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Reliability evaluation for the pump assembly using an accelerated test

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Abstract

The pump motor assembly in a washing machine is used to drain the dirty water generated during washing the clothes. This research was aimed to develop an accelerated test as to demonstrate a reliability goal of the assembly within an affordable amount of time and in an economic way. They were evaluated under step stress margin tests first in order to verify their operating limit in certain environmental stresses and then an accelerated test (AT) was conducted to measure the annual failure rate and MTTF of them. The high temperature and the voltage were used as stress factors to accelerate the failure of the assembly. The value of the acceleration factor was estimated by 16 at the high stress condition compared to the use condition. It also showed that all 18 units must survive for 500 h at the stress condition (40 °C, 264 V) to assure the 0.07% annual failure probability of the assembly at the use condition in 90% confidence level.

Keywords: Pump motor; MTTF; Accelerated test; Acceleration factor

1. Introduction

Two kinds of tests are widely used to assure product reliability; environmental tests and life tests. Environmental tests found out latent defects that can be eliminated or reduced prior to life tests [3]. On the other hand, life tests predict the lifetime of products at normal use condition. As today's products become more reliable, it is getting more difficult to estimate their failure time distributions or reliabilities within an affordable amount of time and in an economic way.

HALT, quite different from standard life testing, design verification testing and end-of-production testing, are becoming recognized as a powerful tool to improve product reliability, reducing warranty costs and increasing customer satisfaction [2]. Although, HALT is a powerful tool to find out the latent defects that can be eliminated or reduced prior to the life tests at the development stage, however, it is difficult to estimate the lifetime of the product.

Accelerated tests (ATs) have been widely used in industry to overcome such difficulties. An AT employs higher-than-usual levels of a stress to quickly obtain reliability-related quantities (e.g. the qth quantile of the lifetime distribution).

In this study, we conducted step stress margin tests first in order to verify their operating limit in certain environmental stresses and then an accelerated life test (ALT) was conducted to evaluate a reliability goal of the pump motor assembly.

2. Background

Fig. 1 shows the drain structure in the washing machine.

Fig. 2 shows the pump motor assembly used in the washing machine. The main function of the assembly is to drain the dirty water generated during washing and drying the clothes. It constists of two sub-assembly filter and impeller.

Fig. 3 shows drain mechanism of the pump assembly. Water level is detected by air trap through the pressure of air in the hose-filter tub. The pump motor starts on to drain the water when water level exceeds the pre-specified value and stop when the level is below the pre-specified value. The air hose is used to protect a back flow of water by the siphon effect.

There are many failure modes in the field such as fracture of impeller, freezing of remained water and so on. The main failure modes of a pump motor assembly are noise and defect of water draining. We analyzed the failure data obtained from the real field. Fig. 4 shows failure rate curve of them.

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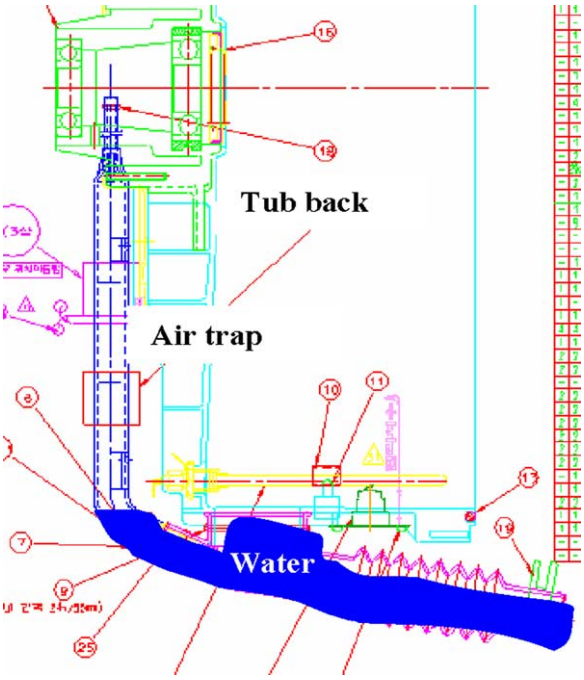

Fig. 1. Drain structure in a washing machine.

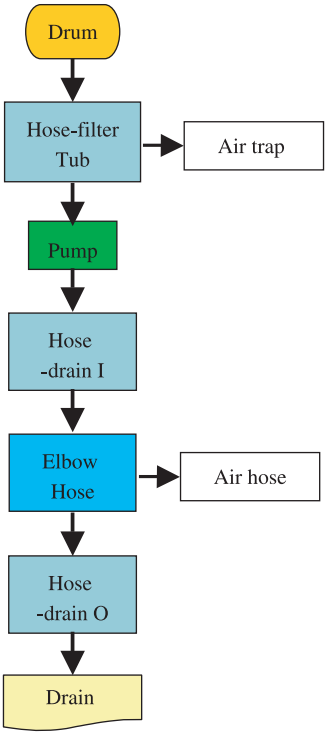

Fig. 3. Drain mechanism of the pump assembly.

3. Accelerated life test

3.1. Reproduction test plans

It is well known that the failure of a pump motor assembly is stimulated by temperature, voltage, solid particles suspended in water. To reproduce the failure mode occurred in the field, we accepted the temperature, the voltage, and detergent containing salt and sand as shown in Fig. 5. To find the operation limits of a pump motor, we conducted a step-stress test in which the stress on each test item is not constant but changes with time. Based on the above pre-test, we determined test plans as shown in Table 1. The rated voltage of the motor is 220 V. Annual operating time of the assembly in the field is surveyed to be 255 h.

The test jig is shown in Fig. 5. Recycle tank is used to supply water repeatedly. Also a power on/off cycle test was performed. The time for power on testing took 2 min and power off 1 min.

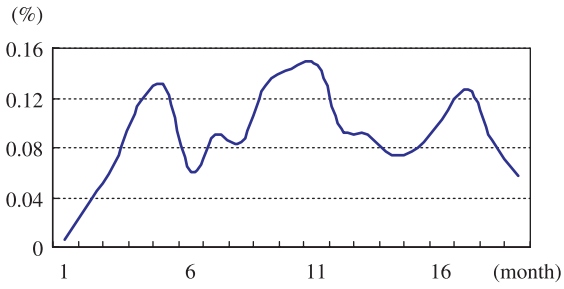

Fig. 4. Failure rate curve of the pump motor assembly.

3.2. Test results

We observed if any failures occurred, and obtained the results as shown in Table 2. The main failure modes were abnormal noise and malfuction.

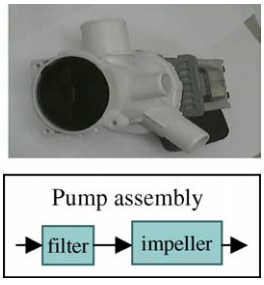

Fig. 2. Pump motor assembly in a washing machine.

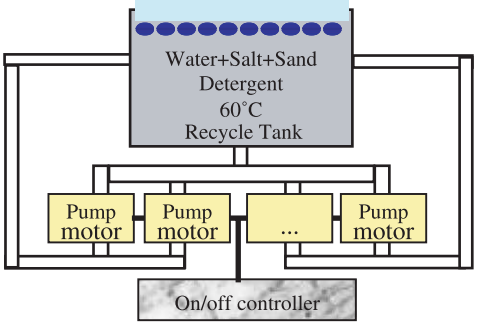

Fig. 5. Test jig.