Proceedings of the Institute of Acoustics

VARIATION OF THE EMITTED NOISE LEVELS OF APPLIANCE DRAIN PUMPS

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1.INTRODUCTION

This paper describes the reasons of variations over the emitted noise levels of the home appliance drain pumps specifically used in washing machines and dishwashers. Variation of the noise emissions of the drain pump is mostly dependent to the mechanism and operating principles of the drain pumps. Changes of these specific features can lead noticeable variations over the noise emission. Although the pump generate vibrations when operated under load, another noticeable contribution to the noise emission of drain pumps can come from the suction noise that is caused by the fact of sucking air and water when most of water has been drained. Pulsating suction noise of drain pumps can be very annoying due to fluctuations in the characteristics.

Our studies show that noise emission of appliance drain pumps generally vary with the factors of ;
- Features of mechanics,
- Operating principles of the pump,
- Inherent properties of the housing structure and the location,
- The amount of drained water,
- Ambient conditions.

Noise sources of the drain pumps , consist of the mechanic and electromagenitic components. Structure and air borne vibrations of the drain pumps can show tendency to interact with resonance frequencies of the machines. The mutual interaction of these components can lead to the amplification of the radiated sound energy through the large surface of the chassis, kick plate and side walls of cabinet.

Possible treatment methods are considered within limits of three seperate approaches of ;
- Development of passive absorbers,
- Modification of the mechanics,
- Electronic control,

Results of the studies denote that variation over the emitted noise levels of the drain pumps can be improved by fully understanding mechanism and noise sources of the object and by developing suitable treatment methods to reduce the annoying noises born due to the variations.

2.MECHANISM OF HOME APPLIANCE DRAIN PUMPS

2.1. Operating principles

Shaded pole motors usually have salient poles with one portion of each pole surrounded by a short circuited turn of copper called a shading coil. Induced currents in the shading coil cause the flux in the shaded portion of the pole to lag the flux in the other portion. The result is like a rotating field moving in the direction from the unshaded to the shaded portion of the pole, and a low starting torque is produced.

In synchronous motor, the steady state speed is determined by the number of poles and the frequency of the armature current. Thus, a synchronus motor operated from a constant frequency AC source must run at a constant steady-state speed.

2.2.Basic features

Drain pumps are consist of pump housing and the pump motor. Pump also includes the impeller and fan units. Impedance protected synchronous motors and shaded pole drain pump motors developed for dishwashers have no fan units and thermic protection due to noticeably short drain time of dishwashers.

Drain pumps are mounted rigidly to the tub units. In dishwashers direct mounting over pump assembly is provided, but in washing machines mounting is provided by the use of drain hoses between the tub and pump unit.

2.3.Noise sources

Noise contribution of the drain pumps generally come at lower frequencies. The origins of the airborne noises in drain pumps are impeller and fan units. Fan and impeller noises are both dependent to the rotational speed of the pump and could be calculated from the formula of ;

$$f_b = n \times N \qquad (1)$$

where f_b is the blade passing frequency in hertz, n is fan speed, number of revolutions per second, N number of blades in fan or impeller. Blade passing frequency is repetition rate of impulses caused by blade that passes from a given point by providing an impulse in the air at this point. The blade frequency determines the fundamental tone which is produced. Doubling the number of blades of a fan, or doubling the rate which it rotates , doubles the frequency of the fundamental. Also , the harmonics can be produced which depend on the geometry of fan and impeller units. Cooling fan can also effect the turbulence which results in the generation of noise and increased static pressure drop in the system. Thus the airflow at the inlets and outlets of a fan should be as smooth as possible to minimize the generation of turbulence.

Pump also generates significant vibrations while operating under load. All these vibrations are specific low frequency contributors of the appliances. The primary noise source of the pumps involves the hydrodynamic pulsations which are inherent in all pumps. Pulsating noise is due to the combined suction of air and water towards the end of the cycle. It varies with the diameter of suction hose and amount of water left in the pump housing. When the water is completely drained out, it shows tendency to fall back.

Other sources of pump noise that may impart vibration to the pump's support structure and interaction with the surrounding structure.

3.PROBLEM IDENTIFICATION

3.1.Classification of the noise sources

Table-1 shows the basic noise sources of the home Appliance Drain Pumps and the frequencies where these faults generally arises .

Noise source	Classification	Frequency
Fan noise	Airborne	$n \times N$ hz.
Impeller noise	Airborne	$n \times N$ hz
Magnetic interaction	Radiation	$n \times f_s$ hz

Noise source	Classification	Frequency
Pulsating suction noise	Air & Structure borne	$n \times f_s$ hz
Radiated sound energy	Air & Structure borne	$n \times f_s$ hz
Imbalanced motor bearings	Structure borne	rpm / 60 hz
Imbalanced impeller	Structure borne	$n \times N$ hz
Turbulence	Air borne	$n \times N$ hz
Cavitation	Vaporization	> 3 Khz
Imparted vibration to the support structure	Structure borne	$n \times f_s$ hz
Hydrodynamic pulsations	Air & Structure borne	$n \times f_s$ hz

Table-1, Noise Sources of the home Appliance Drain pumps

3.2. Characteristics of noise

Noise characteristics of the Home Appliance Drain Pumps shows fluctuations with the varying operating conditions. It, can be diffucult to set up the similar test conditions to provide the repeatability of the measurements during the cases of uncontrolled loading. Figures 1 and 2 illustrates that how the pump characteristics varies dependent to the amount of water kept at the suction hose of pump.

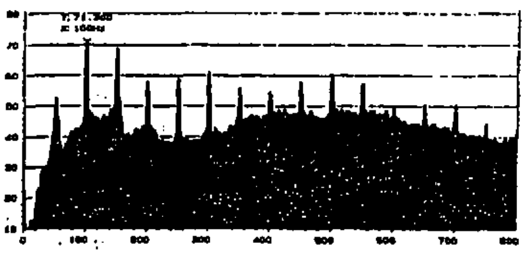

Figure-1, Vibration spectrum obtained at 5.5 lt

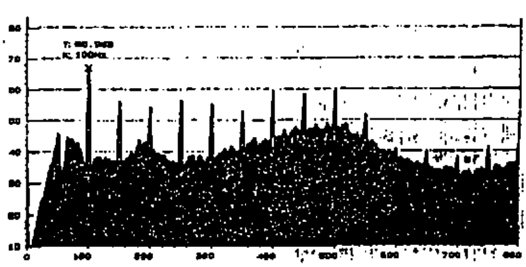

Figure-2, Vibration spectrum obtained at 0.5 lt

4.VARIATION OF THE EMITTED NOISE

Noise emission values of Home Appliance drain pumps vary directly with the load, kept at suction hose. Table-3 shows How the 100 hz component can be effected from varying amount of load

These variations are generally the resultant effect of the combined action developed by magnetic and mechanic components of the vibration. It includes the impeller blade frequencies, pulsating suction, hydrodynamic pulsations and contribution from surrounding structures, magnetic interaction.

The combined effects of all these contributions generally interact with the 100 Hz. component of the machine structure. This interaction lead to the mechanical resonances and the amplification of the noise within the product. This causes the significant drops over the noise quality of the products.

5.POSSIBLE TREATMENT METHODS

Various passive treatment methods, modifications over the mechanics and even the use of electronics to control the pump operation could be applied over the noise sources and paths. Table-2 shows list of the treatment methods that could provide noticeable reductions over the specified sources.

Noise source	Tretment methods	Achieved gain
Impeller blade tone	•Change of geometry and material	1-3 dBA
Fan blade tone	•Change of geometry and material	1-2 dBA
Magnetic interaction	•Reduce the stack height •Increase the height of pump location	1 dBA
Pulsating Suction Noise	•Closed loop control	4 dBA
Imparted vibrations	•Use of proper rubber housings	1 dBA
Radiated sound energy	•Use of passive absorbers over the surrounding structures •Isolation of the pump	1-3 dBA

Table-2, Application of possible treatment methods

Treatment methods which are applied over the sources and radiation paths are very effective over the 100 hz component that has the most dominant varying component of annoying noise .

6.CONCLUSION

Variations over the emitted noise level of appliance drain pumps , although mostly dependent to the pulsations and shows inherent chracteristics. It also keeps the contributions of the other components which are all determined within the scope of this study.

The Variation of the noise levels of the Home Appliances Drain Pumps can be very annoying specially for the users of Dish Washers and Washing Machines. When the reasons of these variations are well understood, the proper treatment methods could be developed to control these variations. The most often faced problem of providing the repeatability of the measurements can only be achieved by controlling all the test conditions, specially the amount of water kept within suction reservoir or pump housing.

Results of our studies denote that variation of the emittted noise levels of the Home Appliance Drain pumps can controlled within the limits but coud not be eliminated. Efforts to minimize these variations can also provide noticeable improvements over the annoying noise and provide noticeable reductions over the radiated sound powers of the product.