Analysis of Life Characteristics of Servo Motor for Mobile Robot

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1. Introduction

Demand for industrial robots is growing rapidly due to modernization and automation of production facilities, energy efficiency, shortening product life cycle and demand for quality improvement. The global manufacturing robots market is expected to grow to more than 15% a year between 2017 and 2020[1]. Servo motors used to control the position, speed and torque of a load device in a desired state in the industrial field are used as key components for controlling the manufacturing robots and are required to be high reliability to be used in various operating environments. The reliability of the servo motor is closely related to the reliability of the entire system in which the servo motor is used. In general, accelerated life test is a method of evaluating product reliability under normal use conditions by analyzing life result obtained by causing failure by testing under conditions more severe than product use level[2]. In this paper, we analyze the failure modes of servo motors for mobile robots and analyze the degradation characteristics and lifetimes of servo motors by analyzing the results of accelerated life tests considering the field conditions.

2. Failure analysis

As shown in Table 1, the failure modes, effects, and criticality of the servo motor were analyzed [3-4]. The main failure of the servomotor is the breakage of the bearing, and the failure factor is analyzed by the torque and foreign matter applied to the motor.

Table 1 FMECA(Failure Modes, Effects, and Criticality Analysis)

Primary components	Failure causes	Failure effects	Criticality		
			Frequency	Severity	Criticality
Bearing	Foreign material, Poor lubrication	Noise, Increase friction	H	H	9
	Foreign material, Pollution	Noise, Increase friction	M	H	7
Stator winding	Overload, Poor assembly	Impossible operation, Torque reduction	L	H	5
	Shock, Deformation	Impossible operation, Torque reduction	L	M	3
Rotor	Overload, Degradation	Impossible control, Torque reduction	L	H	5
	Shock, Deformation	Impossible operation, Torque reduction	L	M	3
Output shaft	Overload	Increase friction	L	M	3
	Overload, Poor assembly	Noise, Increase friction	L	M	3
Frame	Poor assembly, External impact	Noise	L	M	3

3. Analysis of accelerated life test result

In this paper, the trends in the four performance degradation measurement periods obtained at the 0, 80, 170, and 238 hours of the life test obtained in the accelerated life test were analyzed using the linear model.

Fig.1 Servo motor accelerated life test

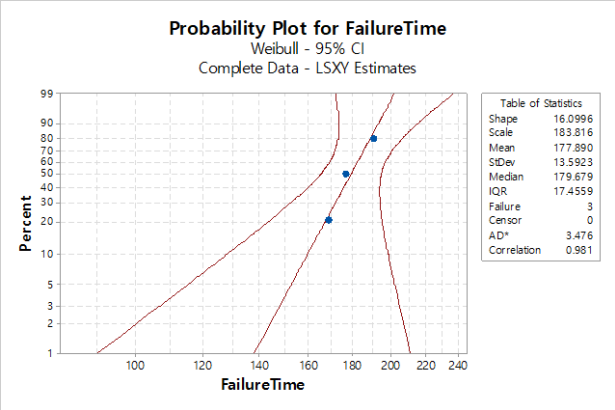

Fig.2 Schematic diagram of Weibull distribution

Fig. 2 shows the estimation of the parameter of the Weibull distribution, which is the life distribution of the servomotor for mobile robot. The shape parameter is 16.1, the scale parameter is 183.8 hours, the average life time is 177.9 hours, and the median value is 179.7 hours. The 95% confidence interval of the shape parameter is (3.72, 69.75). Therefore, it is considered that the shape parameter of the servomotor for mobile robot is 3.72 rather than 16.1.

Table 2 gives estimates of the parameters and reliability scale for the servomotors, and the life expectancy results are obtained when the shape parameter is 3.72. From the analysis results, the B10 lifetime of servo motor for mobile robot can be guaranteed to be 83.6 hours at the confidence level of 90%.

Table 2 Parameters and reliability scale estimate

Items	Point estimate	Interval estimate	
Shape parameter (β)	16.1	95% Confidence limit	95% Confidence limit
		3.72	69.75
Scale parameter (η, hours)	191.8	90% Confidence limit	
		153.1	
Average life time(MTTF) (hours)	173.1	90% Confidence limit	
		138.2	
B_{10} life time(hours)	104.7	90% Confidence limit	
		83.6	

4. Conclusion

In this paper, the failure modes and life prediction of servo motors for mobile robots are calculated.

1) Main failure of servomotor for mobile robot is breakage of bearings, which is a cause of failure of torque and foreign matter applied in load.
2) The performance degradation trends using servo motor deterioration data were analyzed to calculate the lifetime predicted value, and it was confirmed that the Weibull distribution was suitable by verifying the fitness of the lifetime distribution.
3) Shape parameter (3.72) and metric parameter (153.1 hours), which are inherent reliability parameters of servo motor, were calculated and the average life span (138.2 hours) and B10 life span (83.6 hours) were calculated

References

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