Economical Maintenance Decision for Hart Time Maintenance

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Abstract:

Time arrangement of hart time maintenance items of equipment is discussed in this paper. Faults with different effect are discussed in this paper. Faults with safety fault effects and mission fault effects are analyzed at first, and then the economic criterion of maintenance is acquired. Fault with economic effect is discussed subsequently, and the corresponding economic criterion of maintenance is acquired.

Keyword: Scheduled maintenance　Maintenance decision　Hart time maintenance

1 Introduction

Different type of maintenance is adopted according different fault mode when carrying out Reliability-centered maintenance. There are many hart time maintenance items in ship scheduled maintenance. If the time of maintenance is rigidly adhered to, total maintenance action, maintenance time and maintenance cost may increase. There are many dominative hard time maintenance items in a ship. For saving cost, many hard time maintenance items are arranged delay or ahead of schedule. Maintenance cost influenced by fault effect, fault rate and serviced time is optimization calculated in this paper.

2 Fault with safety effects and mission effects

If faults bright safety effect or mission effect, the equipment must be repaired before its' reliability decline to the minimum value. If equipment reliability is less than the minimum value, It must be discarded or repair in the oncoming scheduled maintenance. If equipment reliability is meet to the requirement till the next time scheduled maintenance, the equipment will not be repaired in the oncoming scheduled maintenance. If the equipment reliability fall down and less then the minimum value between the oncoming time scheduled maintenance and the next time scheduled maintenance, it must be discuss before the equipment is overhauled or discarded.
Take example for overhaul, hypothesizes:

· Equipment reliability must be higher than the required value R0.
· Equipment reliability after overhauled is equal to new maintenance.
Equipment operation time is T0, maintenance cost of overhaul in the oncoming scheduled maintenance is Cp. equipment operation time is Tf when reliability equal to Rf. if equipment overhaul in mission period, maintenance cost would increase for the additional maintenance project cost Cs, additional transportation cost Ct, and additional manpower cost Ca. if formula (1) is come into existence, equipment overhaul should execute in the oncoming scheduled maintenance.

$$\frac{C_p}{T_0} \le \frac{C_P + C_t + C_a}{T_f} \qquad (1)$$

3 Fault with economic effects

If equipment fault in the mission period, mean cost of fault repair is Cf, usually, Cf>(Cs＋Ct＋Ca).
□ If the equipment is overhauled in the incoming scheduled maintenance, its' operation time is T0, and maintenance cost per hour is C_p / T_0.

□ If the equipment will be overhauled after T hour operation after the incoming scheduled maintenance, fault free probability is R(T0+T)/ R(T0). And fault probability is [1- R(T0+T)/ R(T0)]. The total

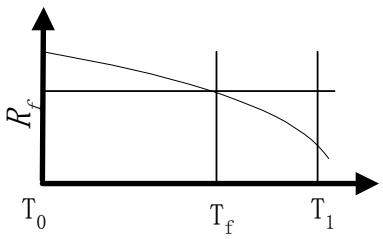

Fig.1 Equipment reliability

maintenance cost in the T period is that:

$$C(T)=(C_s+C_t+C_a)R(T_0+T)/R(T_0)+C_f[1-R(T_0+T)/R(T_0)] \qquad (2)$$

Equipment mean-time-to-failure is that:

$$\overline{T}_u = T_0 + \frac{1}{R(T_0)}\int_{T_0}^{T_0+T} tf(t)dt + \frac{R(T_0+T)}{R(T_0)}T \qquad (3)$$

Maintenance cost per operational time is that:

$$\frac{C(T)}{\overline{T}_u} = \frac{(C_s + C_t + C_a)R(T_0+T)/R(T_0) + C_f[1 - R(T_0+T)/R(T_0)]}{T_0 + \frac{1}{R(T_0)}\int_{T_0}^{T_0+T} tf(t)dt + \frac{R(T_0+T)}{R(T_0)}T} \qquad (4)$$

So:

$$\frac{C(T)}{\overline{T}_u} = \frac{(C_s + C_t + C_a)R(T_0+T)/R(T_0) + C_f[1 - R(T_0+T)/R(T_0)]}{T_0 + \frac{1}{R(T_0)}\int_{T_0}^{T_0+T} tf(t)dt + \frac{R(T_0+T)}{R(T_0)}T} \qquad (5)$$

$$\frac{C(T)}{\overline{T}_u} = \frac{(C_s + C_t + C_a)R(T_0+T) + C_f[R(T_0) - R(T_0+T)]}{T_0R(T_0) + \int_{T_0}^{T_0+T} tf(t)dt + R(T_0+T)T}$$

$$= \frac{(C_s + C_t + C_a)R(T_0+T) + C_f[R(T_0) - R(T_0+T)]}{T_0R(T_0) + \int_0^{T_0} tf(t)dt + \int_{T_0}^{T_0+T} tf(t)dt + R(T_0+T)(T+T_0) - \int_0^{T_0} tf(t)dt - R(T_0+T)T_0} \qquad (6)$$

$$= \frac{(C_s + C_t + C_a)R(T_0+T) + C_f[R(T_0) - R(T_0+T)]}{2T_0R(T_0) + \int_0^{T_0+T} R(t)dt - \int_0^{T_0} R(t)dt - R(T_0+T)T_0}$$

Derivative of formula (6) is that:

$$\begin{aligned}&[(C_s + C_t + C_a)R'(T_0+T) + C_fR'(T_0+T)]\cdot \\ &\quad [2T_0R(T_0) - \int_0^{T_0} R(t)dt + \int_0^{T_0+T} R(t)dt - R(T_0+T)T_0] \\ &= \{(C_s + C_t + C_a)R(T_0+T) + C_f[R(T_0) - R(T_0+T)]\} \\ &\times [R(T_0+T) - T_0R'(T_0+T)]\end{aligned} \qquad (7)$$

□ The equipment will be overhauled in the next scheduled maintenance, mean operational time between the two scheduled maintenances. Fault free probability is R(T0+T)/ R(T0) in this period, and fault probability is [1- R(T0+T1)/ R(T0)].

So mean maintenance cost in the period equal that:

$$C(T) = C_pR(T_0+T_1)/R(T_0) + C_f[1 - R(T_0+T_1)/R(T_0)] \qquad (8)$$

Equipment mean operation time is that:

$$\overline{T}_u = T_0 + \frac{1}{R(T_0)}\int_{T_0}^{T_0+T_1} tf(t)dt + \frac{R(T_0+T_1)}{R(T_0)}T_1 \qquad (9)$$

Maintenance cost per operation hour is that:

$$\frac{C(T)}{\overline{T}_u} = \frac{C_pR(T_0+T_1) + C_f[R(T_0) - R(T_0+T_1)]}{R(T_0)T_0 + \int_{T_0}^{T_0+T_1} tf(t)dt + R(T_0+T_1)T_1}$$

$$= \frac{C_pR(T_0+T_1) + C_f[R(T_0) - R(T_0+T_1)]}{T_0R(T_0) + \int_0^{T_0} tf(t)dt + \int_{T_0}^{T_0+T_1} tf(t)dt + R(T_0+T_1)(T_1+T_0) - \int_0^{T_0} tf(t)dt - R(T_0+T_1)T_0} \qquad (10)$$

$$= \frac{C_pR(T_0+T_1) + C_f[R(T_0) - R(T_0+T_1)]}{2T_0R(T_0) - \int_0^{T_0} R(t)dt + \int_{T_0}^{T_0+T_1} R(t)dt - T_0R(T_0+T_1)}$$

minimum Maintenance cost per operation hour in three situations will be selected to execute.

4 Conclusion

Repair range is extended for the conservative conception, but on the other hand shorten maintenance period and saving cost are expected. These two means are not scientific. There is a optimized period for any hard time maintenance, but these optimized period must be adjusted when scheduled maintenance of a ship is taken into account.

Conference

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