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DYNAMIC ANALYSIS OF HIGH POWER VERTICAL MIXED FLOW PUMP

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Abstract

In this article the vertical mixed flow pumps and problems accompanying during working of the devices vere presented. At the begining few issues which are consider in this type of machines were mentioned. The results of measurements a velocity of vibrations on the pump were presented in next point of the paper and compared with norm. Important issue in the article is modeling, therefore 3D model, discreet model of the rotor, numerical analysis of the rotor, four-masses discreet model and equations of the free motion of the rotor were presented. For finding stiffness and suppression parameters of bearings the special research stand were built and shown in the article. Range of future works was also described.

Keywords: *vibrations, dynamic analysis, impeller pump, mixed flow pump, structural model*

1. Introduction

The object considered in this work is mixed flow pump with two impellers, which works in company from Włocławek. Large dimensions, complicated structure and mechanical processes which accompany during working of the device provide too difficult dynamic analysis of the machine. Additionaly is not possible to measure vibrations on part of the device which is plunged in the water. Rotary motion of the mojor shaft with two impellers is a basic motion in the pump. In these devices, a special attention is directed on:
- stability of rotor and critical rotations,
- unbalancing of blades and the rotor,
-defining the level of dynamic loading of bearings and the support structure,
- identyfication loads generated during working of the machine [2].

2. Specifity of research object

High power - 1250kW and efficiency - 5000 m^3/h are characteristic for the device.
These parameters have influence on the way of supporting the pump, the device is spupported on two foundations. Basic parts of the machine: electrical motor which is based on upper foundation (fig. 1.) and pump – supported by bottom foundation (fig. 2.).

Fig.1. Electrical motor of mixed flow pump

Fig.2. Part of machine to escape the water

In one hall were installed 8 same pumps, because demand of water is different. The measure of vibrations is difficult when few devices are working together. Ratory speed of the pump is established on 740 rpm.

3. Results of measures

Measures of vibrations were based on norm PN – ISO 10816-1:1998, which describe border levels of intensity of vibrations for classified devices (tab. 1). The considered pump is classified as III class, but intesity of vibrations in B zone (for devices admitted to long exploitation).

Tab. 1. Border values of intensity of vibrations according to PN-ISO 10816-1:1998

<table>
<tr><th>Velocity of vibrations RMS in mm/s</th><th>Class I</th><th>Class II</th><th>Class III</th><th>Class IV</th></tr>
<tr><td>0,28</td><td rowspan="3">A</td><td rowspan="4">A</td><td rowspan="5">A</td><td rowspan="6">A</td></tr>
<tr><td>0,45</td></tr>
<tr><td>0,71</td></tr>
<tr><td>1,12</td><td rowspan="2">B</td></tr>
<tr><td>1,8</td><td rowspan="2">B</td></tr>
<tr><td>2,8</td><td rowspan="2">C</td><td rowspan="2">B</td></tr>
<tr><td>4,5</td><td rowspan="2">C</td><td rowspan="2">B</td></tr>
<tr><td>7,1</td><td rowspan="5">D</td><td rowspan="2">C</td></tr>
<tr><td>11,2</td><td rowspan="4">D</td><td rowspan="2">C</td></tr>
<tr><td>18</td><td rowspan="3">D</td></tr>
<tr><td>28</td><td rowspan="2">D</td></tr>
<tr><td>45</td></tr>
</table>

Measure points of vibrations are shown on figure 3, results of measures in table 2.

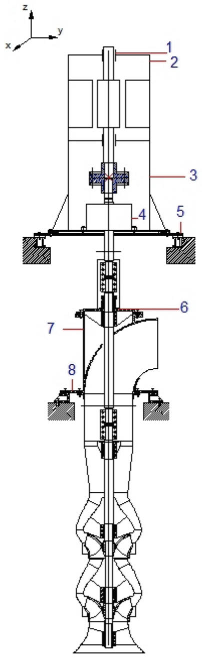


Fig. 3. Measure pionts of vibrations

Tab. 2. Results of measures

Measure point	Direction of measures vibrations					
	x		y		z	
	Veloc. [mm/s]	Accel. [m/s^2]	Veloc. [mm/s]	Accel. [m/s^2]	Veloc. [mm/s]	Accel. [m/s^2]
1	4,0108	1,2332	5,5884	1,8884	-	-
2	5,0412	1,3568	5,158	1,6092	-	-
3	1,394	1,2896	1,5112	1,7412	-	-
4	1,276	0,61	1,1312	0,7532	-	-
5	-	-	-	-	2,2176	0,7012
6	0,6392	0,7288	1,3912	0,6996	-	-
7	1,1968	0,4456	0,7972	0,7984	-	-
8	-	-	-	-	0,4552	0,5628

4. Modelling

For creating spatial model (fig. 4.) of the pump, documentation 2D were used. The model was useful to numerical analysis and wizualization how the device works. Additionally, the model is used to fast estimate physical properties of elements like for example: moments of inetria or centers of masses.

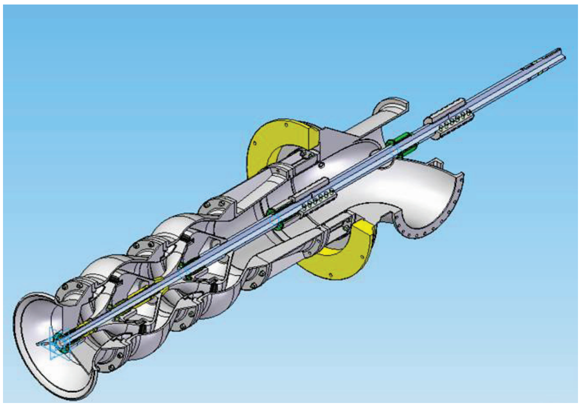
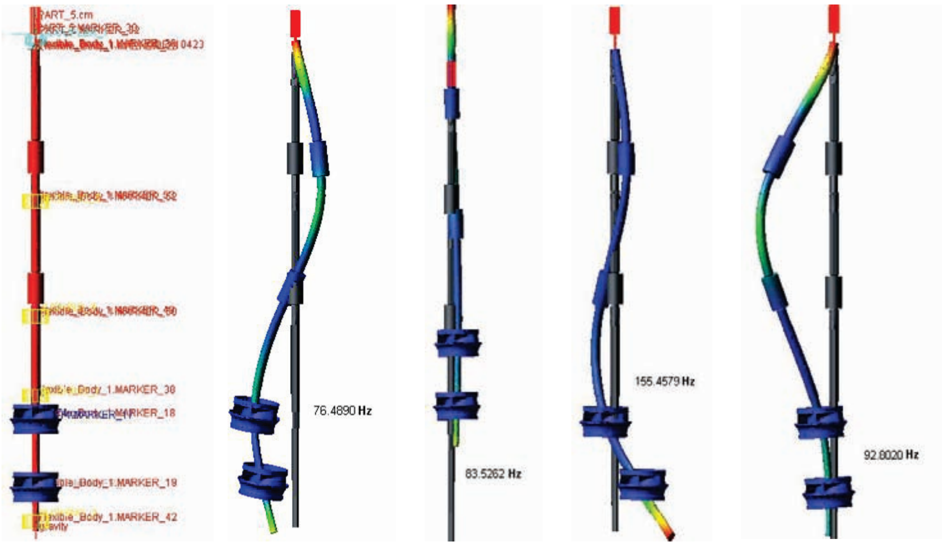


Fig.4. Cutting view of vertical mixed flow pump

Basic part of the pump is consisting from three rotors, which are connected by stiff clutches and two impellers. Whole part was numerical analyzed in MSC.ADAMS program. Parameters of stiffness and suppression were taken from literature: $k=1\cdot10^5$ N/mm, c=1Ns/mm. Results of the analysis are shown on figure 5.



Rys. 5. Numerical analysis in MSC.ADAMS program

Results of the numerical analysis and energetical Rayleigh's method were used to creation four-masses discreet model of rotor stiffness supported (fig. 6.).

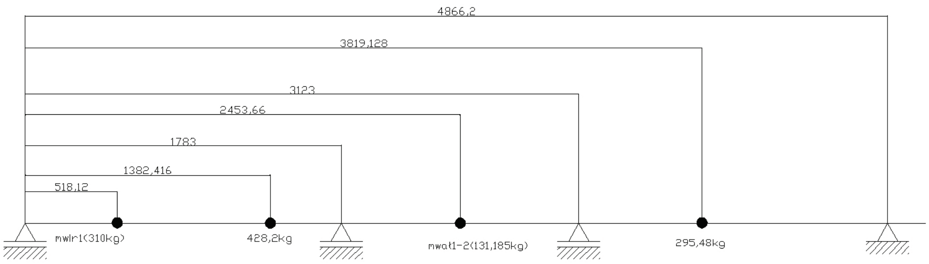


Fig. 6. Discreet model of rotor

For the model equations of the free motion were written (1):

$$\begin{aligned}
&\delta_{11}m_1\ddot{y}_1+\delta_{12}m_2\ddot{y}_2+\delta_{13}m_3\ddot{y}_3+\delta_{14}m_4\ddot{y}_4+y_1=0\\
&\delta_{21}m_1\ddot{y}_1+\delta_{22}m_2\ddot{y}_2+\delta_{33}m_3\ddot{y}_3+\delta_{24}m_4\ddot{y}_4+y_2=0\\
&\delta_{31}m_1\ddot{y}_1+\delta_{32}m_2\ddot{y}_2+\delta_{33}m_3\ddot{y}_3+\delta_{34}m_4\ddot{y}_4+y_3=0\\
&\delta_{41}m_1\ddot{y}_1+\delta_{42}m_2\ddot{y}_2+\delta_{43}m_3\ddot{y}_3+\delta_{44}m_4\ddot{y}_4+y_4=0
\end{aligned} \tag{1}$$

where:
δ_{ij} – Maxwell's coefficients,
m_i – discreet masses,
y_i – statical deformation of rotor,

and solved. At present the model is werryfied.

The discreet model is simply in relation with real object. Therefore, in next step the parameters of stiffness and suppression of supports will be regarded. Parameters of k and c were taken from literature. Verification of the parameters will be done in experiments. Price of real bearings in high, therefore research stand for bearing with different diameter, clearance between toe and bearing, pressure of reinforced water, rotary speed of rotor was built (fig. 7.).

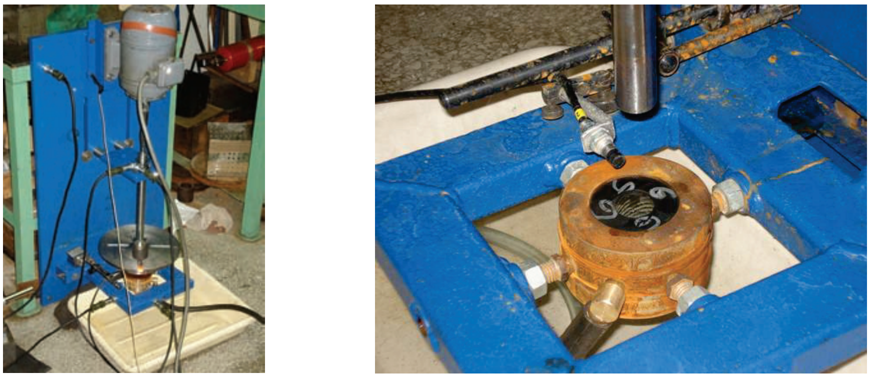


Fig. 6. Research stand

For different diameters of bearings, it is planed to find formula which will be use for finding k and c parameters.

5. Range of future works

Next works will concern the following topisc:
- creation of mathematical model which will nclude stiffness and suppression parameters,
- identyfication of bearings parameters,
- identyfication loads generated during working of the machine,
- reserching of stability of rotor and critical rotations,
- reserching of inluences between different places of supports and durability of plugging and bearing,
- reserching of inluences kinematical random impacts from trunk and rotor's vibrations,
- describing guidelines for construction changing.

6. Conclusions

1. Problems with veryfication of ceated model exist, because is not possible to measure vibrations on all parts of the object.
2. Measures of velocity of vibrations showed that them (these, their?) values are higher than those described in norm.
3. Created discreet model will be developed by consider parameters based on reserches.
4. Beginning calculations showed that torsional vibrations can be skipped.

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