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TECHNICAL DIAGNOSTICS OF PIPELINES OF HYDRAULIC SYSTEMS

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ABSTRACT: The hydraulic systems are industrial noise sources, the level of which mainly depends on the good condition of the regulative valves. The noise of the regulative valves is produced as a result of turbulence of the fluid flow at a pressure drop across the valve. The present article examines the methods for specifying the noise from the regulative valves into the hydraulic systems in connection with the needs of the technical diagnostics.

ТЕХНИЧЕСКА ДИАГНОСТИКА НА ТРЪБОПРОВОДИ ОТ ХИДРАВЛИЧНИ СИСТЕМИ

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РЕЗЮМЕ: Хидравличните системи са източници на промишлен шум, чието ниво зависи в голяма степен от изправността на регулиращите клапани. Шумът от регулиращите клапани е резултат от турбулентността на флуидния поток при спад на налягането в клапана. В настоящата статия се разглежда методика за определяне на шума от регулиращите клапани в хидравличните системи за нуждите на техническата диагностика

Introduction

The hydraulic systems are considerable industrial noise sources. This noise is mainly produced by the regulative valves located along the pipeline and directly depends on their construction and good condition. There are two types of noise in the regulative valves, namely mechanical noise and hydraulic noise. The mechanical noise is caused by the vibrations of the valve elements, as a result of the accidental fluctuations of the pressure in the frame or as a result of the contact of the fluid and the movable and flexible elements. It is also often when vibrations of the resonance frequency of the elements cause their destruction. As a whole the noise from mechanical vibrations is considered a useful side effect, which a warning for some possible damage, but is not subject to valuation.

The hydraulic noise is subdivided into hydrodynamic noise that is caused by cavitation, and streamline noise as a result of the turbulence of the gas phase of the flow. The two types of noise are of great interest for the technical diagnostics of pipeline systems.

Valuation methods for noise of the regulative valves

The development of an analytical method, which can provide a precise description of the mechanism of the hydrodynamic and aerodynamic noise in the regulative valves, is a complex problem. The constructive variety of valves and pipelines makes the finding of a common approach for process modeling even more difficult. More precise methods for evaluating the noise characteristics may be obtained on the basis of an experiment.

Evaluation of aerodynamic noise

The acoustic power, generated by the compressed flow through the regulative valve is subject to the following dependency:
for a valve that has one outlet

$$W = f\left[C_g^2(\Delta P)^2 \Delta\left(\Delta P/P_1\right)\right] \tag{1}$$

for a valve that has N numbers of outlets

$$W = f\left[\frac{1}{N} C_g^2(\Delta P)^2 \Delta\left(\Delta P/P_1\right)\right] \tag{2}$$

where: Δ – functional parameter
ΔP – pressure fall
P_1 – pressure of the incoming flow, absolute pressure
C_g – size coefficient of the gas, which can be determined by the following three equations:
for the gas flow

$$C_g = \frac{Q}{P_1}\sqrt{\frac{GT}{520}}\,\frac{1}{\sin\left(\frac{3417}{C_1}\sqrt{\frac{\Delta P}{P_1}}\right)} \tag{3}$$

for the flow of water or other type of steam

$$C_g = \frac{Q_s}{1{,}06\sqrt{d_1}P_1}\frac{1}{\sin\left(\frac{3417}{C_1}\sqrt{\frac{\Delta P}{P_1}}\right)} \quad (4)$$

for fluid flow

$$C_V = Q_L\sqrt{\frac{G_L}{\Delta P}} \quad (5)$$

where: C_g - size coefficient of the gas

C_V – size coefficient of the fluid

$C_1 = \frac{C_g}{C_V}$ (indicator provided in the valve technical data by the company-producer)

Q – velocity of the gas flow

Q_s – velocity of the flow of the water steam

Q_L – velocity of the fluid flow

G - gas density (Table 2)

G_L – fluid density

P_2 – pressure at the valve entrance

ΔP – fall of the valve pressure

T - absolute gas temperature at the valve entrance, $^\circ R$ (degrees Renkin: $T_R = 1{,}8T^\circ C + 491{,}67$)

On the basis of the above dependencies can be made a valuation of the level noise in the environment, as a result of compressed fluid through the valve, namely:

$$L_P = L_{\Delta P} + \Delta L_{C_g} + \Delta L_{\Delta P/P} + \Delta L_K \quad (6)$$

where: L_P, dB – general noise level measured at a preliminarily specified point (at a distance of 1.2 m from the valve outlet and at a distance of 0.7 m from the pipe surface);

$L_{\Delta P}$, dB - general level of the acoustic pressure determined according to ΔP;

ΔL_{C_g}, dB – correction for C_g

$\Delta L_{\Delta P/P}$, dB – correction for the valve and the pressure fall

ΔL_K, dB – correction for the acoustic processing according to the pipe thickness, the type of the pipeline insulation and noise killers (in accordance with the technical characteristics of the producer).

d_1 - steam density

Table 1

Gas	G
Acetylene	0.90
Air	1.00
Butane	2.00
Ethane	1.03
Methane	0.55
Natural gas – 0.6 G	0.60
Propane	1.52
Propylene	1.45

Diagrams for industrial application have been developed on the basis of equation No. 6 (Fig.1 and Fig.2)

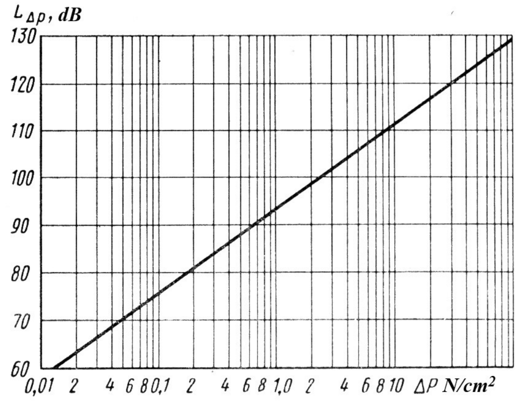

Fig.1. General level acoustic pressure for all types of valves.

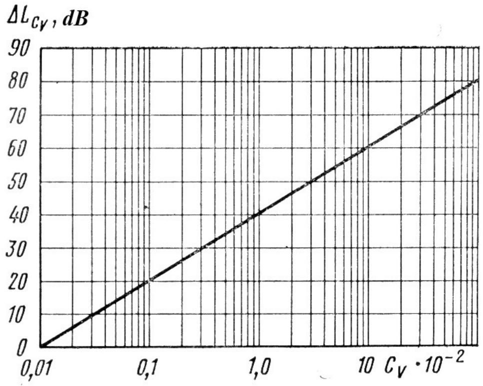

Fig.2 . Correction ΔL_{C_g} for all types of valves.

Evaluation of hydrodynamic noise

The acoustic power generated by the non-compressed fluid flow through the regulative valve is subject to the following dependency:

$$W = f\left[C_V^2\Delta\left(\Delta P, \frac{\Delta P}{P_1 - P_V}\right)\right] \quad (7)$$

where: W – acoustic power, W;

C_V – size coefficient of the fluid;

P_1 – pressure at the valve entrance, N/m^2

P_V – pressure of the steam on the fluid flow, N/m^2

ΔP – pressure fall in the valve, N/m^2

The valuation of the hydrodynamic noise emitted to the environment is made according to the following dependency:

$$L_P = L_{\Delta P} + \Delta L_{C_V} + \Delta L_{\Delta P/(P_1 - P_V)} + \Delta L_K \quad (8)$$

where: L_P, dB – general noise level measured at a preliminarily specified point (at a distance of 1.2 m from the valve outlet and at a distance of 0.7 m from the pipe surface);

$L_{\Delta P}$, dB - general level of the acoustic pressure determined according to ΔP and $\Delta P/(P_1 - P_V)$;

ΔL_{C_V}, dB – correction for C_V;

$\Delta L_{\Delta P/(P_1 - P_V)}$, dB – correction for the a specific type of valve and for flow regime

ΔL_K, dB – correction for the acoustic processing according to the pipe thickness, the type of the pipeline insulation and noise killers (in accordance with the technical characteristics of the producer).

Diagrams for industrial application have been developed on the basis of equation No. 8 (Fig.3 and Fig.4).

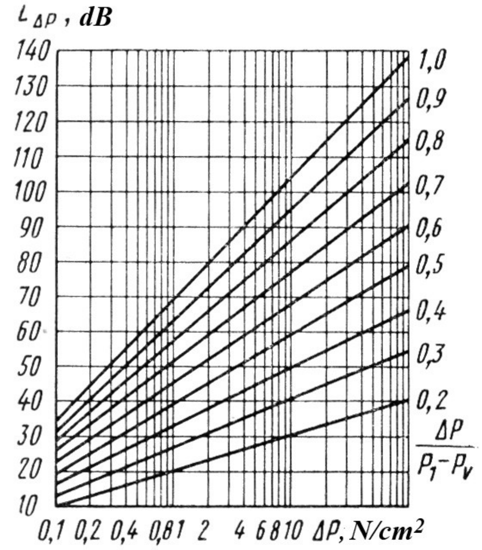

Fig.3. General level acoustic pressure for all types of valves.

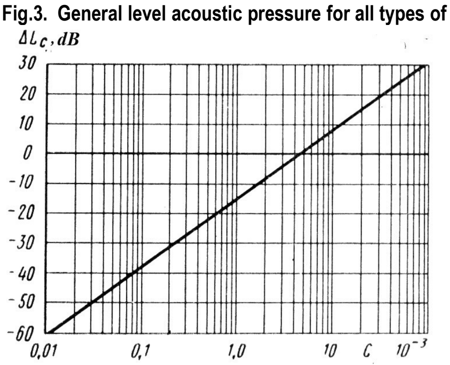

Fig.4. Correction ΔL_{C_V} for all types of valves.

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Conclusions

The noise in the hydraulic systems is an indicator, subject to periodical control, in connection with the sanitary labour standards, as well as in connection with the establishment of damages and failures in the work of the system elements. Pumps, compressors and regulative valves are part of the general noise produces by the hydraulic systems. Their good condition is of great importance for the pipeline systems, especially when petrol products are transported through them. The possibility for determining the level of the noise, produced by the regulative valves, and separating it from the general noise in the hydraulic system, enable the diagnosticians to identify the incipient damages to the valve in due time and to localize more precisely the damages along the pipeline.

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