17th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2013, Istanbul, Turkey, 10-11 September 2013

DIAGNOSTICS OF CENTRIFUGAL MILK SEPARATORS

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ABSTRACT
The paper investigates vibrational behaviour of vertical rotor bearings of centrifugal milk separator. There are presented vibration isolation mechanism transmissibility and vibration measurements results obtained directly and through the isolation system. Conclusions were drawn after analysing the vibration levels.
Keywords: vibration transmissibility, vibro-diagnostics, milk separator

1. INTRODUCTION
Defects of vertical rotors with rolling bearings and vibration isolation mechanisms used in centrifugal milk separators are usually detected using non-destructive diagnostic techniques [1-3]. In the most cases vibrations of the rotor or its housing are measured at regular time intervals, and then vibration spectra are analyzed. The defects can be determined by comparing the amplitudes of frequency spectra, which increase shows the deterioration of rotor system and cause of such deterioration much earlier to the deterioration will be a critical. However, it is known [4,5] that vibration measurements results and diagnostic findings are not always consistent with the defects identified in the rotor system during maintenance. The following vibration parameters are usually measured for the purposes of diagnostics and non-destructive testing: the frequency, the maximum absolute (peak) value of vibration amplitude (vibration velocity, acceleration) or the difference between the highest and lowest vibration amplitude (velocity, acceleration) values, the root mean square amplitude value or RMS. Vibration velocity allows assessing dynamics of the system at, by comparison, a small frequency range. Vibration velocity root mean square (RMS) value is used to assess vibration severity, because vibration velocity directly defines vibration energy and is a measure of vibration destructive power. It is particularly important to measure rotor vibrations directly, not the vibrations of bearing housing. However, in practice usually it is not possible to measure the rotor vibrations directly; therefore it is necessary to judge the state of the rotor system by results of indirect measurements assessing the influence of vibration isolation system and its transmissibility. The aim of present work was to investigate vibration isolation system transmissibility and possibilities of direct and indirect vibration measurements.

2. OBJECT OF RESEARCH
Centrifugal milk separator shown in Figure 1, a was taken as object of research. Its vibration isolation system is presented in Figure 1, b and c.

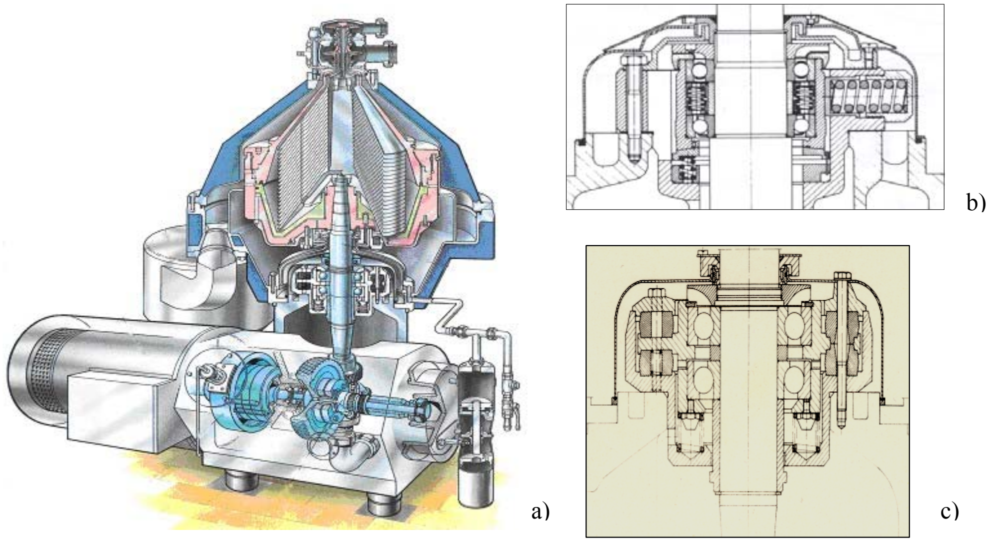


Figure1. Scheme of centrifugal milk separator (a) and its vibration isolation system (b, c)

3. INVESTIGATION OF VIBRATION ISOLATION SYSTEM

Dynamic models of milk separator vertical rotor vibration isolation system (Figure 1, b and c) are presented in Figure 2.

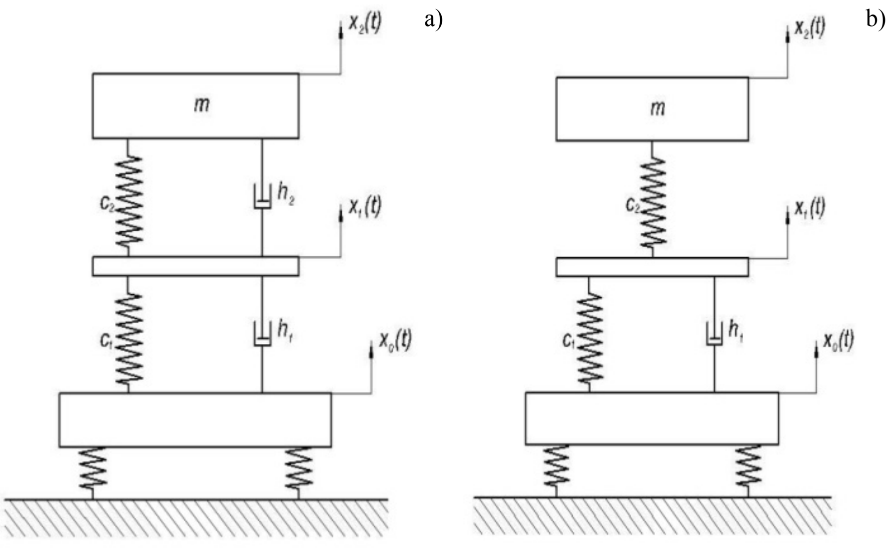


Figure 2. Dynamic models: a) – viscous elastic damping; b) – elastic damping; $x_0(t)$ – rotor excited vibrations; $x_1(t)$ – rotor bearings vibrations; $x_2(t)$ – vibrations of isolation system and housing; m – mass; c_j – stiffness; h_j – damping coefficient

Equation of motion of vibration isolation system (Figure 1, b and c) can be written as follows:

$$m\ddot{x}_2(t) + h_j\dot{x}_2(t) + cx_2(t) = (c + ih_j\omega)x_0 \exp i\omega t, \tag{1}$$

where $c = \dfrac{c_1 c_2}{c_1 + c_2}$.

Transmissibility factors of this system were determined as described in literature [3]. When the kinematical harmonic excitation of vertical rotor $x_0(t) = x_0 \sin \omega t$ acts on vibration isolation system, the relative acceleration amplitude transmissibility can be expressed as follows:

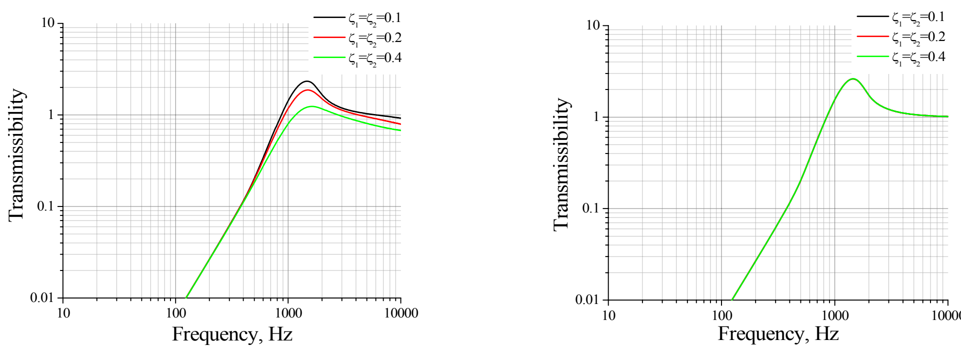
$$T_{x2-x0} = \sqrt{\frac{\left[\left(\dfrac{\omega_1}{\omega_{01}}\right)^2 + \left(\dfrac{\omega_2}{\omega_{02}}\right)^2\right]^2 + 4\left(\dfrac{\omega_1}{\omega_{01}}\right)^2 \left(\dfrac{\omega_2}{\omega_{02}}\right)^2 \left(\xi_1 \dfrac{\omega_2}{\omega_{02}} + \xi_2 \dfrac{\omega_1}{\omega_{01}}\right)^2}{1 + 4\xi_1^2 \left(\dfrac{\omega_1}{\omega_{01}}\right)^2 \left[1 + 4\xi_2^2 \left(\dfrac{\omega_2}{\omega_{02}}\right)^2 + \left[\left(\dfrac{\omega_1}{\omega_{01}}\right)^2 + \left(\dfrac{\omega_2}{\omega_{02}}\right)^2\right]^2 + \Omega\right]}}, \tag{2}$$

where ξ_j is the dimensionless damping coefficient ($\xi_j = \dfrac{h_j}{2\sqrt{c_j m}}$, $j = 1, 2$); ω_{0j} are the natural frequencies of rotor bearings and vibration isolation system; ω_j are the frequencies of rotor bearings and vibration isolation system.

In the case when vibration isolation system only has a hysteretic damping (Figure 2, b), the relative acceleration amplitude transmissibility is equal to:

$$T_{x2-x0} = \sqrt{\frac{\left[\left(\dfrac{\omega_1}{\omega_{01}}\right)^2 + \left(\dfrac{\omega_2}{\omega_{02}}\right)^2\right]^2 + 4\xi_1^2 \left(\dfrac{\omega_2}{\omega_{02}}\right)^4 \left(\dfrac{\omega_1}{\omega_{01}}\right)^2}{1 + 4\xi_1^2 \left(\dfrac{\omega_1}{\omega_{01}}\right)^2 \left(1 + \left(\dfrac{\omega_2}{\omega_{02}}\right)^4\right) + \left[\left(\dfrac{\omega_1}{\omega_{01}}\right)^2 + \left(\dfrac{\omega_2}{\omega_{02}}\right)^2\right]^2 - \Omega_1}}. \tag{3}$$

Calculation results are presented in Figure 3.



a) b)

Figure 3. Relative transmissibility as function of frequency: a) – viscous elastic damping; b) – elastic damping

4. VIBRO-DIAGNOSTICS MEASUREMENTS

Vibration measurement results are presented in Figure 4. It can be seen from Figure 4 that the most damaged elements are the balls of the rolling bearing and the inner bearing rings. However when the mechanism works in the usual regime the direct measurement of vibration parameters of the bearings is impossible. So, it is necessary to measure through vibration isolation system.

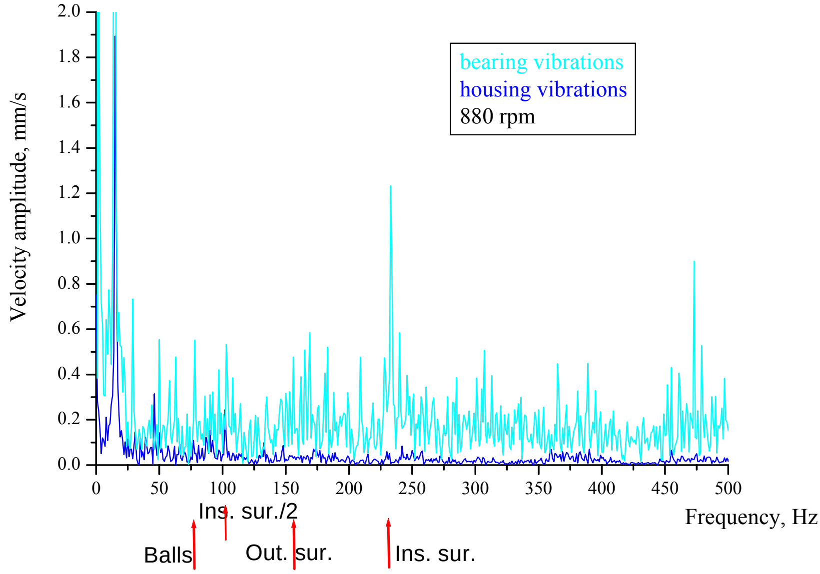


Figure 4.The vibration velocity spectra

5. CONCLUSIONS

1. Transmissibility of vibration isolation system shows that resonant frequency is much higher than rotational frequency of the rotor.
2. It is established the significant influence of vibration isolation system on precision of vibro-diagnostics measurements.

6. REFERENCES

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