DEVELOPMENT OF EFFICIENT METHODS TO REDUCE THE EMITTED NOISE LEVELS OF APPLIANCE DRAIN PUMPS

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ABSTRACT The goal of this study is to develop treatment methods for improving the noise quality of Home Appliance Drain Pumps. Developed treatment methods covers the various methods including the control of the water level through the developed electronic circuitry and the various modifications over the design of impeller and fan units.

In the first part of the studies Dominant noise sources of the pumps are analyzed. Specific noise problems of the pumps are classified on the basis of mechanic and magnetic origins . Factors including the pressure variations at suction head , magnetic interactions with structure, specific fan noises are studied sequentially.

The second part of the studies are considered for development and application of treatment methods. Results denoted the basic problems and ways to improve the noise quality by treating the dominant sources of drain pumps.

1.INTRODUCTION

Noise sources of the drain pumps, consists of the mechanic and electromagnetic components. Structure and air borne vibrations of the drain pumps can show tendency to interact with the 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 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 noise emissions.

2.OPERATIONAL FEATURES OF 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 synchronous motor, operated from a constant frequency AC source must run at a constant steady state speed.

2.2.Basic features

Drain pumps are consists 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 dish washers 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.Identification of the 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. These two components of the drain pumps have also significant contributions to the mechanical noise.Fan and impeller noises are both dependent to the rotational speed of the pump. Blade passing frequencies could be calculated from ;

$$f_b = n \times N \qquad [1]$$

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. Figures 1 and 2 illustrates How the blade passing frequency of 100 Hz. varies in proportion with the increasing number of blades.

n_1= 50 Hz.
N_1= 2

$$f_{b1} = 50 \times 2 = 100 \text{ Hz.}$$

when the blades are changed,

n2 = 50 Hz.
N_2= 3

$$f_{b2} = 50 \times 3 = 150 \text{ Hz.}$$

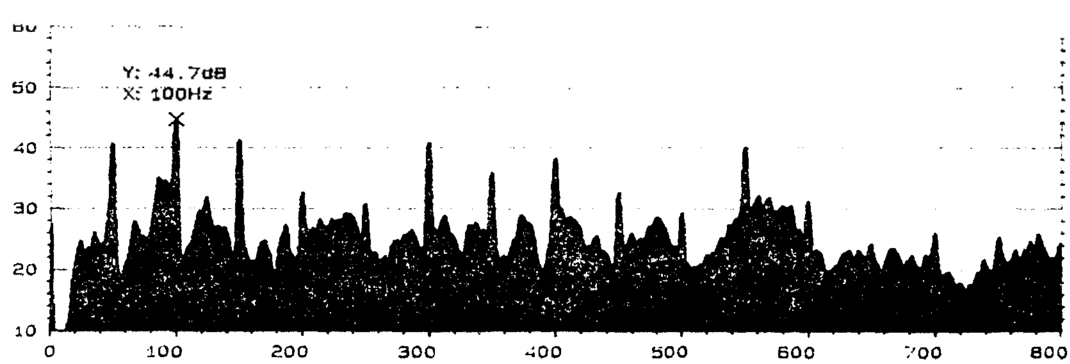

Figure-1, Fundamental frequency is 100 Hz. when the number of blades are 2

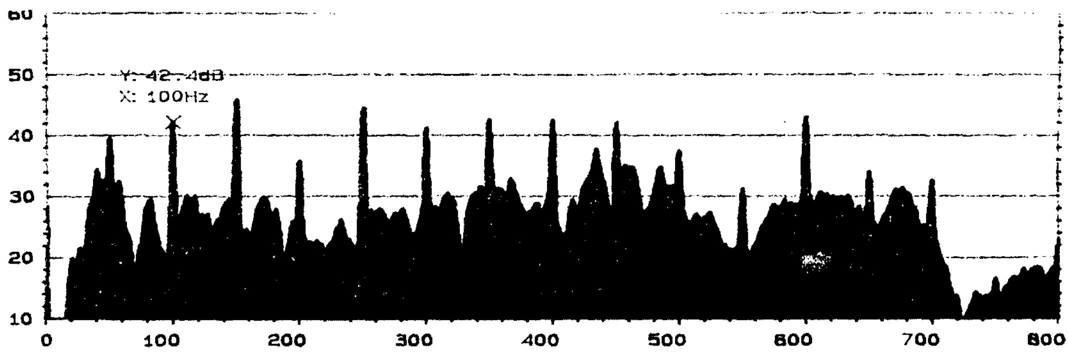

Figure-2, Fundamental frequency is 150 Hz. when the number of blades are 3

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

Noise source	Classification	Frequency
Fan noise	Airborne	n×N hz.
Impeller noise	Airborne	n×N hz.
Magnetic interaction	Radiation	$n \times f_S$ hz.
Hydrodynamic pulsations	Air & Structural borne	$n \times f_S$ hz.
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×N hz.
Turbulence	Air borne	n×N hz
Cavitation	Vaporization	> 3 Khz

Imparted vibration to the support structure	Structure borne	$n \times f_S$ hz.

Table-1, Noise sources of the home Appliance Drain Pumps

2.4.Characteristics of noise

Noise characteristics 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 water levels. Figures 3 and 4 illustrates that how the pump characteristics varies dependent to the amount of water kept at the suction hose of pump.

The annoyance of noise can be quite dominant although the measured value of noise levels are not so high. Pulsations may even have interactions with the mechanics. Simultaneous excitation of the machine mechanics through the pump and wash motor can lead to the amplification of noise. In this cases machine mechanics acts like an acoustic amplifier.

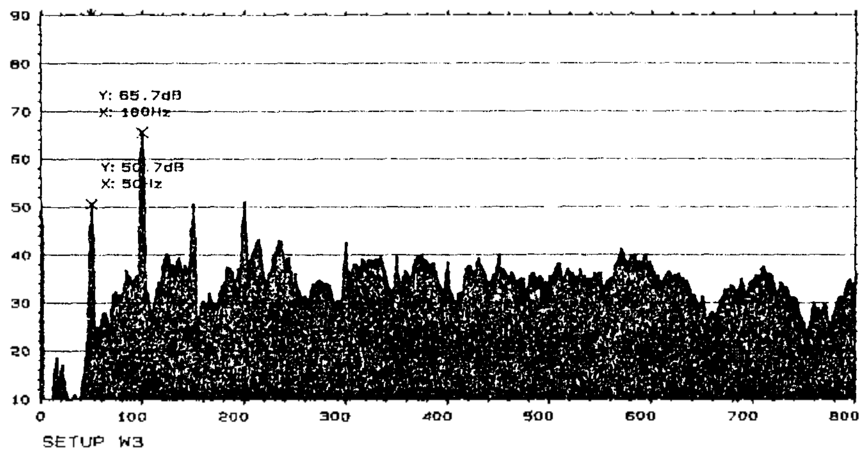

Figure-3, Vibration spectrum obtained at 0.1 meter water column where 5.5 liters water constant at suction and 1 meter head at discharge.

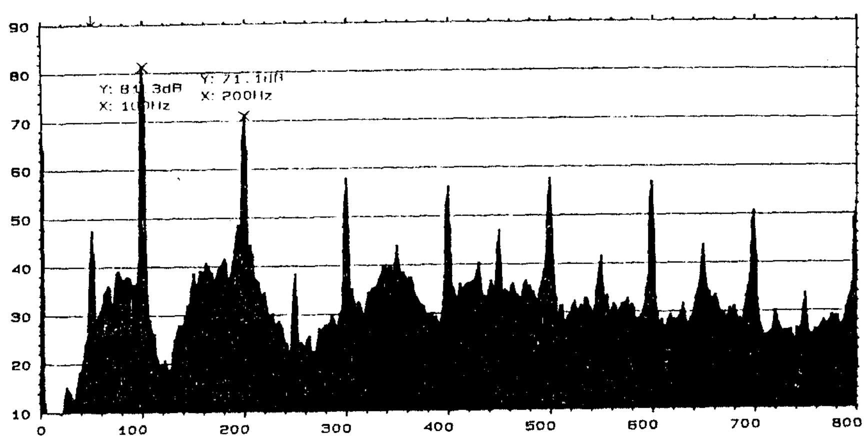

Figure-4, Vibration spectrum obtained at 0 meter water column where 0.5 liter water constant at suction and 1 meter head at discharge.

3.DEVELOPMENT OF TREATMENT METHODS

Various passive treatment methods, modifications over the mechanics and even the use of electronics to control the pump operation are used to treat the noise sources and paths.

Combined applications of all these treatment methods can provide up to 5-6 dBA reduction over the emitted noise levels of drain pumps. Table-2 shows list of the treatment methods that could provide noticeable reductions over the specified sources.

Noise source	Treatment methods	Achieved gain
①Impeller blade tone	•Change of geometry and material	1-3 dBA
②Fan blade tone	•Change of geometry and material	1-2 dBA
③Magnetic interaction	•Reduce the stack height •Increase the height of pump location	1 dBA
④Pulsating Suction Noise	•Control of water level by shutting of the pump at minumum level where the suction begins.	4 dBA
⑤Imparted vibrations	•Use of proper rubber housings	1 dBA
⑥Radiated sound energy	•Use of passive absorbers over the surrounding structures	1-3 dBA
⑦Combined application of the treatment methods	• ①+④+⑤+⑥	5-6 dBA

Table-2, Applied 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.

3.1. Electronic circuit to control the water level of the pump reservoir.

It mainly consists of a piezo electric sensor to detect the excessive vibration when it occurs and the electronic control to evaluate the incoming signal and provide supply to drive the drain pump.

3.2.Passive treatments

It covers the application softer rubber within the housings and passive absorbers over the surrounding structures.

3.3.Design improvements

Basic changes to obtain the proper changes over the fan and impeller blades and the optimize stack heights of the pumps without causing the efficieny loss are all considered under the cover of design improvements.

4.CONCLUSION

Variations over the emitted noise level of appliance drain pumps , although mostly dependent to the pulsations and shows inherent characteristics It also covers 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 head or pump housing.

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

Combined effects of the treatment methods can porvide up to 6 dBA sound power reduction of emitted noise levels of the drain pumps.

5.REFERENCES

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