A Study on the Long-term Reliability of Heat Pipe in use by observing Temperature Change

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1. Introduction

Recently, land systems for military such as main battle tanks, armored vehicles, and self-propelled howitzer are controlled by a lot of electronic equipment. To improve the operation rate of land systems under the extreme conditions, it is necessary to secure the reliability of the electronic devices. One of the most influence failure factor of electronic devices are thermal problems. The reliability increment of heat dissipation system of electronic equipment has a great influence on improving the reliability of equipment. In this study, a method for evaluating the reliability of the heat pipe using the particle filter was conducted to secure the reliability of the electronic device used in the land systems

2. Experimental Method and Prognostics Method

The experimental system consists of a heat pipe, a power supply for heating, an insulation container for evaporation section and a data acquisition, respectively. The surface temperature of the heat pipe are measured with T-type thermocouples for 42 days to obtain the performance degradation. Fig. 1 shows experimental apparatus.

Fig.1 Experimental apparatus

To estimate the temperature degradation trends of the heat pipe based on the measured data, the particle filter method is used. This method is a novel, useful technique used to analyze the observed data in real-time and to predict data trends [1]. Since this method can be applied in non-linear systems with non-Gaussian process noises, this method can be applied to many science and engineering field. The particle filter uses a statistical approach based on the following Bayes' theorem [2].

3. Results and Discussion

The measured results of surface temperatures of the heat pipe measured for 42 days, temperature degradation of the heat pipe can be experimentally obtained, as shown in Fig. 2. In the figure, the temperature trend generally decreases, to predict the temperature of heat pipe after 42 days, we use the particle filter method. This technique can statistically consider every failure mode during the measurements or the data processing.
To validate the particle filter method, the prediction results using experimental data from 16 days are compared with experimental data from 42 days, as shown in Fig. 3. The figure shows that the estimated values follow the experimental data well. We also the compare the estimated results using 24, 32, 42 days data with experimental results from 42 days. As number of data is increased, estimated results are accurately predicted. Table 1 shows estimated results of heat pipe according to used data.

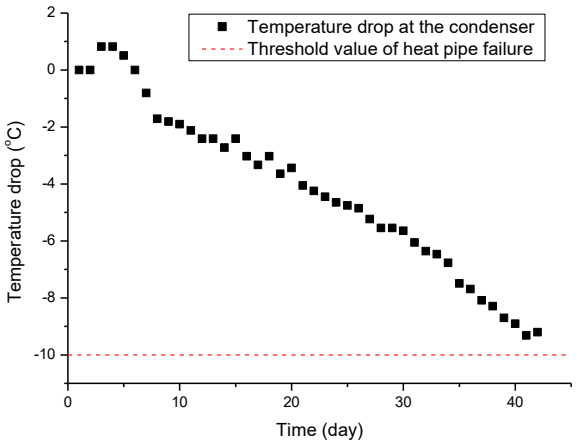

Fig.2 Temperature degradation of the heat pipe

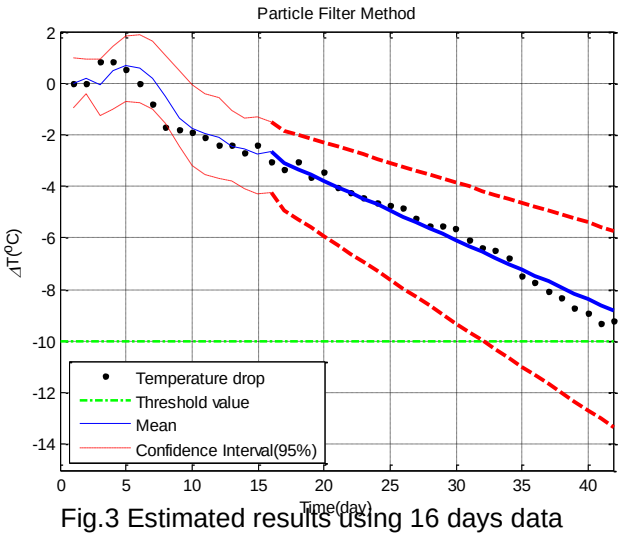

Fig.3 Estimated results using 16 days data

Table 1. Estimates Results according to used data

No. of Data	Mean(Days)	Actual Value
16	32.41	27
24	23.78	19
32	17.56	11
40	47.74	3

4. Conclusion

In this paper, the long-term reliability of the thermal performance of a heat pipe for land systems considering all failure factors can be predicted using the particle filter method with measured data. The temperature degradation is experimentally obtained with the surface temperatures at evaporation and condensation. The measurement is performed under a severe working condition compared with a normal operating conduction, to obtain rapidly the temperature degradation of the heat pipe. Based on the experimental results, the thermal performance trend is estimated with data from 16 days. The prediction results using experimental data from 16 days are compared with experimental data from the 42 days. The estimated values follow the experimental data well. These results and the method show the feasibility of the real-time prognosis of heat pipes which should be used to cool the electronic devices in land systems.

References

[1] D. An, J.-H. Choi, N.H. Kim, Prognostics101: a tutorial for particle filter-based prognostics algorithm using Matlab, Reliab. Eng. Syst. Safety 115 (2013), 161–169.

[2] T. Bayes, An essay towards solving a problem in the doctrine of chances, Philos., Trans., R. Soc. London 53 (1763) 370-418.