Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 150 (2016) 260 – 265

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering, ICIE 2016

Method for Determining of the Valve Cavitation Characteristics

I.R. Chinyaev, A.V. Fominykh, E.A. Pochivalov*

OOO NPF «MKT-ASDM», Naberezhnayaul., 2A, Kurgan, 640000, The Russian Federation

Abstract

Reliable and safe operation of piping systems depends on the cavitation processes occurring in its environment. Based on the analysis of cavitation processes' studies, the existing methods of cavitation characteristics' determination and experience in the use of GOST R 55508-2013 the authors proposed a method of experimental determination of the cavitation coefficient and developed the technique of experimental data processing when determining these coefficients. Based on the experimental data, the authors make conclusions about the influence of pressure before and after the tested valve and the differential pressure flow on the bandwidth characteristic and cavitation characteristic of valves.

Peer-review under responsibility of the organizing committee of ICIE 2016

*Keywords:*cell valve; the method of determining; cavitation characteristics.

1. Introduction

Cell valves are widely used because of the advantages: the opportunity to get any throughput characteristic by location and size of the holes in the cage, balanced plug, anti-cavitation properties.

2. The relevance

Reliable and safe operation of piping systems depends on the cavitation processes occurring in its environment. Requirements to accuracy of regulation of flows increase due to development of automated control systems of techno-logical processes. Research questions and establish patterns of movement of liquid in the valves and fluid interaction with a gate node for the purpose of de-termination of rational values of design parameters of the valves

---

* Corresponding author. Tel.: +8-3522-65-50-18.
E-mail address: poshivalov_79@mail.ru

Peer-review under responsibility of the organizing committee of ICIE 2016
doi:10.1016/j.proeng.2016.06.759

to improve the control accuracy of the service environment and avoid damage to the parts of the valve in the stroke range of the plunger is important.

3. Statement of the problem

Based on the analysis of existing methods of determining cavitation characteristics and experience in the use of GOST R 55508-2013 to develop proposals for improving methods of experimental determination of the cavita-tion coefficient and the coefficient critical pressure valves and to develop a data processing procedure in the determination of these coefficients. To determine the influence of pressure before the valve, after the valve and the differential pressure at the hydraulic and cavitation characteristics of the valve.

4. The theoretical part

In the process of solving the tasks performed by the authors analysis of studies of cavitation processes [1-7], methods for determining the cavitation characteristics of pipeline valves [8-12]. Developed samples of pipe fittings with improved characteristics [13-17]. Performed calculation and experimental studies [18-21]. Production tests showed increasing the service life significantly [22]. Developed the design documentation and manufactured two prototypes of the cell valve DN 50 PN 160 [23-27]. In accordance with GOST R 55508-2013 [8] defined the hydraulic characteristics of cell valve DN50 PN160 in the laboratory of OOO NPF «MKT-ASDM».

When the experimental determination of GOST R 55508-2013 [8] cavitation characteristics of the valve of the cell 189 is made of measurements of the operation of the plunger 48 and the measurements when the water flow under the plunger. In this case, the Reynolds number was varied from 10000 to 500000. The cavitation characteristics were determined at the minimum possible pressure value, P_2 is equal to 124630...202650 Pa (absolute). The pressure drop ΔP rises due to the increase in pressure P_1. According to the method GOST R 55508-2013 failed to determine the beginning of the deviation of flow characteristics $Q = f(\sqrt{\Delta P})$ from linear dependence in the entire stroke range of the plunger. In this case, through the transparent glass in the pipeline after the valve was observed for two-phase fluid (gas bubbles and liquid).

Based on the analysis of existing methods of determining cavitation characteristics [9-12] and experience [8] proposed the method of experimental determination of the cavitation coefficient and the coefficient critical pressure according to numbers of paragraphs GOST R 55508-2013[8]:

8.2.3 Set the value to RA pressure P_1 = 1,1 MPa (absolute).

8.2.4 Set the pressure value P_2 after RA 0,2 MPa less than P_1.

8.2.5 To measure water flow rate Q, temperature t, pressure at the inlet P_1 and outlet pressure P_2.

8.2.6 Armature of the stand to maintain the pressure P_1 constant, and the pressure P_2 be reduced to values 0,7; 0,6; 0,5; 0,4; 0,30; 0,20; 0,15 MPa and P_2 low, making measurements at each value of P_2 in accordance with 8.2.5.

8.2.7 Set the pressure to RA P_1 = 1,6 MPa. To maintain P_1 constant. P_2 to install sequentially 1,1; 0,9; 0,7; 0,6; 0,5; 0,4; 0,30; 0,20; 0,15 MPa and P_2 low, making measurements at each value of P_2 in accordance with 8.2.5.

8.2.8 To process the experimental data.

1. Build the dependencies $Q = f(\sqrt{\Delta P})$ for each position REl.
2. Processing of experimental data when determining coefficient K_C:

- for the data array that satisfy the condition for single-phase flow in a quadratic field, to determine the coefficients of the regression equation having the form:

$$Q = a_0 + a_1 \cdot \sqrt{\Delta P}; \tag{1}$$

- for the rest of the data array, including the last point of the previous array to determine the coefficients of the regression equation having the form:

$$Q = a_0 + a_1 \cdot \sqrt{\Delta P} + a_2 \cdot (\sqrt{\Delta P})^2; \tag{2}$$

- solve the system of these equations.

The solution to the system of equations is the point with coordinates Q and √ΔP, which defines the deviation of flow characteristics Q=f(√ΔP) from the linear dependence. Cavitation factor is determined by:

$$K_c = \Delta P_c / (P_1 - P_{н.п.}), \quad (3)$$

where ΔP_c– pressure drop across the valve corresponding to the beginning of the deviation of the flow characteristic of the form Q = f(√ΔP) from linear dependence, Pa;

P_1 – the absolute pressure before the valve, Pa;

$P_{нп}$– absolute pressure of saturated vapor, Pa.

3. Processing of experimental data when determining the critical pressure K_m:

- - to determine the derivative of equation (2), equate to zero.

The solution of the equation is the point with coordinates Q and √ΔP, which defines the mode locking of consumption.

The ratio of the critical pressure drop is defined by:

$$K_m = \Delta P_m / (P_1 - r_C \cdot P_н). \quad (4)$$

where ΔP_m – critical differential pressure, the differential pressure corresponding to the locking of the discharge, Pa;

r_c– semi-empirical coefficient critical ratio of pressure-dependent physical properties of the medium (water).

4. Next, according to GOST R 55508-2013.

Further investigation of the cavitation characteristics of the valve of the cell the most extensively held with the water supply to the plunger and the plunger position h = 0,2, since in this position of the plunger is most pronounced occur cavitation processes and most fully realized the possibilities of the stand. Performed research of the influence of the pressure P_1 when the values 1,1; 1,6; 2,1 and 2,6 MPa (11,0; 16,0; 21,0; 26,0 kg/cm^2) cavitation factor K_c and the ratio of the critical pressure drop K_m, Fig. 1.

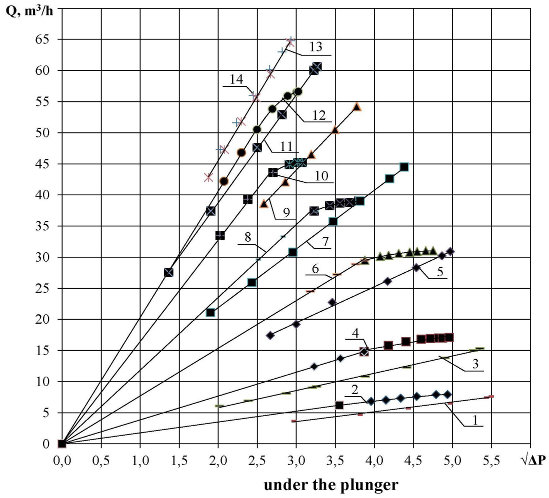
Processing of experimental data in the determination of the factors K_c and K_m carried out by the proposed method. The solution to the system of equations for each value of the pressure P_1 is the point with coordinates Q and √ ΔP, which defines the deviation of flow characteristics Q=f(√ ΔP) from the linear dependence, table 1.

Table 1. Dependence of the coefficient cavitation K_c from the pressure P_1.

Pressure P1, kg/cm2	11,0	16,0	21,0	26,0
√ΔP	2,760	3,089	3,615	3,982
ΔP, kg/cm2	7,617	9,542	13,069	15,856
Kc	0,692	0,596	0,622	0,610

The average value of four measurements of the K_c=0,630. The maximum deviation from the average value obtained is 9,8% at P_1=11,0 kg/cm^2. The average value of three measurements at P_1=16,0; 21,0 and 26,0 kg/cm^2K_c=0,6093, and the maximum deviation from the average value does not exceed 2,2%. The results of the experiment showed that more accurate values of the cavitation coefficient K_c can be determined if the values of pressure to test the valve more than 1,6 MPa (16,0 kg/cm^2).

Solution of quadratic equation for all values of pressure P_1, Fig. 1, are the points with coordinates Q and √ΔP, which define the start mode locking of consumption. The results of processing of experimental data when determining the critical pressure K_m are shown in table 2.



№ line	1, 4	2, 6	3, 7	5, 8
Pressure P_1, kg/cm^2	11,0	16,0	21,0	26,0

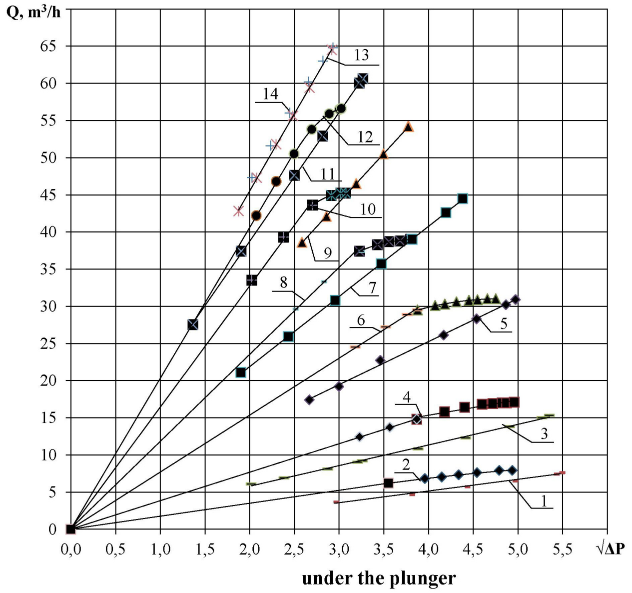
Fig. 1. The dependence of water flow through the cell valve from the square root of differential pressure (kg/cm^2), obtained by the proposed method when stroke of the plunger h = 0,2

When solving equations of the second degree the values of the coefficient critical pressure $K_m \geq 1,0$. Apparently, when approaching differential pressure maximum $\Delta P_{max} = P_1 - 0,0$ dependence $Q=f(\sqrt{\Delta P})$ more intensive approaches line parallel to the axis $\sqrt{\Delta P}$ than quadratic dependence. To create the maximum possible ΔP_{max} can creating a vacuum after IA. Plot of deviation of flow characteristics $Q=f(\sqrt{\Delta P})$ from the linear dependence should be described by a polynomial of degree more than two. When testing water parameters, corresponding to GOST coefficient critical pressure has a K_m value close to one.

Table 2. The dependence coefficient of the critical pressure drop K_m from the pressure P_1.

Pressure P_1, kg/cm^2	11,0	16,0	21,0	26,0
$\sqrt{\Delta P}$	3,634	4,20	4,55	5,12
ΔP, kg/cm^2	13,206	17,63	20,73	26,22
K_m	1,2	1,10	0,988	1,01

In the method described in [8], clause 8.2.7, p. 40 indicated: «The constancy of consumption implies that in RA occurred the locking of the flow». Further analysis of the graphs in Fig. 1 and Fig. 2 shows that all the rightmost points, the maximum possible, for all values of pressure P_1 are on the line obtained by the method of [8].



Odd - GOST R 55508-2013; even – the proposed method

№ line	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14
Stroke of the plunger, h	0,05	0,1	0,2	0,3	0,4	0,5	0,6

Fig. 2. The comparison of the dependences of the flow of water through the cell valve DN 50 PN 160 from the square root of differential pressure (kg/cm^2) obtained by the method of GOST R 55508-2013 and by the proposed method

Locking of the flow rate by the method described in GOST R 55508-2013, can't occur, the locking of the flow is constant, because P_2 has a minimum value. For values to the right of $\sqrt{P_1}$ flow regimes no.

Dependence, obtained by the proposed method at different values of pressure P_1, for all positions of the plunger end with the line obtained by the method of GOST R 55508-2013, as the operation of the plunger, and when water is delivered under the plunger. Further research will be conducted taking into account the recommendations [1, 4, 24, 25, 28].

5. Conclusions the results of detection of the cavitation criteria

Developed proposals to improve the methodology for determining the cavitation characteristics of pipeline valves.

Obtained values of the coefficient cavitation K_C, and the coefficient of the critical pressure drop K_m cell valve DN 50 PN 160.

References

[1]R.R. Ionaitis, Concept and examples of renewal and modernization of pipe fittings and reinforcing security, Pipeline valves, and equipment. 4 (2014) 12–20.

[2]R.R. Ionaitis, Passive elements of systems important to safety of nuclear installations, Publishing house of the MSTU, Bauman, Moscow, 2003.

[3]E.E. Blagov, B.Y. Ivnitskiy, Throttle-control valves in the energy sector, Energy, Moscow, 1974.

[4]E.E. Blagov, Prediction of flow regimes fluid in a hydraulic constriction de-vices, Armaturostroenie. 4 (2007) 45–52.

[5E.K. Spiridonov, S.Y. Bitiutskikh, Characteristics and calculation of cavitation jet mixer, Chemical and petroleum engineering. 4 (2015) 6–9.

[6]E.K. Spiridonov, Characteristics and calculation of cavitation mixers, in: Proceeding of Industrial-Engineering, the international scientific and technical conference. (2015) 14–16.

[7]E.K. Spiridonov, A.R. Ismagilov, Universal method of analysis and design of liquid-gas jet pumps, Hydraulic machines, hydro pneumatic automation, Current state and prospects of development, in: Proceeding of collection of scientific papers of the 8th all-Russian scientific-technical conference with international participation. (2014) 101–103.

[8] GOST R 55508-2013, Pipeline fittings, The method of experimental determination of the hydraulic and cavitation characteristics, 2013.

[9] Standard CKBA 029-2006, CJSC NPF Central design Bureau of valve industry, Pipeline fittings, The method of experimental determination of the hydraulic and cavitation characteristics, 2006.

[10] RTM 108.711.02-79, Valves energy, Methods for determining throughput capacity of the regulatory bodies and the choice of the optimal flow characteristics, 1979.

[11] RM4-163-77, Guidance material, The calculation and application of regulators in systems of automation of technological processes, 1977.

[12]Y.A. Gorelov, Comments on the article, Armaturostroenie. 4 (2015) 55.

[13]E.A. Pochivalov, S.A. Sukhov, A.V. Fominykh, I.R. Chinyaev, A.L. Shanaurin, RU Patent 138816. (2014).

[14]G.A. Zaslavsky, V.A. Ryazanov, S.A. Sukhov, A.L. Shanaurin, I.R. Chinyaev, A.V. Fominykh, RU Patent 158069. (2015).

[15]V.S. Eroshkin, I.R. Chinyaev, A.L. Shanaurin, G.A. Zaslavsky, V.A. Ryazanov, A.V. Fominykh, RU Patent119835. (2012).

[16]R.S. Romanov, V.A. Ryazanov, A.V. Fominykh, A.L. Shanaurin, I.R. Chinyaev, RU Patent 2563944. (2015).

[17]A.V. Matveev, V.A. Ryazanov, A.V. Fominykh, I.R. Chinyaev, A.L. Shanaurin, RU Patent 2549391. (2015).

[18]I.R. Chinyaev, A.V. Fominykh, S.A. Sukhov, Improving the reliability and efficiency of slide gate shut-off and regulating valves, Exposition oil gas. 3 (2013) 80–82.

[19]I.R. Chinyaev, A.V. Fominykh, E.A. Pochivalov, S.A. Sukhov, Determination of capacity characteristics valves shut-off and regulating, Exposition oil gas. 2 (2015) 38–40.

[20]I.R. Chinyaev, A.V. Fominykh, V.S. Eroshkin, Cavitation in gate valve, Territory Neftegaz. 5 (2013) 48–49.

[21]A.V. Fominykh, D.N. Ovchinnikov, I.R.Chinaev, Determination of hydraulic characteristics of locking and regulating valves, Agrarian Bulletin of the Urals. 2 (2012) 27–30.

[22]S.A. Sukhov, Improving the efficiency of the regulatory process fluid flows through improved design of slide gate valves, Armaturostroenie. 1 (2014) 58–61.

[23] GOST 12893-2005, Control valves single seat, double-seat and cellular, General technical conditions, 2005.

[24]V.P. Eismont, Regulators, Publishing house Deaton, St. Petersburg, 2012.

[25]D.F. Gurevich, Calculation and design of pipeline valves: Calculation of pipeline valves, Publishing house of the LCI, Moscow, 2008.

[26]I.E. Idelchik, Handbook of hydraulic resistance, Mashinostroenie, Moscow, 1992.

[27]A.D. Altshul, Hydraulic resistance, Nedra,Moscow, 1982.

[28]V.I. Chernoshtan, E.E. Blagov, Experimental determination of the critical flow criterion, Armaturostroenie. 4 (2012) 50–57.