Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 13 (19): 4018-4020, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.4018.4020

Analysis on Formation and its Specific Property of the Electromotor Circuit

[1]Ma Qiao, [1]Yu Guibo, [1]Wang Shuhai, [1]Yuan Zhanjie and [2]Yang Zhongjun
[1]Department of Guns Engineering, College of Ordnance Engineering, Shijiazhuang, 050003, China
[2]Wuhan Military Representative Beau of PLA, WuHan, 43000, People's Republic of China

Abstract: The electromotor is the hard core o f the antenna tilting mechanism circuit of the gun According to the basic failure rate model and working failure rate model of the national military standards, the electromotor working reliabilities are analyzed under different working conditions and environments. The reliability analyses of the redundancy structures of the antenna tilting mechanism circuit are done and the comparisons and analysis of the results are done and the useful conclusions for design and engineering are presented.

Key words: Electromotor, failure rate model, reliability redundancy structure

INTRODUCTION

To obtain the reliable data of the whole electrical units is on the reliability analysis of electrical unit, according to the reliable data of components or parts of the system as well as the partial system and the reliability analysis of reliable models which can be analysis step by step from bottom to top. Reliability analysis is very important to improving the designing scheme of electrical products and to enhancing the reliability of the electrical products (Lu and Zheng, 1995). This article made reliable analysis on the core part of the motor of the antenna tilting mechanism of the gun according to the failure rate model in the national military standards manual.

ELECTRICAL CIRCUIT OF THE ANTENNA TILTING MECHANISM OF THE GUN

The electrical circuit of the antenna tilting mechanism of the gun is shown in Fig. 1. The electrical circuit in Fig. 1 contains four components: Electrical resistance, two-electrode valve, motor and the switch, but another two components which are printed board and the point of the weld should be taken in consideration during analyzing the reliability of the circuit. The power supply in the Fig. 1 is external supply and the article assumed the degree of the reliability to be 1 on the reliability analysis. Because motor is the core part of the electrical circuit, the influencing factors of the motors' reliability should be researched mainly.

MODEL OF MOTORS' RELIABILITY ANALYSIS

For the electrical facilities, the characteristic is that the lifetime obeys Exponential (Relex Software Co. and Intel Intellect, 2005) which is shown as:

$$f(t)=\begin{cases}\lambda e^{-\lambda t} & (t\geq 0,\lambda\geq 0)\\ 0 & (t\leq 0)\end{cases}$$

In reality, the lifetime of the products is often the mean lifetime of the products on study and the mean lifetime in the probability theory is also be called the mathematical expectation of the lifetime. For the products which can not be fixed, the mean lifetime of the products indicates the mean working time before the products were broken which can be called Mean Time To Failure and be abbreviated by MTTF (Gan and Kang, 1999). If the lifetime of the products obeys Exponential, there is. Then we can get:

$$MTTF=\int_0^{\infty} tf(t)dt=\int_0^{\infty} e^{-\lambda t}dt=\frac{1}{\lambda}$$

In the nation military standard, the model of the working failure rate of motors in the electrical facility

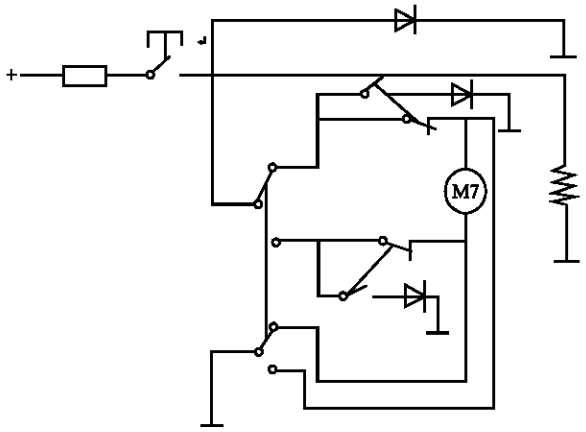

Fig. 1: Electrical circuit of the antenna tilting mechanism of the gun

Corresponding Author: Ma Qiao, Department of Guns Engineering, College of Ordnance Engineering, Shijiazhuang, 050003, China

reliability prediction handbook (GJB/Z, 1995) can be expressed as:

$$\lambda_p = \lambda_b \pi_E$$

λ_p is working failure rate. λ_b is basic failure rate. π_E is environmental parameter.

INFLUENCING FACTORS OF THE MOTORS' RELIABILITY

The influencing factors of motors' reliability as well as the working conditions of the circuit are shown in Table 1.

The analysis of the reliability of the motor will be comprehensive and objective by the way to estimate the mean time before failure that takes the change of only one factor and fixes the other factors.

Environmental impacts on the reliability of the motor: The Fig. 2 shows the impacts of the various environments on the reliability of the motor. From the Fig. 2, conclusions can be drew that the MTTF lasted the longest when the motor worked on the GB-ground or the SF-spaceflight environment which could be as long as 380000 h while on the ML-missile launching environment condition, the working time only reached 20000 h, therefore the condition of working environment of the motor will have a great impact on the reliability.

Impacts of the operating state on the reliability of the motor: The impacts of the operating state on the reliability of the motor can be shown in the Fig. 3. When the motor works under the low speed (<1000 r min^{-1}), the MTTF lasted the longest at about 60000 h while under the rectifier type, the working time could only reached 10000 h.

IMPACTS OF REDUNDANT ON THE CIRCUIT RELIABILITY

Before studying the impacts of redundancy on the antenna tilting mechanism of the gun, several kinds of reliable parameters and the working environment of the components should be given. Due to the fact that the two-valve in the circuit only plays the role of indication, the quality of which does not affect its function, the two-valve can be ignored in the reliability analysis. The working condition analyzed in the article is GM2-sharply moving on the ground, 20°C, the reliability parameters of the resistance shown in the Table 2, the reliability parameters of the switch shown in Table 3, the reliability parameters of the printed board shown in Table 4 and the reliability parameters of the point of the weld shown in Table 5.

Taking redundancy structure is a way to improving circuit reliability. There will be a comparative analysis in the paper by different redundancy structures of two identical antenna tilting mechanism circuit of the gun, such as serial, parallel, alternative, both of them, the reserve structure as well as parallel-serial (Yang and Liao, 1992). As shown in Fig. 4.

MTTF of a single circuit is 25 768 h and it was set to 1. The histogram shows MTTF of the different redundant structure with respect to a single circuit in multiples in Fig. 4. As can be seen from Fig. 4, series structures are equal to both of them structures in theory. Their reliability is minimum, only an half of the single circuit. Alternative structures are theoretically the same as parallel structures and their reliability is 1.5 times. The reliability of parallel-serial structures is 1.95 times, ranking only second to the reserve structures whose is 2 times and is the maximum. Then from the above analysis, in the design of the circuit, parallel, alternative, the reserve structures as well as parallel-serial structures can be used to improve circuit reliability.

Table 1: Parameters of the motors' reliability

Influencing factors of reliability	Working conditions
Environment	GM2 intense terrestrial mobile
Operational state	Medium speed

Table 2: Resistors' reliability parameter table

Resistor type	Carbon film resistors
Resistance	20 kΩ
Quality grade	B 1
Operating power	15 mW
Rated Power	250 mW

Table 3: Switches' reliability parameter table

Switch type	Button-kink type	Slide-type	Micro type
Quality grade	B1	B1	B1
Load form	Resistive load	Resistive load	Resistive load
Switching rate (times/day)	10	10	10
Active access point	2	6	4
Current ratio	0.5	0.5	0.5

Table 4: PCB's reliability parameters table

Quality grade	A
No. of circuit board layers	1 Layer
Metalized No. of holes	860

Table 5: Solder joints' reliability parameters table

Welding point type	Printed circuit board soldering iron
Quality grade	B
No. of welding point	260

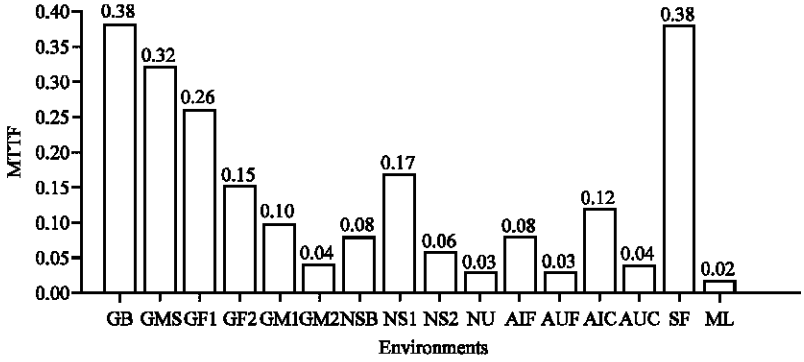

Fig. 2: Mean time before failure during different environment

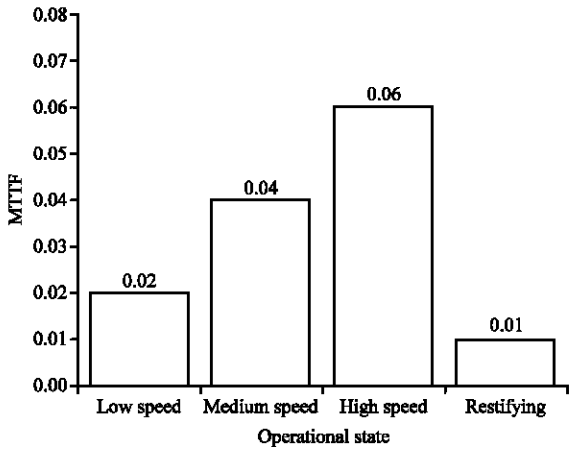

Fig. 3: Mean time to failure during different operating state

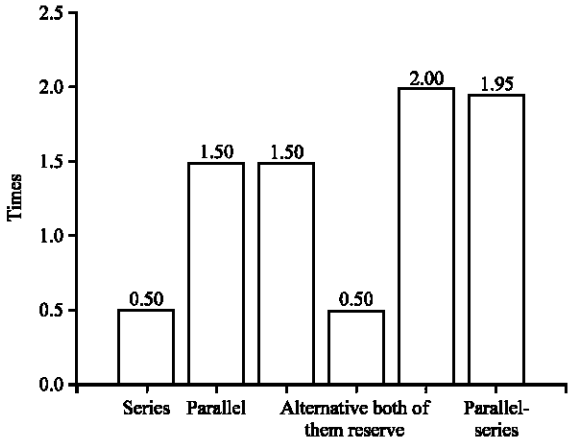

Fig. 4: Comparative MTTF in different redundancy structures

CONCLUSION

According to the comparative analysis of influencing factors of the motors' reliability that is hard core to antenna tilting mechanism of the gun, in circuit design, adjusting the reliability parameters of the core components is a way to improving the reliability of the entire circuit. At the same time, considering circuit reliability, cost and function of the actual situation, we could maximize the use of parallel, alternative, reserve structures or parallel-serial structures to improve the reliability of the circuit. So that, the gun could play the best performance every time.

REFERENCES

GJB/Z, 1995. Reliability of Electronic Devices Expected Manual. 1st Edn., Chinese People's Liberation Final Assembly Ministries, Beijing.

Gan, M. and J. Kang, 1999. Military Equipment Maintenance Engineering. 1st Edn., Defense Industry Publishing House, Beijing.

Lu, T.X. and P. Zheng, 1995. Reliability Design and Analysis. 1st Edn., Defense Industry Publishing House, Beijing.

Relex Software Co. and Intel Intellect, 2005. Reliability Practical Guide. 1st Edn., Beijing University of Aeronautics and Astronautics, Beijing.

Yang, Q. and Q. Liao, 1992. Basis of System Reliability Engineering. 1st Edn., Science Publishing House, Beijing.