

# Technique of assessment of technical condition of pump units according to the levels of vibration and energy efficiency indicators

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**The purpose.** To develop a technique of assessment of technical condition of pump units (PU) according to the levels of vibration and indexes of power efficiency which will enable in due time to determine time of holding engineering service and major overhaul of pump-power facilities of pumping stations (PS) of irrigation systems in conditions of their exploitation. To carry out analysis of results of on-site investigations of PS gained at power diagnostic studies and vibration monitoring. To determine correlation between vibration and its influence on use reliability and power efficiency of PU. **Methods.** Information-analytical — for the analysis and assessment of domestic and foreign proceedings on the yielded theme; experimental — for determination of power characteristics and levels of vibration of PU with application of modern means of measurement technology and vibration monitoring; statistical and system approaches — mfor the analysis and processing experimental data. **Results.** Data gained at on-site investigations of PS of irrigation systems are analyzed. Scientific-methodological approach is offered to assessment of technical condition of PS according to the levels of vibration and indexes of power efficiency, based on a hypothesis about correlation between indexes of vibration (vibration speed and vibration acceleration) and aberration of coefficient of performance (CP) of PU. **Conclusions.** Necessity is proved of perfecting technique of holding power diagnostic studies of PU with assessment of technical condition of PS according to the levels of vibration which will enable objectively assess technical condition of pump-power facilities of PS of irrigation systems.

**Key words:** *vibration, power efficiency, pump units, centrifugal pumps, technical condition, technique, efficiency.*

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**Formulation of the problem.** In the irrigation systems of the Ukraine, the PU are operated from 25 to 50 years. On many PS, the pump equipment needs to be upgraded and repaired. According to energy surveys carried out on many objects of Ukrainian water distribution systems, about 50% of PU which currently is in operation have 10-20% coefficient of efficiency (COE) lowered compared to their passport values [1]. When conducting energy surveys of the same type of PU with the same operating modes, it was found that significant deviations of the efficiency are units with higher levels of vibration.

Increased levels of vibration in the PU result in a shortening of their service life, the destruction of concrete slabs on which PU is fixed, as well as the failure of individual nodes PU.

The reasons for the occurrence of vibration in PU can be divided into three groups: electromagnetic, mechanical and hydraulic. Vibration of electromagnetic origin is characteristic for all types of NA with driven asynchronous motors, which have a complex nature of the electromagnetic field. Probable sources of vibration of the mechanical origin are the imbalance of the rotor of the drive motor and (or) impeller wheel, the non-alignment of their joints and the damage to the bearings.

Vibrations of hydraulic origin arise as a result of dynamic interactions of a stream of water, with streamlined parts of centrifugal pumps and pressure pipelines with shut-off and adjustment valves.

Measurement of technological parameters and indicators of the level of vibration of the PU, as well as improvement of the existing methodology of carrying out of energy surveys of the PS of water management systems [2], with the assessment of the technical state of PU by the levels of vibration, is an important and urgent task aimed at increasing energy efficiency and operational reliability of PU in water management systems.

**Analysis of recent research and publications.** Oscillations (vibrations) in the PU are considered, first of all, from the point of view of their impact on the durability of the elements of the design of the unit, the effect

on the foundations of PU or concrete overlap of the PS, as well as the impact on the person. These issues were dealt with by domestic and foreign scholars and they are covered in works [3-9].

According to the results of the inventory of reclamation funds, the main factors in reducing the demand for existing irrigation systems with a long lifetime are: low operational reliability; high cost of water supply, due to significant operating costs and excessive power consumption by pump equipment.

**The purpose and methods of research.** For a comprehensive assessment of the technical state of PU on the PS, a methodology for carrying out on-site surveys of aggregates using modern measuring instruments and vibration monitoring is used. The basis is based on the existing method of conducting energy audit at the objects of water management systems, as well as, tested during field inspections of the PS, the method of conducting vibrations-monitoring PU [10, 11].

In the course of vibrations-monitoring of PU, an automated control system for hydrodynamic loads of PU in the transitional and stationary modes of their work [12] is developed in the Institute of Water Problems and Land Reclamation.

The complex method allows to conduct energy surveys and vibrations-monitoring of PU. The assessment of the technical state of the PU is carried out on the basis of the deviation of the actual efficiency of the unit from its passport value and the vibration levels measured in the stationary mode of operation of the PU at certain informative points. Simultaneously with the obtaining of operating parameters of the PU, necessary for the determination of the actual efficiency, the vibrations-monitoring of the PU is carried out with the fixation of the vibration parameters - the root mean square values of the vibration velocity (RMS), at informative points in two mutually perpendicular planes (horizontal and vertical) [11].

According to the international standard ISO 10816-1: 1995 [12], the informative points are those that have the greatest impact on the general level of vibration of the PU, it is: electric motor and pump bearings, engine housing and pump housing. The layout of the location of vibration detectors at informative points is shown in Fig.1.

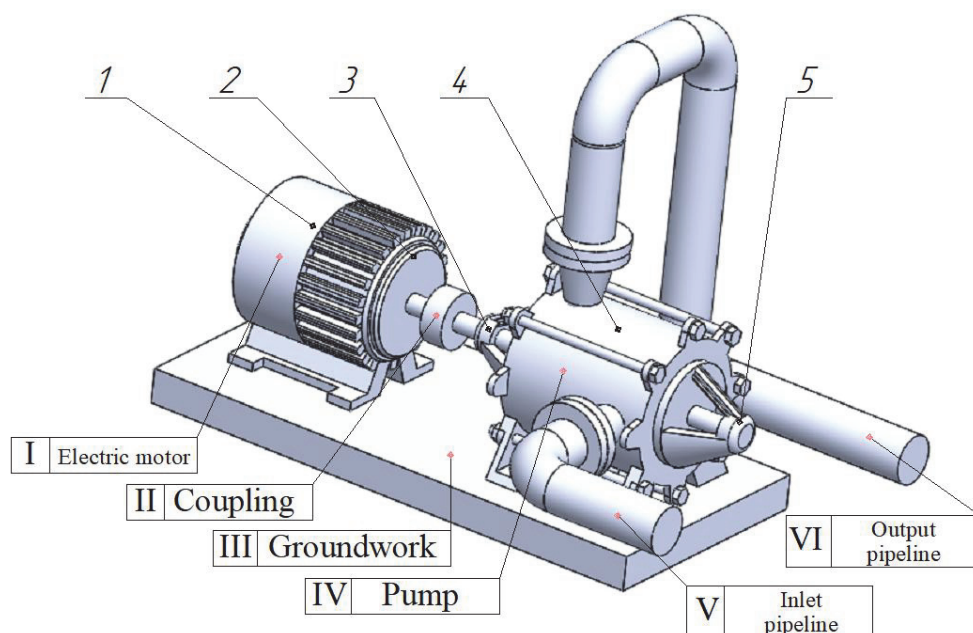


Fig.1. Scheme of location of vibration detectors at informative points on the example of PU with a centrifugal pump type 150CVE 350-23 / 2:

- 1 – engine housing; 2 - the bearing of the engine; 3, 5 - bearings of the pump;
- 4 - pump housing

Performance characteristics of different PU, obtained during energy surveys and vibration monitoring at the PS, are presented in Table 1.

Table 1

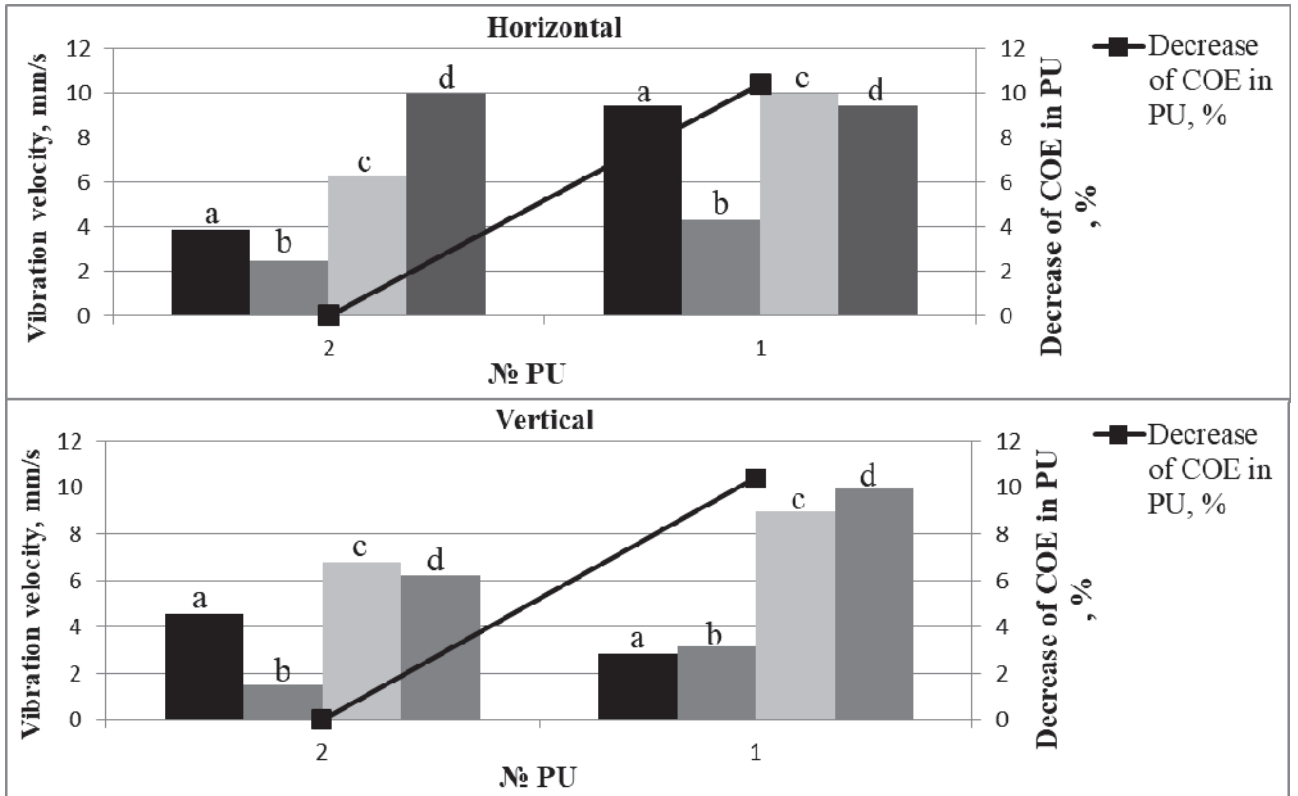
Performance characteristics of PU during the received energy and vibration surveys in PS of emergency irrigation systems

N F U	Type of pump	Po wer of PU, kW	Decre ase of COE in PU $\delta_{\eta},\%$	Load factor		RMS vibration velocity on corps of pump, mm/s		RMS vibration velocity on pump bearings, mm/s		RMS vibration velocity on motor bearings, mm/s	
				pu mp	elect ric motor	verti cal	horiz o-ntal	vertic al	horiz o-ntal	vertic al	horiz o-ntal
1	250QV D 500-54	158 ,4	-3,2	0,5 8	0,59	3,1 59	4,32 5	8,95 5	10	10	9,43 3
2	250QV D 500-54	210	0	1,1	0,78	1,5 08	2,47 1	6,8	6,24 3	6,21 8	10
3	D2500 -62-2	637	-16,2	1,2 9	1,2	1,1 94	1,16 6	1,83 7	1,72 9	0,46 2	0,29 8
4	D2500 -62-2	617	-14,4	1,2 2	1,16	0,4 41	0,50 6	1,16 6	1,26 1	2,46 2	1,35 1
5	D2500 -62-2	516	-1,2	1,2 3	0,97	0,2 87	0,39 3	1,41 8	1,39 9	1,55 6	0,59 8
6	300D- 70	212 ,5	0	0,5 8	0,49	0,6 28	1,16 3	6,62 5	2,22 8	3,42 9	4,10 7
7	300D- 70	202 ,7	13,6	0,4 6	0,75	1,1 49	1,31 2	7,67 5	9,25	5,08 8	4,72 8
8	300D- 70	189 ,3	24	0,4	0,7	0,8 17	1,32 7	5,91	9,25	6,03 6	6,11 5
9	150CV E 350- 23/2	107 ,6	-15,6	1,0 5	0,75	0,7 91	0,65 9	8,16 9	3,62 5	0,69 5	0,95 6
10	150CV E 350- 23/2	117 ,6	-10,0	1,2 6	0,83	0,4 03	0,37 6	1,46 1	0,95 1	1,39 0	1,83 4
11	150CV E 350- 23/2	103 ,3	-12,3	1,1 4	0,64	0,8 57	0,56 2	1,01 5	0,99 8	0,43 5	0,53 8

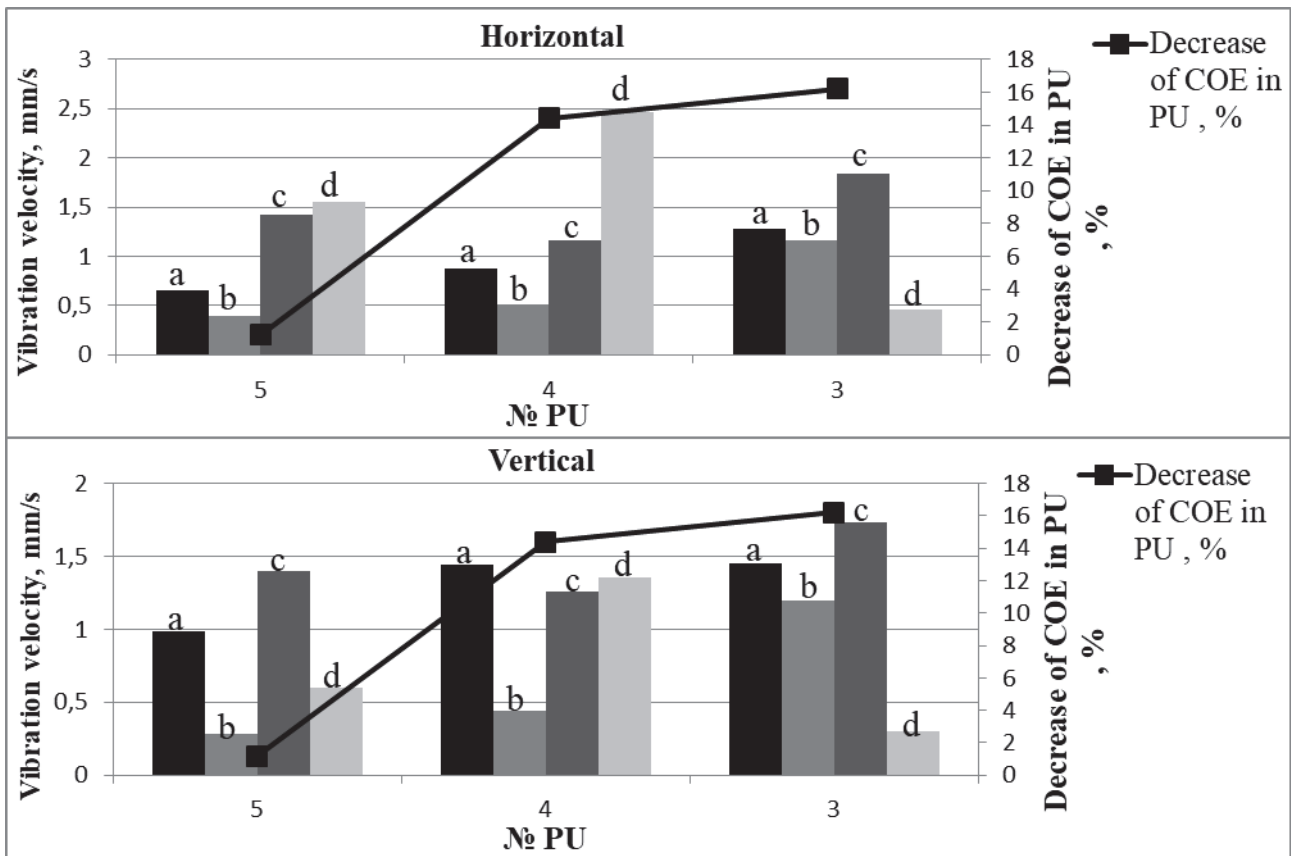
The analysis of tariffs for water supply services in closed irrigation systems has shown that the component cost of water supply for actual electricity costs is 65...85% of the full cost of water supply. Thus, the component cost of supplying water for actual electricity costs is up to 37% of the full cost of crop production [13,14].

According to the results of field inspections were determined levels of horizontal and vertical vibration velocity on cases of horizontal centrifugal pumps of type: 250QVD 500-54, D2500-62-2, 300D-70 and 150CVE 350-23 / 2, on bearings of asynchronous electric motors and bearings of single-type pumps, as well as deviation of actual efficiency of PU from their passport values are shown in fig.2.

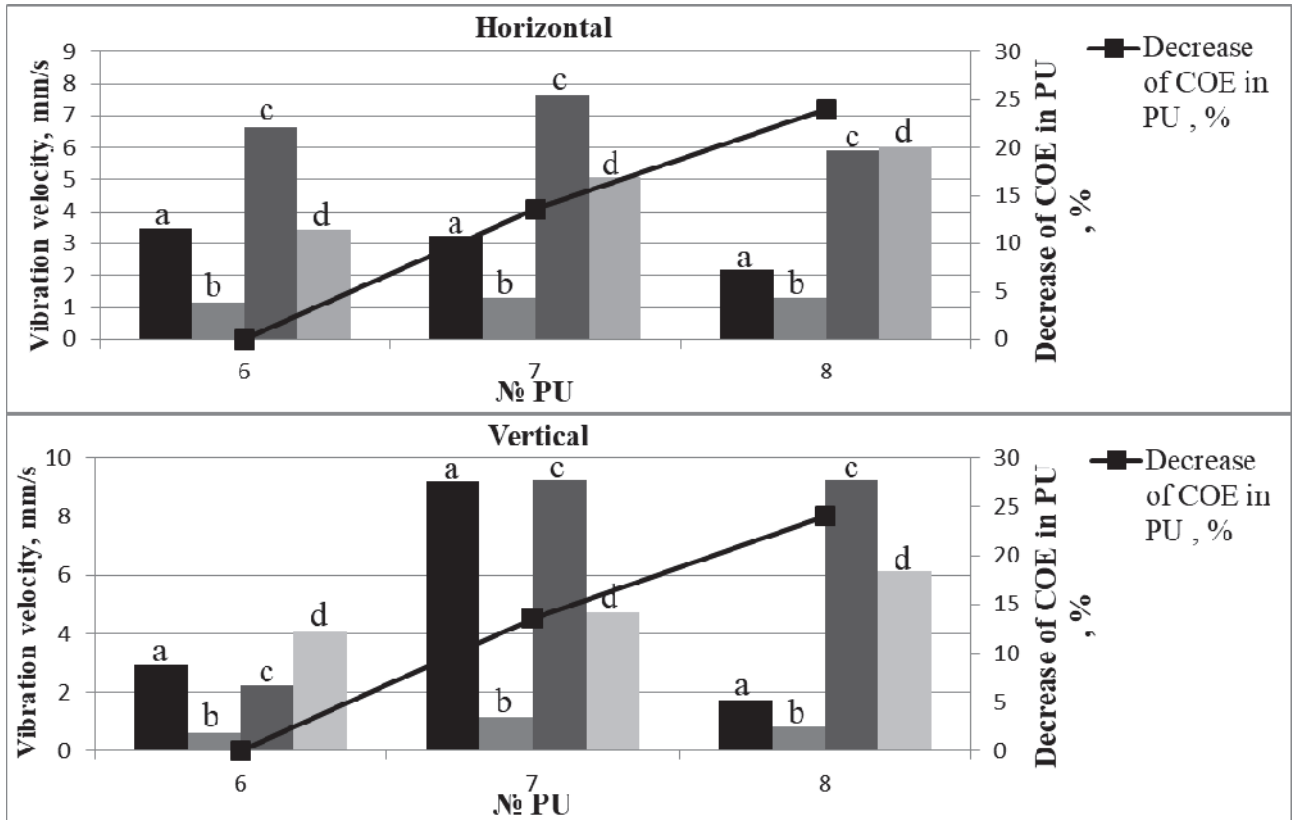
I – 250QVD 500-54



II – D2500-62-2



### III – 300D-



### IV – 150CVE 350-23/2

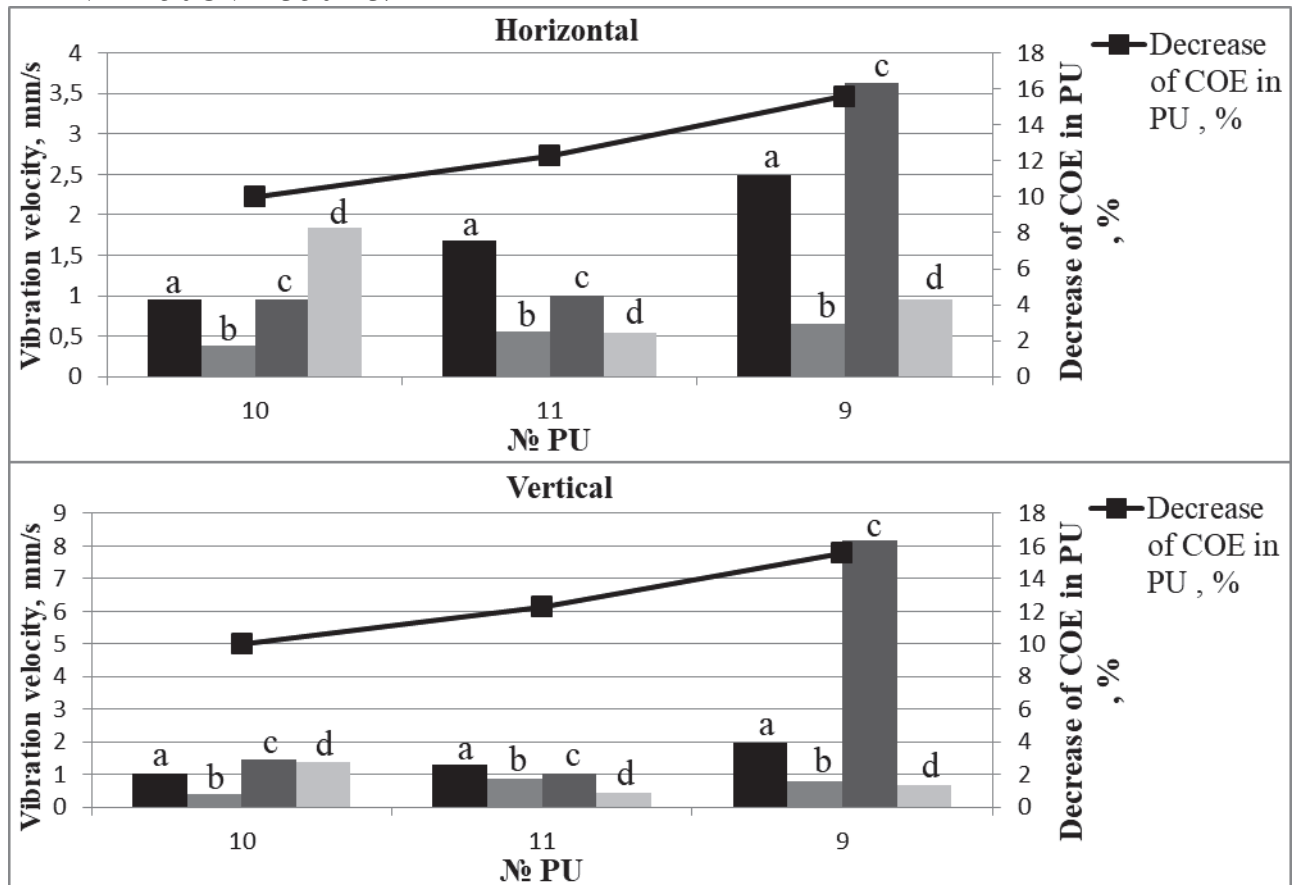


Fig.2. Absolute deviation of efficiency of NA with centrifugal pumps of type 250QVD 500-54, D2500-62-2, 300D-70 and 150CVE 350-23 / 2 at different levels of horizontal and vertical vibrations  
 a, c - bearings of the pump; b - pump housing; d - electric motor bearing.

On the basis of received data of field inspections PU, the functional dependences of the absolute deviation of the efficiency of PU from the RMS of the vibration velocity for the PU with centrifugal pumps of

type: 250QVD 500-54, D2500-62-2, 300D-70 and 150CVE 350-23 / 2 are constructed. The constructed functional dependences for four types of PU are presented in Fig.3.

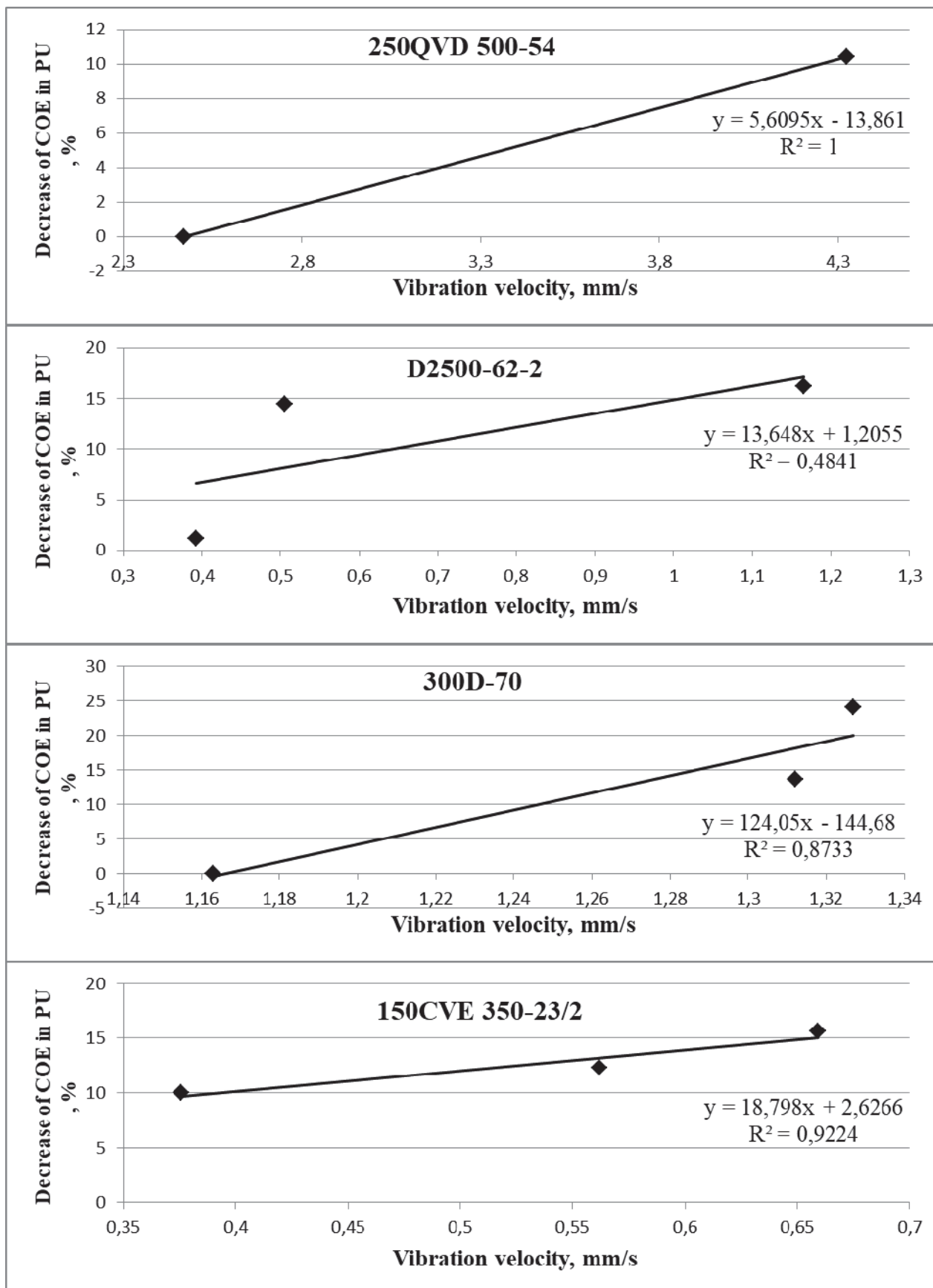


Fig.3. Dependences of absolute deviation of efficiency of different types of PU from levels of vibration velocity.

The dependencies shown in Fig.3 are valid for all informational points of registration of vibration velocity of PU with centrifugal pumps: 250QVD 500-54, D2500-62-2, 300D-70 and 150CVE 350-23 / 2, both in horizontal and vertical planes.

Estimation of the technical state of PU in the conditions of operation of the PS is to construct a functional dependence of the efficiency from the levels of vibration, as well as a certain level of vibration, in which the efficiency of the PU decreases to the maximum permissible limit, and in which it is necessary to stop the operation of the unit and timely repair and restoration work. The maximum permissible limits of the levels of vibration are determined by the International Standard [12].

In assessing the technical state of the PU, the permissible vibration levels are determined, at which its efficiency will meet the requirements of energy efficient water supply, established by the departmental regulatory document for various types of pumps [15].

## Conclusions

The proposed methodology for assessing the technical state of PU according to the levels of vibration and energy efficiency indicators will allow to objectively evaluate the technical state of the pump equipment of the irrigation systems, timely determine the terms of maintenance and overhaul.

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