70, May 2014
[10.] Saha B.K, Numerical Simulation of a Pressure Regulated Valve to Find Out the Characteristics of Passive Control Circuit, International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:7, No:5, 2013

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809