Accelerated Life Test and Signal Monitoring of an Industrial Pressure Sensor

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ABSTRACT

Sensing pressure is widely needed technique in the industry such as plant, vehicle, aerospace, and etc. Since each pressure sensor has its own ranges of operating conditions, but the manufacturers give quite large design margins. So although the sensors has own lifetimes, they are regarded as hardly failed products. This study developed the accelerated life test system of pressure sensors, and the failure monitoring and predicting module in the system was a differentiated tool developed using a data-driven algorithm. This module were expected to save the test time since specimens which do not fail yet can be regarded as failed ones. As a preliminary commitment, 8 specimens were used in the test bench. Although classical Weibull analysis and accelerated life test method can handle these censored data, prognostic judgments of the censored data can give another analysis result. The signal-based analysis in this study showed that mean and deviation values of pressure sensor signals did not represent the failure prediction metric and so researchers should devised other approaches to substitute the classical reliability analysis.

1. MOTIVATION

In these days, abundant data from various sensors have been being produced in the industry such as power plant, aerospace, wind farm, and etc. This trend pushes us into data-driven engineering more and more(Pecht, 2008). Normally pressure sensors are considered as hardly failed components since they have higher reliability. For this reason accelerated life test should be conducted for this industrial component(Kim, 2013). However further acceleration technique will be beneficial to handle possibly produced censored data though several statistical analysis techniques already exist. So this study dealt with some data from a typical pressure sensor to analyze failed ones with statistical reliability technique and not failed ones with proposed signal analysis technique.

2. TEST & CONDITION MONITORING SCHEME

Pressure is one of most widely used physical interests related to sensors. The following test system in Figure 1 shows the test apparatus of pressure sensor manifold with controlled input pressure.

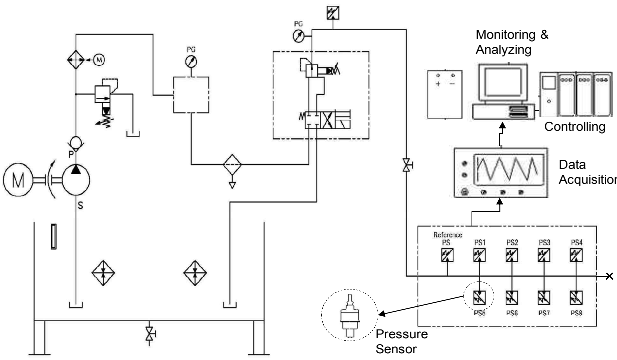


Figure 1. Configuration of Test Apparatus

Table 1. Test and condition monitoring specifications

Acceleration Factor	Pressure
Amplitude	50 bar, 80 bar
1 load cycle	100% load for 3.3 sec, 0% for 1 sec
Failure detection test condition	Const. pressure, 10 bar
Failure predicting factor	Signal-based parameter analysis

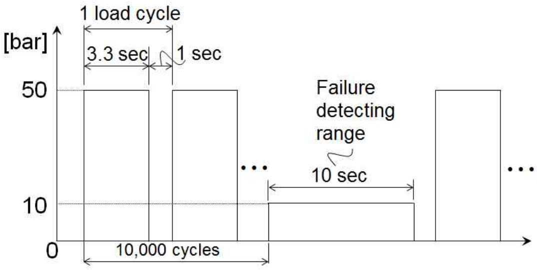
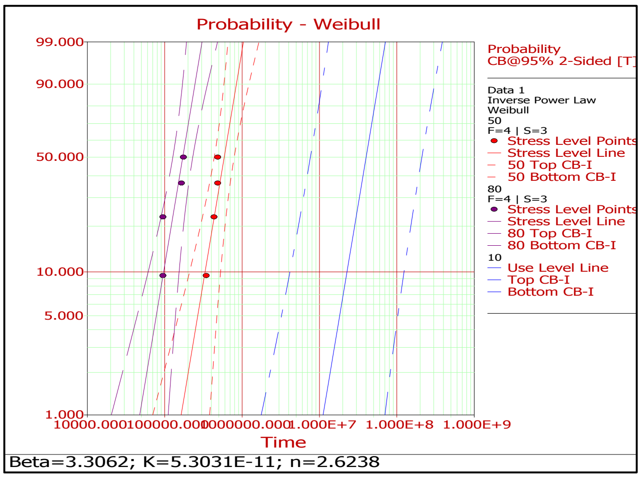
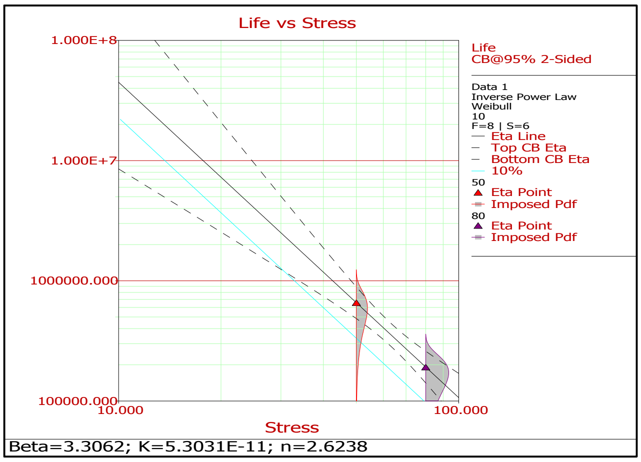


Figure 2. Controlled test pressure history: input signal

Table 1 describes the test and condition monitoring specifications. The pressure pulse cycles were depicted in Figure 2. It shows 10,000 cycles of pressure pulses as loading period and 10 second of constant pressure as failure detecting period.



(a) Weibull plot



(b) Life-Stress curve

Figure 3. Reliability analysis plots

Table 2. Reliability analysis result

	Estimated value	95% confidence level	
		low	high
Shape parameter	3.3	1.78	6.14
Acceleration factor	2.6	1.73	3.52
Model parameter	5.3×10^{-11}	1.3×10^{-12}	2.2×10^{-9}
Scale parameter (Cycle)	4.4835×10^{7}	8.5241×10^{6}	2.3582×10^{8}
MTTF (Cycle)	4.0225×10^{7}	7.6566×10^{6}	2.1133×10^{8}
B_{10} life (Cycle)	2.2702×10^{7}	4.1587×10^{6}	1.2392×10^{8}

3. RESULTS AND DISCUSSIONS

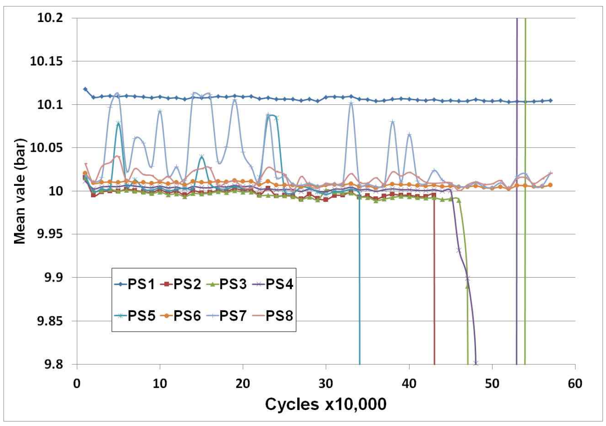
The first section describes the results of accelerated life test of seven specimens, and the next one does the condition signal monitoring and analysis.

3.1. Reliability Analysis

Two levels of accelerated life test was carried out. Three of all specimens had no failures, so they were censored. The Weibull plot and life-stress curve are shown in Figure 3. Table 2 summarized the results of the reliability analysis

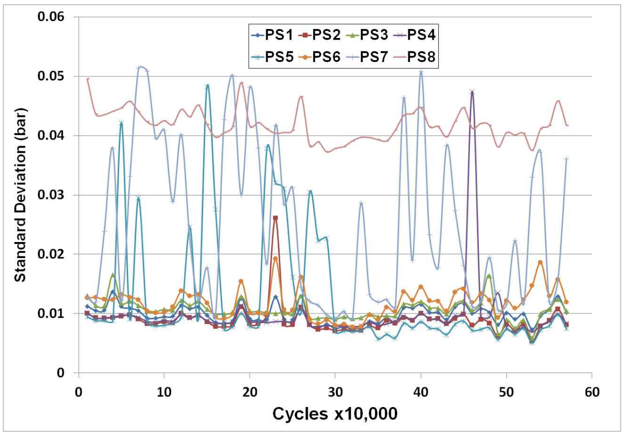
3.2. Monitoring and Analyzing Signals

Pressure signals were monitored and analyzed to catch the signs of failures. Judging from the signal, it was difficult to find signs of failure. Nevertheless several characteristics could be discovered. First, the failure suddenly happened into the mean value '0'. Second, the standard deviation was not that important. The difference among the deviations were considered as product deviations themselves.



(a) Mean values

Figure 4. Signal history of failure detecting period (continued)



(b) Standard deviations

Figure 4. Signal history of failure detecting period

4. CONCLUSION

This study described the accelerated life test analysis of a typical industrial pressure sensor which is a hardly failed component. Weibull parameters and acceleration factor were derived, and furthermore signal analysis was carried out to find out life prediction techniques. A model-based maintenance technique will be developed in the future after some verification and validation process.

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BIOGRAPHIES

Jung-Hun Shin received BEng, MEng, and DEng degrees at Korea Advanced Institute of Science and Technology in 1999, 2002, and 2013 respectively. His academic degrees were related to computational science and engineering. His industrial interests have been robust and reliable design in various machines such as precision and mechatronic, and medical ones. Now he is devoting himself to computational and data-driven science and engineering using supercomputing infrastructure.

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