Mechanical Systems and Signal Processing 54-55 (2015) 367–376

Contents lists available at ScienceDirect

Mechanical Systems and Signal Processing

journal homepage: www.elsevier.com/locate/ymssp

Characterization of a water pump for drum-type washing machine by vibration power approach

YongHwa Heo, Kwang-joon Kim*

NoViC, Department of ME, KAIST, Daejeon, Korea

ARTICLE INFO

Article history:
Received 18 March 2013
Received in revised form
6 July 2014
Accepted 7 October 2014
Available online 23 October 2014

Keywords:
Vibration source characterization
Blocked force
Free velocity
Vibration power
Source mobility

ABSTRACT

Water pumps used in drum-type washing machines to save water are likely to make the washing process noisier than the one without those because the water pumps attached usually onto cabinet structure work as additional vibration and noise sources. In order to either counteract such vibration and noise problems by stiffness design of the cabinet structure or classify the water pumps from the view point of an acceptance test, characterization of the water pumps as excitation sources would be essential. In this paper, several methods to characterize a water pump as an excitation source are investigated. Measurements by traditional methods of blocked force and/or free velocity for a water pump of 35 W are presented. Two methods of vibration power suggested rather recently are reviewed. Then, another method of the vibration power is proposed. Estimations of the vibration power for the water pump operating on a beam structure are obtained and discussed comparatively.

1. Introduction

According to the requirement on product noise labeling conducted for home appliances in Europe, the noise level of drum-type washing machines will be also labeled soon [1]. Noise of drum-type washing machines is induced mostly by movement of water and clothes during washing, spinning of drum and operation of water pump. The water pump, attached onto cabinet structure of the washing machine in order to make the washing process more water-saving, works as an additional vibration and noise source. The primary step toward counteraction with such structural noise problem would be characterization of the water pump as a vibration source.

In this paper, characterizations of a water pump of 35 W as a vibration source are investigated. First, measurements of blocked force and/or free velocity of the water pump, which are rather conventional approach, are presented. Then, two rather recent methods of vibration power are reviewed and the another new method is proposed. Estimations of the vibration power for the water pump operating on a simple beam structure are presented for comparative investigations.

2. Conventional characteristics of a water pump as vibration source

A vibration source has been conventionally characterized by blocked forces and/or free velocities, measurements of which for a water pump of 35 W used in a drum-type washing machine are presented in this section.

* Correspondence to: The Center for Noise and Vibration Control (NoViC), Department of ME, KAIST, Science Town, Daejeon, Korea. Tel.: +82 42 350 3024.
E-mail address: kjkim@kaist.ac.kr (K.-j. Kim).

http://dx.doi.org/10.1016/j.ymssp.2014.10.001
0888-3270/

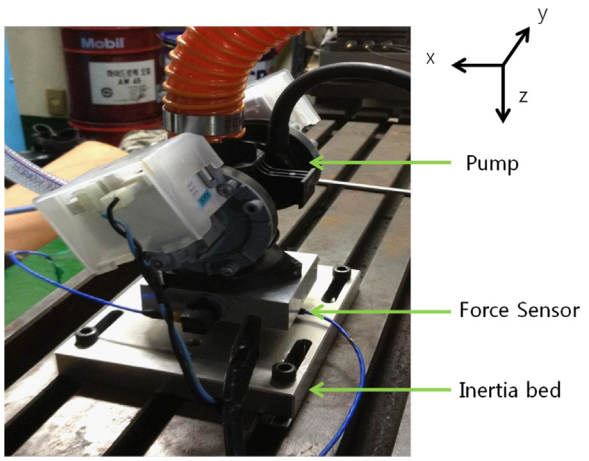

Fig. 1. Experimental set-up for measurement of blocked forces on inertia bed.

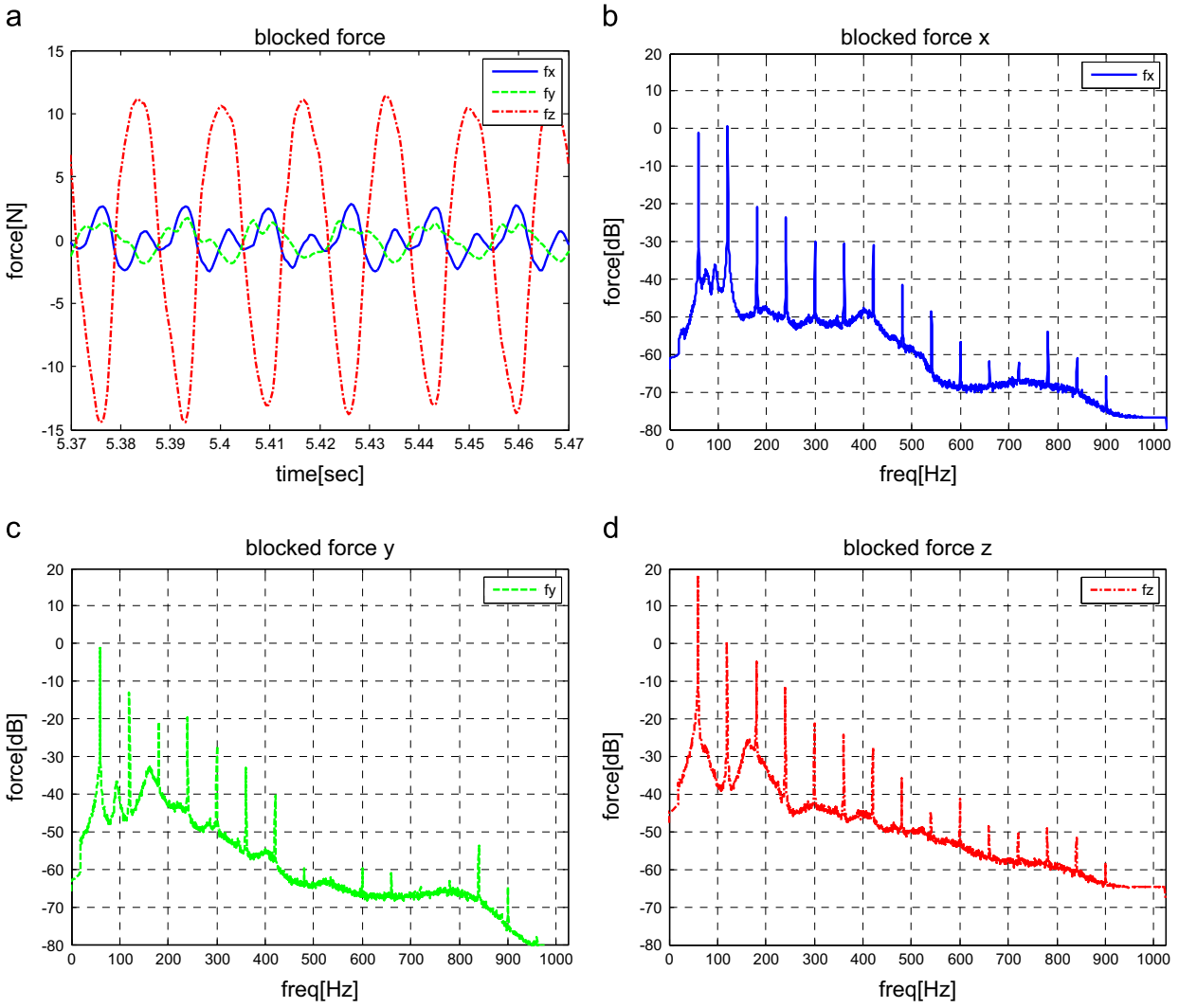

Fig. 2. Blocked forces at a point on inertia bed in *x*, *y*, and *z* directions. (a) Blocked forces in *x*, *y*, and *z* directions in time domain. (b) Blocked force in *x* direction in frequency domain. (c) Blocked force in *y* direction in frequency domain. (d) Blocked force in *z* direction in frequency domain.