REVIEW ON VIBRATION REDUCTION OF A VERTICAL AXIS DRUM BASED WASHING MACHINE

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ABSTRACT

Today, there is a rapid increase in the demand for saving energy in all industries and industrial applications and even in home appliances such as microwaves, refrigerators, air conditioners, power tools, vacuum cleaners and washing machines. In a fully automatic washing machine, an unbalanced mass of clothes in a spin drum can cause vibration problems. Each time a washing machine enters its spin cycle, it begins to create high frequency vibrations. The unbalanced mass of clothes causes vibration because in the spin drying stage, the drum spins at a relatively high speed causing the clothes to be pressed against the inner wall of the spin drum and this can become a large unbalanced mass until the end of the stage. In this review paper the causes of mechanical vibrations and different methods to reduce vibrations in washing machine are studied. From the research it is concluded that adding springs and dampers to the machine can cause the major reduction in the vibrations.

Keyword: -*Vertical axis washing machine, Vibration, Design, Analysis;*

1. INTRODUCTION

The development of high speed spinning washing machines is a big problem in the current market scene. There has also been a rapid increase in the demand for saving energy in all industries and industrial applications and even in home appliances such as microwaves, refrigerators, air conditioners, power tools, vacuum cleaners and washing machines.

When a machine is taken apart, one can find a number of different parts inside of it. Each of these parts is used in a number of different ways, but the end goal is to have each part working accurately, cohesively and safely. If a machine is off balance or is vibrating more than requisite, it may cause damage to any number of the parts inside it as well as to the floor on which it has been placed. Once there is damage, repairs will need to be made. A machine cannot be safely repaired while still in use so even the smallest of repair means a loss in productivity. Reducing machine vibration controls the damages that can be seen in machines and their surrounding environment while maximizing the production efficiency.

Washing machines are an important type of domestic machines and have been used for the welfare of the human beings for many years now. In a fully automatic washing machine, an unbalanced mass of clothes within a spin drum can cause vibration problems. Because of the nature of the operation of the machine, its laundry behaves like a rotating unbalance during the spinning cycle of its operation. This transmits very large forces to the cabinet and emits noise. This frequently occurs during the water extraction process when the drum starts to rotate and this gives rise to significant centrifugal imbalance forces and the laundry mass rotates in an imbalanced manner. This results in vibration and shaking. The elimination of such vibrations will make it possible to design less noisier washing machines for higher wash loads within the same housing dimensions. Therefore, the suspension parameters of the drum have to be properly designed to limit the vibration transmissibility and increase the isolation efficiency.

Current environmental awareness demands the improvement of washer efficiency. The first thought that comes to mind with respect to efficient is optimization. The basic factors that can be considered for the optimization of a washing machine are its washing capacity, power consumption, cost and vibration. The industrial drive technology can be classified into two different groups. The first of these groups includes machines driven electrically and requiring speed control systems for different applications like machine tools and measuring machines for which accuracy in movement is imperative. The second group consists of consumer electrical systems, for example pumps, washing machines, vacuum cleaners and fans in which precision torque or speed control systems are not necessary. Poor efficiency and distortion are some of the common disadvantages of these systems. High efficiency, reduced noise, extended lifetime, rapid time to market at optimum cost are the issues faced by many industries.

Low vibration characteristic is becoming an increasingly important performance measuring index for washing machines. In an automatic washing machine, the drying process comprises of the spin motions of a basket, while the washing process involves the oscillating motions of the basket. The power is transmitted, through a belt from a motor, to the identical rotating axis of the basket during both the washing and spin drying. After the washing mode, the laundry is dried by the spin drying mode. In the washing cycle, the clothes tend to form a clump, and hence create an unbalance mass in the basket. During the drying cycle, when the basket spins with relatively high speed, this unbalanced mass can cause serious vibration problems. The amount of the unbalance mass depends on both the weight of the laundry and the condition of the washing machine.

2. LITERATURE REVIEW

Bagepalli et al. [5] has investigated the dynamic modeling of agitator-type washers. He studied two concepts for suspension systems: non-translating "xed node design (NTFN) and translating free node design (TFN). He concluded that the NTFN concept is useful for minimizing the walking force, whereas the TFN concept, which was found to be the preferred design, is useful for minimizing transient excursions.
Turkay et al. [6] has presented a dynamic model for horizontal axis washers. They carried out theoretical and experimental dynamic analyses for transient and steady state conditions. Later, the validated model was used to optimize the spring stiffness of suspension and the two dry-friction coefficient of shock absorber and lateral damper. They used an optimization routine that minimizes the maximum displacements for transient and steady state conditions subjected to the constraint of inequality of stepping forces.

Conrad and Soedel et al. [7] has discussed extensively the qualitatively observed characteristics and mechanism of walk by using simplified models for both horizontal and vertical axis washers. Based on numerical simulations, they concluded that the vertical axis washing machine tends to walk inbounded region while the horizontal axis washing machine tends to walk unbounded ina direction dictated by the rotational direction of the wash basket.

Evangelos Papadopoulos et al. [8] modeled a horizontal axis washing machine focusing on port-ability. He proposed an innovative method of minimizing vibrations i.e. an improved estimation of the drum angular position and velocity results in greatly reduced residual vibrations. Finally, the study noted that the passive and active methods of stabilization are inexclusive and hence, they could be employed in parallel, which would improve the washer`s spinning response. But, the problem with this technique was that it led to a drastic increase in the cost.

S. Bae et al. [4] performed dynamic analysis of an automatic washing machine during spin drying mode. It is given that the centrifugal force acting on the hydraulic balancer is directly dependent on the fluid's centroidal distance in the hydraulic balancer, and the centroidal distance is a function of the eccentricity of the geometric center of the hydraulic balancer from the axis of rotation. A mathematical model of the hydraulic balancer in steady state was validated by the experimental result of the centrifugal force. The results of the experiments performed on a washing machine during spin drying mode were compared with the simulation result. An investigation of the parameters affecting the vibration of the washing machine was also done within the parameter study. It was concluded that that the vibration would be reduced by increasing the mass and the inner radius of the hydraulic balancer, and by decreasing the volumetric ratio.

Fig 1. The hydraulic balancer

Seok-Ho Son et al. [9] formulated a design optimization problem in which the maximum displacement of the spin component in a low-RPM setting was minimized while satisfying the design constraint on the maximum displacement of the spin component in a high-RPM setting. They successfully obtained optimal results using the meta-model based design optimization and performed another experiment to verify the validity of the results by installing optimally designed layers.

Sichani et al. [10] in his work explained vibration responses of a horizontal washing machine which have been measured during run-up and run-down. Multiple impulse tests were also conducted to compare and check the validity the results. The identification of modes of the washing machine was done both by the EFDD and SSI methods with operational tests. Modes of the body between 0 to 55 Hz were identified along with their damping ratios, natural frequencies and shapes in both the methods. A comparison of the results of OMA and the classical modal testing (impact test with an instrumental hammer) was conducted. Also, the applications of stochastic subspace identification and stabilization diagrams were investigated. The false peaks and closely coupled modes were easily detected. It is concluded that run-up/run-down can identify modes of a vibrating system except for cases where the modes are located close to the working frequency of the rotating parts of the system.

Cristinospelta et al. [1] (2008) has studied the various effects of vibrations on a washing machine and techniques to reduce the damage. They proposed to reduce vibrations by replacing passive dampers with magneto rheological dampers. Their work is the analysis and design of a control system for vibration and noise reduction in a washing machine. The implementation of the control system is done via a semi-active magneto rheological (MR) damper located on the suspension that links the drum to the cabinet. The system analyzed and different mounting positions of the dampers have been tested. The design and testing procedure of two different adaptive algorithms has been proposed. The control system is implemented on a rapid prototyping ECU and its testing is done on a washing machine instrumented with three 3-axis MEMS accelerometers. Tests in an anechoic chamber have been done, in order to study the effect of vibration control on the acoustic noise. It is concluded that the electronically controlled magnetorheological dampers are more effective than the standard passive dampers.

Fig 2: The controllable RD-1097-01 friction damper by Lord.

FengTyan et al. [13] in his work explained a multibody dynamic model developed for a front loading type washing machine in detail. This model was constructed for verifying the bearing model between the tub and drum, and for analyzing the suspension system created by two springs and magnetorheological dampers between the case and basket. A multibody dynamic model of a drum-type washing machine with MR fluid dampers was generated in a commercial package “RecurDyn”. The resultant displacements from Recurdyn-Simulink simulation were conducted by utilizing this virtual system. It is concluded that what are required, and relocate the springs and MRdampers at the ours will efficiently. It is also concluded that the PI control strategy is the best for reducing the vibrations of the bakset and the case at the same time.

A.K.Ghorbani-Tanha et al. [14] describes about the Operation of home appliances like washing machines can produce unwanted vibrations and noise and the purpose of this study was to analyze and develop a control system for reduction in vibration of washing machines employing smart materials.

Thomas Nygards et al. [15] developed a multibody model of a commercial washing machine (front-loaded) and performed dynamic analysis (Eigen frequencies, Eigen modes, force transmission) and kinematic analysis (drum motion) of the washing machine during spinning. They developed the model to analyze dynamics and vibration of washing machines (front-load) which can be used to solve multiple problems in terms of optimization for washing machines both with conventional passive suspension as well as with active suspension systems. The model was developed basically to show the feasibility of a two-plane automatic balancing device for vibration reduction.

Sanjay Mohite et al. [16] proposed a design using multimode multiple matrix convertor. In this the output voltage was synthesized by switching the IGBTs (Insulated Gate Bipolar Transistor) in a matrix. Switching was done by control signals generated by Sinusoidal Pulse Width Modulation (SPWM) techniques where SPWM technique was used to control desired output voltage across load. A computer simulation model was developed using MATLAB. Simulated results have been observed and analyzed. It is concluded that the approach of FIRST building a simulation model and then building a large power 3 phase to single phase conversion at 20 kHz, has given the confidence that this topology can be used to build a converter to control the speed in a washing machine drive.

Sunil Patel and S.A. Kulkarni et al. [17] (2013) explained the optimization of crosspiece of washing machine by using the concept of Finite Element Analysis. One simple component was taken to obtain the correlation of optimization FEA results and the practical results. After validating simulation results of optimization, an industrial component crosspiece of a washing machine with drum assembly was considered for optimization. The material reduction objective was satisfied here by using simulation software tools like Optistruct, Hypermesh, Hyper view. The manufacturable part was obtained from the output shape from optistruct. Again simulation testing is performed for static loading. In the end, the results before optimization and after optimization were compared for crosspiece. It is concluded that the Optimization of component with the help of Finite Element Analysis is a better and less time consuming process than currently available methods. Software like Optistruct, Ls-Optiare well capable of handling complex structural parts for optimization. Parts can be designed faster and better with optimization.

SundeepKolhar and Dhiren Patel et al. [2] proposed an idea for the optimization of a washing machine in terms of reduction in power and water consumption, and drum vibration. A mathematical model was also formulated for reducing the drum vibration and an improved drum design has been proposed to further reduce the vibrations. Based on the values obtained from the mathematical model, the Finite Element Analysis of the old and the new model is performed in Solid-Works Cosmos software and it was observed that the displacement of the drum reduced to a considerable extent in the new model.

Ms. NehaVirkhare and Prof. R.W. Jasutkar et al. [18] provided a description about the washing machine system consisting of neuron fuzzy and fuzzy techniques that will enable the system to take its own decisions like release of water and washing powder as per need of cloth.

3. CONCLUDING REMARK

Following points to be noted from all the above study -

- In this paper we introduced the methods of reducing mechanical vibration in washing machine.
- We studied the different components that have been used to reduce vibration in washing machine.

From the above study we have seen that the electronically controlled magnetorheological dampers are more effective than standard passive dampers. It has been also seen that the use ball bearings along the periphery of the drum can reduce the vibrations effectively.
With the help of above study, it is planned to prepare a vibration analysis model for a vertical axis drum type washing machine. It is propose to use 4 springs and 4 dampers on the top side of th e drum. Using the created model, parameter tests will be conducted to reduce the vibration of the drum type washing machine. The obtained results should improve the performance of washing machines efficiently in terms of washing capacity, power consumption , and vibration.

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