Development of Equipment for Accelerated Life Testing of a BLDC Motor for Automotive Electric Oil Pump

Y. T. Kim[1*], C. S. Hahn[1], W. G. Shin[1], B. H. Park[2] and S. G. Kim[3]

[1]Electric Powertrain System R&D Center, Korea Automotive Technology Institute, Chonan, Korea
[2]Agency for Defense Development, RAMS&Q Solution, Seongnam, Korea
[3]Division of Mechanical & Automotive Engineering, Kongju National University, Chonan, Korea

[*]Corresponding author: kimyt@katech.re.kr

1. Introduction

Recently, Accelerated life test (ALT) is widely used to evaluate the product reliability rapidly and economically [1-3]. This study present an ALT method of the BLDC motor for automotive electric oil pump(EOP). The accelerating stress factor of the ALT is a high temperature, which can reduce the lifetime of BLDC motor [4-7]. The accelerating high temperature level is determined after gathering and analyzing the real world usage profiles in the vehicle and testing through the preliminary test with HALT.

In this paper, we performed the ALT of BLDC motor with small sample size due to restricted of test chamber and jig.

2. ALT Stress plan

The Generally, the life of a motor is determined by its rotational speed, electrical load, mechanical load and ambient temperature. In particular, the BLDC motor for automotive EOP is mounted in the engine compartment, and in the case of automotive engine rooms, the hot environment is very poor and the fault occurs.

To perform ALT in this study, the high temperature is determined by the acceleration factor.

In order to determine the level of acceleration at high temperatures, the actual conditions of use are collected and analyzed, and HALT is performed as a preliminary test.

2.1 Real world usage profile

Since the BLDC motor for EOP is mounted in the car's engine room, the temperature of the car's engine room is collected and analyzed under practical conditions. The highest temperature in the engine room is 128 °C at the rear of the engine.

Fig. 1 Data collection of
real world usage temperature profile

Table 1 Real world usage temperature profile

Site	1	2	3&4	5	6
Tmax	68	114	60	128	123

2.2 Preliminary test(HALT)

The maximum acceleration stress level of the accelerated life test is determined within the operating limit.

Highly Accelerated Life Testing (HALT) is a limit test for verifying the operating and breaking limits. Therefore, in this study, HALT is performed as a preliminary test to determine the maximum acceleration stress level of the hot accelerated life test and the operating limit of the high temperature is determined at 130 °C.

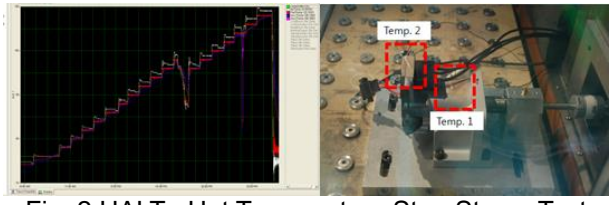

Fig. 2 HALT : Hot Temperature Step Stress Test

The maximum accelerated stress level of the accelerated life test is determined at 120 °C, taking into account the actual conditions of use and the HALT operating limit temperature.

3. ALT Test and analysis

In order to perform ALT of BLDC motor for automotive EOP, it is very important to develop equipment for driving BLDC motor at the same time as hot acceleration. In addition, a methodology is required to test the ALT using a small amount of samples and to predict the lifetime if no failure occurs.

3.1 ALT Test apparatus

In this study, ALT equipment is developed for driving BLDC motors at the same time while accelerating at high temperatures as shown in

Figure 3 and Figure 4.

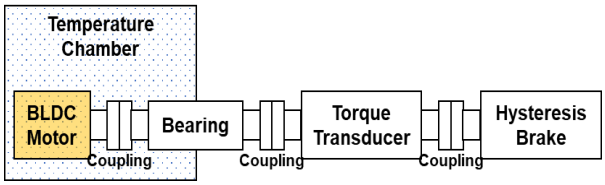

Fig. 3 BLDC motor operational ALT test apparatus diagram

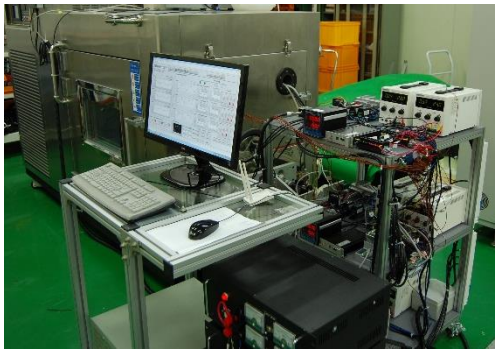

Fig. 4 BLDC motor operational ALT test apparatus

3.2 ALT Data Analysis

The BLDC motor acceleration life test was tested at the normal operating temperature of 23°C, the acceleration temperature of 80°C, and the temperature of 120°C. In each test condition, three specimens were tested at the limits of the physical configuration of the equipment.

4. Conclusions

In this study, the Accelerated Life Test (ALT) equipment for BLDC motors for EOP is proposed The results are summarized as follows;

1. ALT equipment is developed for driving the BLDC motor at the same time while accelerating the high temperature.
2. It was tested at three levels of 23°C normal usage temperature, 80°C acceleration temperature, and 120°C. In each test condition, three specimens were performed at the limits of the physical configuration of the equipment.
3. For more accurate calculation of the acceleration factor, it is required to test and analyze the correct life span until the failure occurs.

Acknowledgment

This research was supported by the Industrial R&D Program funded by Ministry of Trade, Industry and Energy (No. 10035306, No. 20001447).

References

[1] M. B. Kong, I. G. Park, Estimation of Failure Rate and Acceleration Factor in Accelerated Life Testing under Type-I Censoring, Journal of the Korean Institute of Industrial Engineers 29(2), 2003.6, 145-149.

[2] J. J. Baek, K. W. Rhie, A. Meyna, A Study on a Reliability Prognosis based on Censored Failure Data, Transaction of the Korean Society of Automotive Engineers 18(1), 2010.1, 31-36.

[3] K. H. Yoo, B. H. Park, K. T. Kim, G. Y. Kim, D. S. Kim, J. S. Jang, C. S. Hahn, H. S. Cho, Reliability Tests for BLDC Motors Used in Green-Cars, Journal of Applied Reliability 11(1), 2011.03, 97-110.

[4] S. H. Lee, S. W. Park, M. G. Kim, H. G. Seon, S. R. Hong, M. S. Han, A Study on Reliability Compliance Test based on Thermal Fatigue Accelerated Test for CVVL BLDC Motor, Journal of Applied Reliability 15(4), 2015.12, 241-247.

[5] RS B 0065(2008), Power steering pumps for passenger cars.

[6] T. G. Lee, J. S. Moon, H. S. Yoo, J. H. Lee, Thermal Reliability Analysis of BLDC Motor in a High Speed Axial Fan by the Accelerated Life Test, Korean Journal of Air-Conditioning and Refrigeration Engineering 17(12), 2005.12, 1169-1176.

[7] B. J. Sung, D. S. Kim, A Reliability Study of Direct Flow Control Type Hydraulic Pump by the Electric Motor, The Korean Institute of Electrical Engineers, 2011.7, 1033-1034.