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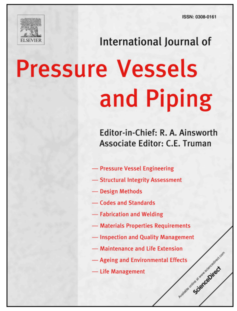

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Experimental Study of Dual-Impeller String Vibration in a Baffled Mixing Vessel

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Abstract

Vibration characteristics of a 45° pitched blade impellers (PBIs) operating in a standard baffled mixing vessel were studied. Experiments were conducted for eight different impeller configurations with combinations of: no of impellers (single or double), diameter to tank diameter ratios $D/D_T = 1/2$ and 5/7, and impeller spacing of 0, 0.75D, and 1.5D. The impeller orbit frequency and shape, mean square deflection, and phase relationship were studied with a glycerine-water mixture having Reynolds number, $Re \leq 5000$, and $N/N_{crit} \leq 1.2$. Two high speed cameras were used to measure two orthogonal components of lateral impeller deflection. It was observed that the impeller orbits are periodic at low speed and exhibit chaotic motion at high speed which can be modelled using a random normal distribution. The mean square deflection continues to grow beyond $N^* > 1$ exponentially, and the addition of a second impeller increases the mean square deflection. Frequencies associated with impeller orbits for the $D/D_T = 1/2$ showed that at low rotational speeds, the highest energy in power spectra of the impeller deflection is at twice the impeller rotational speed. With an increase in rotational speed, the energy in the power spectra shifts to synchronous and finally subsynchronous range with a broad band character. The phase relationship and whirl direction of top and bottom impeller was found to be dependent on the rotational speed and impeller spacing.

Keywords: Mixing Vessel, Pitched Blade Impeller, Whirl, Flow Induced Vibration, Rotordynamics

1. Introduction

Mixing vessels are widely used in the chemical, food, and oil industry. The mixing is achieved by one or more mixing impellers, and the fluid flow inside these tanks is desired to be turbulent for better mixing. Radial baffles are usually attached inside the vessel's periphery which intensifies the turbulence, and inhibits large scale vortex formation. An undesired consequence of the turbulence is the pulsating loads on mixing impeller which lead to torsional and bending vibrations of the impeller shaft, and the possibility of whirl instability. Vibrational characteristics of these mixing impellers is not well understood, and the existing methods to predict impeller shaft vibration amplitude and frequency are limited to a single impeller only (Kippers & Holloway, 2014). However, the mixing reactors used in industry often consist of multiple impellers on a single shaft. Vibrational characteristics of these multiple impellers are made significantly different by complex fluid flow patterns and modal vibration.

Early analytical studies of the vibration of rotating systems were conducted by August Föppl (Germany) in 1895 and Henry Jeffcott (England) in 1919. The theory developed was for the prediction of vibration for a simple rotor/bear-

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