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The whole-beat correlation method for the identification of an unbalance response of a dual-rotor system with a slight rotating speed difference

Z.X. Zhang [a,b,*], Q. Zhang [a,b], X.L. Li [a,b], T.L. Qian [a,b]

[a] Institute of Chemical Machinery Engineering, Zhejiang University, Hangzhou, Zhejiang 310027, People's Republic of China
[b] Engineering Research Center of High Pressure Process Equipment and Safety, Ministry of Education, Hangzhou, Zhejiang 310027, People's Republic of China

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ABSTRACT

Identification of the unbalance mass is pivotal in the balancing of a dual-rotor system with a slight speed difference. In the first part, this paper presents the whole-beat correlation method for the whole-machine balancing of the dual-rotor system based on correlation theory. In the second part, an optimized whole-beat correlation method is proposed based on error analysis. In the last part, a balancing experiment is conducted on the horizontal decanter centrifuge, validating the precision, efficiency, and applicability of the recommended method.

1. Introduction

There is a special dual-rotor system in industry. As shown in Fig. 1, this co-axial dual-rotor system comprises an outer rotor together with an inner rotor conforming to the profile of the outer rotor by bearings on the two sides, rotating at a slightly differential speed compared with the outer rotor. The outer rotor is equipped on the bearing pedestal [1,2].

When the inner and outer rotors both are in presence of unbalance mass, there will be a combined vibration described as Eq. (1), which can be tested from the outer bearing pedestal:

$$x(t) = x_1(t) + x_2(t) = A_1 \sin(\omega_1 t + \varphi_1) + A_2 \sin(\omega_2 t + \varphi_2) \tag{1}$$

where $x_1(t)$ and $x_2(t)$ are the vibration signals and $A_i(i=1,2)$ the amplitude, $\omega_i(i=1,2)$ the rotating angular frequency, and $\varphi_i(i=1,2)$ the vibration phase relative to the key-phase. The subscripts 1 and 2 represent the outer and inner rotor, respectively, and $\omega_2 > \omega_1$.

Eq. (2) can be obtained according to the trigonometric formula:

$$x(t) = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos((\omega_1 - \omega_2)t + (\varphi_1 - \varphi_2))} \sin\left(\left(\frac{\omega_1 + \omega_2}{2}\right)t + \left(\frac{\varphi_1 + \varphi_2}{2} + \Delta\varphi\right)\right) \tag{2}$$

where

$$\Delta\varphi = \arctan\left(\left(\frac{A_1 - A_2}{A_1 + A_2}\right)\tan\left(\left(\frac{\omega_1 - \omega_2}{2}\right)t + \left(\frac{\varphi_1 - \varphi_2}{2}\right)\right)\right)$$

* Corresponding author. Tel.: +86 57187952821.
E-mail address: birdflyzzx@zju.edu.cn (Z.X. Zhang).

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