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About some experience of reduction of vibration of power plants and joining mechanical systems

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ABSTRACT

Power plants of different kinds are widely used in modern machinery, energetic, chemical industry, other branches, in transport and domestic conditions. Vibration and related with it mechanical noise of power plants and joining mechanical systems are the factors negatively impacted not only to the health of workers, but also to the durability, reliability, productivity and other parameters of power plants. Methodological approaches to power plants vibration and mechanical noise complex reduction are suggested. Program provision and technical solutions for power plants and joining mechanical systems vibration reduction and results of it approbation are described. Results of approbation are showing good efficiency of technical solutions.

Keywords: Vibration, Power Plants, Reduction I-INCE Classification of Subjects Numbers: 46.1, 49.3

1. INTRODUCTION

Power plants of different kinds (compressors, automobile internal combustion engines, pumps, ventilators, heat-exchanges, stationary engines etc.) are widely used in different branches (mechanical engineering, transport, energetic, chemical industry etc.) during gas and liquids transporting in pipeline systems, in housing and communal services. Vibration and related with it mechanical noise of power plants and joining mechanical systems (pipelines, aggregates etc.) may cause significant influence to reliability, durability, productivity and other parameters during exploitation [1-4]. It impact may cause a number of negative sequences: energetic plants and pipelines parts and units destruction, damage of joining of pipelines and devices, the seal seals etc. Moreover, intensive vibration during exploitation of energetic plants and mechanical noise may cause reduction of attention and increasing of number of mistakes during work. In result together with human health damage also reduction of labor safety, productivity and quality is occurs.

Significant input into generation of vibration and of low frequency noise brings pressure oscillations in flow of heat-carrier. Low frequency pulsations of gas and liquids pressure in pipelines of energetic plants are the source of intensive vibration and may cause premature wear of equipment and negative influence to the health of workers [1-3, 5].

Analysis of scientific papers in the field of noise and vibration reduction shows that in order to efficiently reduce vibration of energetic plants it is necessary to develop methodological basics of classification of methods of reduction. Efficiency of methods and technical solutions of reduction of vibration of energetic plants it is necessary to prove by calculative and experimental way.

In this paper methodological approaches to power plants vibration and mechanical noise complex reduction are suggested, technical solutions of vibration reduction and results of it approbation are described.

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2. METHODOLOGICAL BASICS OF CLASSIFICATION OF METHODS OF ENERGETIC PLANTS AND JOINING MECHANICAL SYSTEMS VIBRATION REDUCTION

In table 1 methodological basics of classification of methods of energetic plants vibration and of joining mechanical systems reduction are shown.

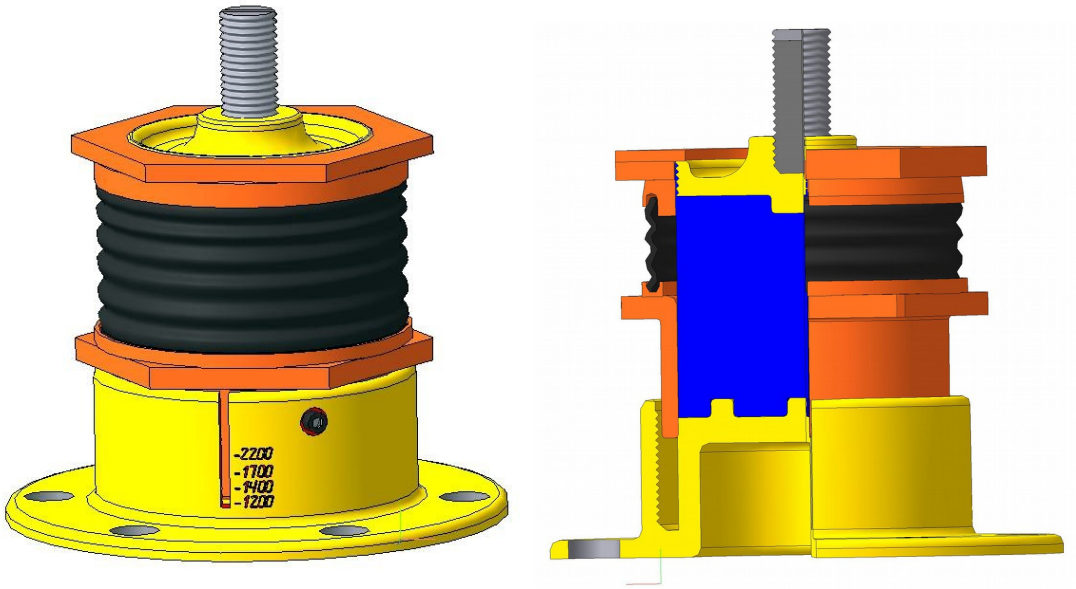
Table 1 - Methodological basics of classification of methods of energetic plants vibration and of joining mechanical systems reduction

№	Criteria of classification	Types of classification	Examples
1.	General approach to reduction of vibration of energetic plants	Reduction in the source of generation	Pulsation dampers
		Reduction on the ways of propagation	Vibration protective covers
		Individual means of protection	Vibration protective glovers
2.	Spatial kind of energetic plants vibration reduction	1.1.One-dimensional propagation of vibration	Pulsation dampers of compressors pipelines
		1.2.Two-dimensional propagation of vibration	Vibration reduction on the surfaces of energetic plant or of foundation of building
		1.3.Three-dimensional propagation of vibration	Vibration reduction inside of passenger compartment
		1.3.1.Reduction inside of walled volume	generated by internal combustion engine
		1.3.2. Reduction at the open space	Energetic plants vibration reduction in the open space of territory
3.	Periodicity of generation of vibration of energetic plants	Periodical	Gas pressure pulsations dampers in pipelines of piston machines
		Non-periodical	Vibration isolating units
4.	Energetic criterion	Passive	Passive vibration isolation
		Active (adaptive and not adaptive)	Active vibration isolating mounts
		Hybrid (active-passive)	Hybrid resonator of Helmholtz
5.	Complexity of vibration reduction of energetic plants from the different sources	Vibration reduction from the single source	Pipeline fastening
		Vibration reduction from the several sources	Concurrent reduction of automobile internal combustion engine and of transmission
		Complex reduction of vibration	Devices of complex reduction of vibration of automobile internal combustion engine
6.	Kind of spectrum of vibration source	Wide-frequency vibration	Vibration isolation
		Narrow-frequency (tonal) vibration	Resonator
7.	Kind of energetic plant	Energetic plants of a single vehicles	Reduction of low frequency sound and vibration in cabin of driver and in passenger compartment of vehicle
		Vibration of stationary energetic plants	Vibration isolating mounts
		Low-frequency vibration of pipeline systems of energetic plants	Gas flow pressure pulsations dampers
			Vibration damping mounts

3. DEVELOPMENT OF METHODS AND APPROACES FOR POWER PLANTS AND JOINING MECHANICAL SYSTEMS VIBRATION REDUCTION

A number of technical solutions for vibration reduction of energetic plants and of joining mechanical systems was developed by author [2-4, 6-12 etc.]. Let us to consider some of them.

One of efficient and often used approaches to reduction of vibration of pipelines of energetic plants is using of vibration mounts. But existing constructions of vibration mounts are having some disadvantages. Construction of adaptive vibration isolating mount with adjustable parameters of vibration damping have been developed. General view of scheme of vibration isolating mount is shown on fig. 1. Construction of vibration isolating mount allow to control the degree of damping, maximal working load and static deformation of mount by using of adjusting nut for variation of working surface of damper. On the basis of developed construction pilot sample of vibration isolating mount was designed and manufactured.



a). b).

Figure 1 - General view of scheme of vibration isolating mount

Different constructions of vibration dampers have been developed using hydraulic resistance occurring e.g. during punching of working fluid through the small calibrated holes. Such constructions allow to change the coefficients of resistance in wide range. Using of silicon oil as working fluid provides stability of the coefficients in wide temperature diapason of exploitation.

Vibration damper may be performed as hermetically closed cylinder filled in by working fluid, in which may occurs vibration displacement of inertial mass made in form of piston and connected with cylinder by system of springs. Equivalent rigidity of system of springs is determined by equation: $\tilde{N}_{\acute{y}} = \omega_0^{\ 2} \cdot m_{\ddot{I}}$, where $m_{\ddot{I}}$ - piston mass and ω_0 - circular frequency of damper adjustment. In order to exclude influence of temperature deformations working fluid should have some excess pressure which is occurring during assembly and supporting by the elastic deformation of the cylinder.

Adaptive pressure oscillations damper of suction system of piston machine is consists of capacity of variable volume supplied with rigid walls on one of which at least one imputing manifold is mounted connecting cavity of capacity with atmosphere, and on the other – at least one outlet branch connecting cavity of capacity with cylinder of piston machine. Capacity is formed by spatial framework fixed on the rigid walls. Framework is covered by cover from the soft inelastic material, e.g. fabric, with possibility of it sagging between framework elements, while the value of variation of volume of capacity is exceeds the value of operating volume of cylinder of piston machine.

Such constructive decision allows to exclude elastic characteristic of cover and thus to

compensate efficiently pressure impulses in suction system. Insignificant mass of cover (comparing with rubber) leads to small damper inertia, and this is increases sensitivity of damper to tracking of pressure impulses of system which is finally increases efficiency of oscillations reduction during dynamic loads.

Efficient reduction of vibration of energetic plants and of joining pipeline systems in low frequency range may be achieved by using of compact active compensators efficiently reducing pressure pulsations in pipeline systems of energetic plants. Construction of hybrid damper of low frequency pulsations in pipelines of compressor mounts is developed by author. Its peculiarity is in reduction of low frequency gas dynamic pulsations in pipeline main and correspondently reduction of reduction of pipeline vibration is achieved. Active-adaptive construction of damper is consists of the buffer capacity with pliable walls from one side and unit of active radiation of sound from the other side. Active sources are installed in special cassettes. In result efficient attenuation of low frequency pulsations of gas flow is achieved.

4. APPROBATION OF DEVELOPED METHODS AND TECHNICAL SOLUTIONS FOR ENERGETIC PLANTS AND JOINING MECHANICAL SYSTEMS VIBRATION REDUCTION

For experimental approbation of suggested methods and technical solutions construction of laboratory unit for investigation of vibration and mechanical noise of energetic plants and of joining mechanical systems. Having significantly simple construction, cheapness, convenient of change of parameters of system, laboratory unit also allows with high degree of precision to modeling low frequency vibrations of pipelines of energetic plants and to estimate efficiency of different vibration isolating mounts for reduction of pipelines vibration. In particular, laboratory unit allows to carry out investigations of reduction of low frequency pipelines vibration and pressure pulsations by using of methods of passive, active and hybrid methods of vibration reduction. Piston compensator of oscillations, oscillating throttle etc. may be used as active compensative source.

As energetic plant – source of vibration and of mechanical noise piston one-stage compressor FUBAG OL 231/24 CM2 is used.

By using of such laboratory unit investigations of acoustical characteristic of energetic plants and of joining mechanical systems for variant "pipeline - energetic plant".

Measurements of vibration acceleration levels were carried out in the characteristic points situated on pipeline in different distances from vibration source and on the body of energetic plant - compressor. Regime of compressor operation was set by intake valves. Pressure in pipeline system was measured by manometer. For all measurements pressure in pipeline system was set to equal 2 atm.

Example of representation of results of measurements for point of measurements of vibration acceleration levels on the body of compressor is shown on the fig. 2, for point of measurements on pipeline behind of the mount during compressor connection to the input valve) – on the fig. 3.

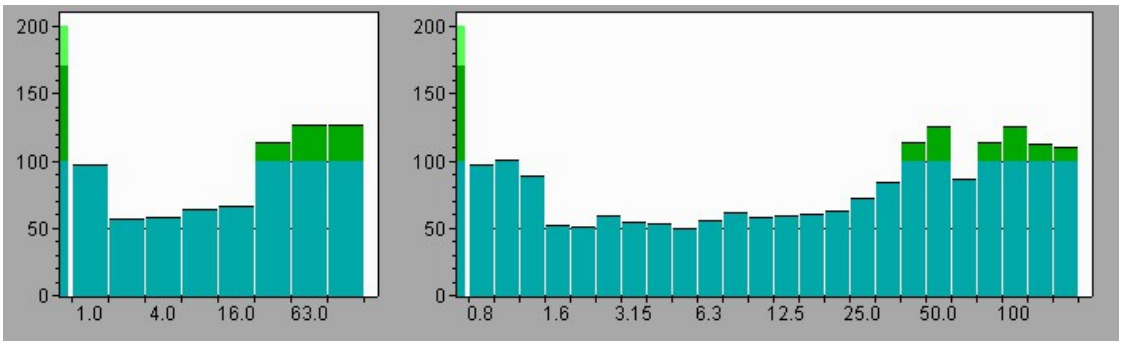


Figure 2 - Spectral characteristic of vibration acceleration levels (octave and 1/3 octave frequency spectra) for point of measurements of compressor body

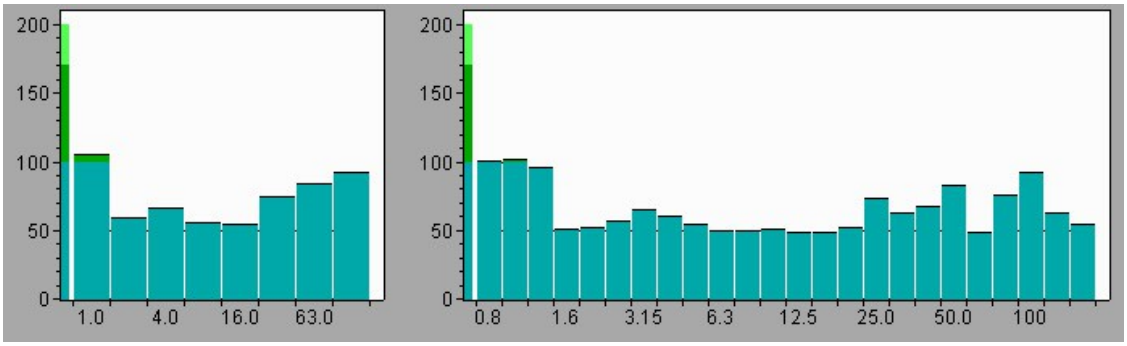


Figure 3 - Spectral characteristic of vibration acceleration levels (octave and 1/3 octave frequency spectra) for point of measurements on pipeline behind of the mount during compressor connection to the input valve

Analysis of measurements results is allowing to conclude that:

1. The most significant values of vibration acceleration levels were observed on energetic plant – compressor (the source of vibration). Equivalent one-figure mean of vibration acceleration level on the body of compressor was equal to 99 dB.
2. In pipeline system the value of measured vibration acceleration levels is increased during removing to the distance from vibration source and reaches maximal value 68 dB in point №3, which is possible to explain by impact of gas pulsating flow.
3. For laboratory unit the source of vibration (energetic plant) may be easy replaced.

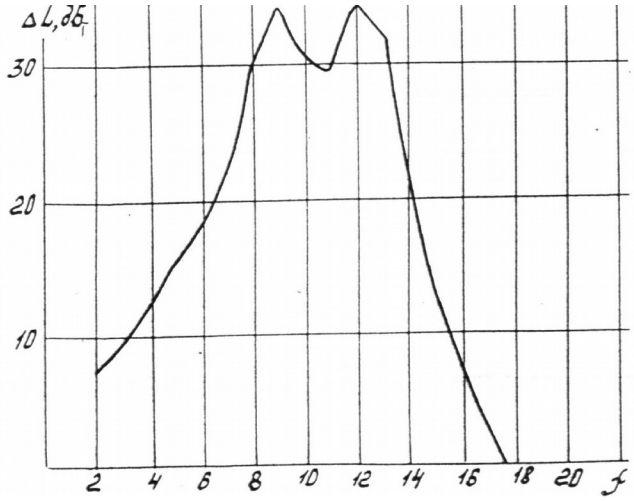


Figure 4 - Estimation of efficiency of attenuation of pipeline vibration by using of developed construction of resonator

By using of laboratory unit experimental investigations of vibration characteristic of developed and manufactured pilot sample of vibration mount were done. Analysis of results of measurements is allowing point out the following main conclusions.

1. Using of pilot sample of vibration mount installed to the energetic plant (compressor) is allowing to reach significant reduction of compressor vibration comparing with using of regular mount of compressor.
2. More high efficiency of pilot sample of vibration mount installed to the energetic plant (compressor) comparing with using of regular mount of compressor is proved experimentally for the different distances from vibration transducer to the source of vibration (compressor).
3. Experimentally achieved effect of reduction of vibration of compressor during testing of pilot sample of vibration mount is increased during increasing the distance between vibration source (compressor) and he place of installing of vibration transducer. For the distance L_1 = 20 cm

efficiency of pilot sample of vibration mount comparing with regular mount of compressor for reduction of vibration acceleration level is achieving 10,5 dB, during the distance L_2 = 10 cm - 8,6 dB.

Also calculative approbation of developed technical solutions was carried out. In particular, results of calculations of parameters of hollow damper with pliable walls showed that significant effect of pulsations reduction with concurrent reduction of volume of capacity is achieved. As it shown on fig. 5, for the frequency $f = 12{,}5\ Hz$ efficiency of vibration reduction by using of developed construction of resonator is 35 dB.

5. CONCLUSIONS

Problems of reduction of vibration of energetic plants and of joining mechanical systems with using of methods and of technical solutions developed by author are considered. Methodological basics of classification of methods of complex reduction of vibration of energetic plants and of joining mechanical systems are suggested. Results of experiments and calculations are allowing to conclude that suggested methods and technical solutions of reduction of vibration of power plants and of joining mechanical systems are efficient.

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