

*

-

-

-

(// // //)

()

(

(:

(

(Tabu Search)

(Simulated Annealing)

()

-

-

-

-

:

.[]

()

MIL-STD-721B

.[]

(1C)

(2C)

[]

[]

" "

(1P)

(2P)

)

[]

(

)

(

" "

[]

()

[]

[]

()

()

[]

[]

[]

[]

[]

[]

" "

[]

(2P)

2P

[][]

()

()

(-)

m k

TP

N

)

(1a, 1P, 2P)

(

()

(1a)

n i 1P

:C_{in}¹

n i 2P

:C_{in}²

:C_n^f

(1P)

n

$$X_{in} + Y_{in} \leq 1 \quad \forall n, i \quad (1) \quad : C_n^{out}$$

$$X_{in} \leq P_{in}^1 \quad \forall n, i \quad (2) \quad : P_{in}^1$$

$$Y_{in} \leq P_{in}^2 \quad \forall n, i \quad (3) \quad : P_{in}^2$$

$$R_{s,n} \geq R_{s,min} \quad \forall n \quad (4) \quad : R_{s,min}$$

$$S_n = \begin{cases} 1 & \text{if } R_{s,n} \geq R_{s,min} \\ 0 & \text{otherwise} \end{cases} \quad (5) \quad : S_n$$

$$X_{in} = \begin{cases} 1 & \text{if } S_n = 1 \\ 0 & \text{otherwise} \end{cases} \quad (6) \quad : X_{in}$$

$$Y_{in} = \begin{cases} 1 & \text{if } S_n = 0 \\ 0 & \text{otherwise} \end{cases} \quad (7) \quad : Y_{in}$$

$$(1- (R_{s,n}) \quad (n=1, \dots, N) \quad : N$$

$$(i=1, \dots, I) \quad : I$$

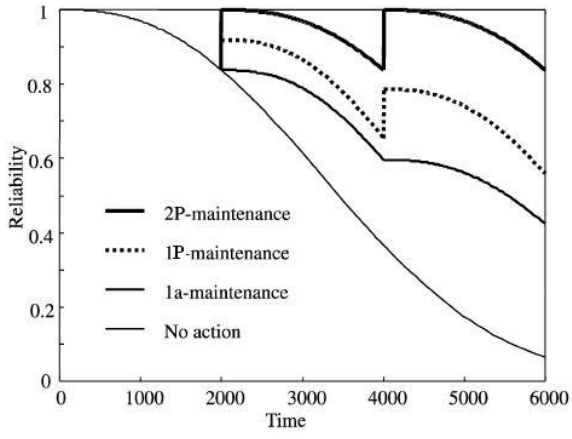
$$\min Z = \sum_{n=1}^N \sum_{i=1}^I X_{in} C_{in}^1 + \sum_{n=1}^N \sum_{i=1}^I Y_{in} C_{in}^2 + \sum_{n=1}^N (1 - R_{s,n}) C_n^f + \sum_{n=1}^N S_n C_n^{out} \quad (8)$$

$$(9) \quad R_{s,n} \geq R_{s,min} \quad (10)$$

$$[] \quad \sum_{i=1}^I X_{in} P_{in}^1 + \sum_{i=1}^I Y_{in} P_{in}^2 \leq P \quad \forall n \quad (11)$$

$R_{s,min}$

$R_{i,0,n}$ ()
 $R_{i,f,n-1}$ n i (...)
 $R_{i,0}$ (n-1) .
 i
 2P 1P 1a
 P
 P_{in}^2 2P P_{in}^1 1P
 m_2 m_1
 1a
 () ()
 1a
 m_1 2P 1P
 m_2
 m_2 m_1 1P
 2P
 m_2 m_1
 " "
 ()



[] []
()

β θ
[]

$$R_{i,0,n} = R_{i,f,n-1} + m_2(R_{i,0} - R_{i,f,n-1}) \quad \forall n, i \quad ()$$

$$R_{i,n}(t) = R_{i,0,n} e^{-\left[\frac{(\forall m)(t-(n-1)t_p)}{\theta}\right]^\beta} \quad \forall n, i \quad ()$$

[]

[]

SA

T

(SA)

[]

[]

(...)

$$P(pm_i \rightarrow pm_{i+1}) = \exp\left(-\frac{\Delta C_i}{T_i}\right) \quad \text{Pr}$$

$$T_i = \alpha T_{i-1} \quad 0 < \alpha < 1 \quad \text{Pr} = \frac{1}{Z(T)} \cdot \exp\left(-\frac{\Delta E}{k_B T}\right)$$

: ()

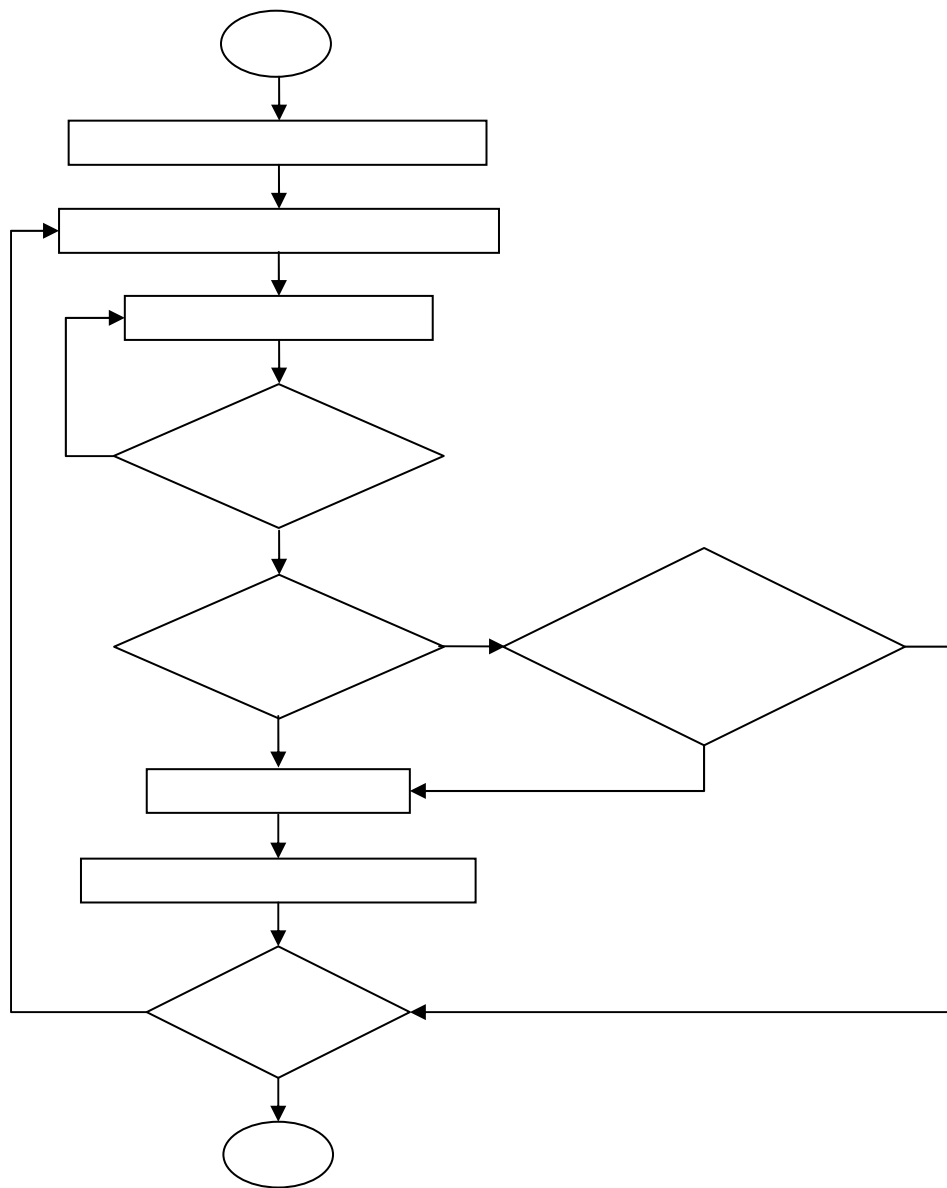
$$(i+1) \quad (i) \quad : pm_i \quad (i) \quad Z(T) \quad k_B \quad \exp\left(-\frac{\Delta E}{k_B T}\right)$$

$$: T_i \quad : P(pm_i \rightarrow pm_{i+1}) \quad (i+1)$$

: α

SA

()



:

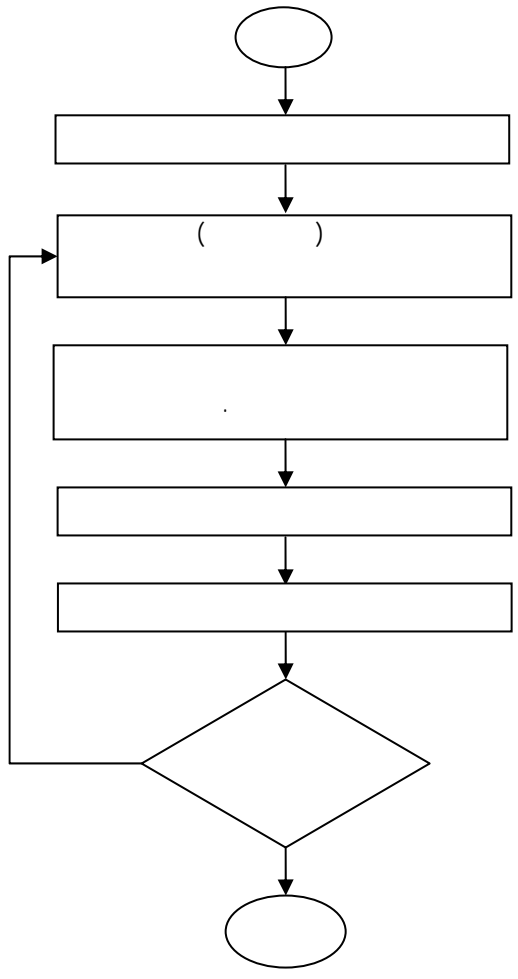
(TS)

[][]

TS

()

[]



TS

[]

TS

TS

TS

SA

TS

TS

()

TS

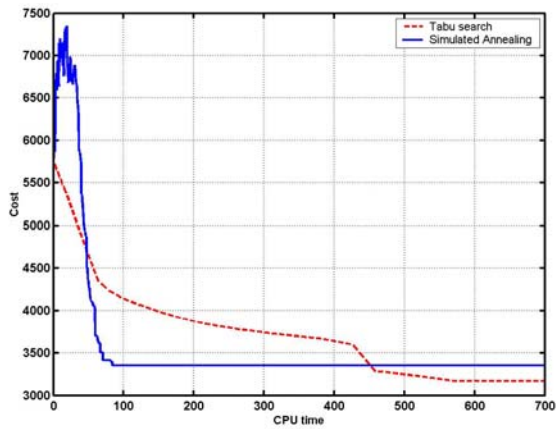
SA

()

()

SA

TS



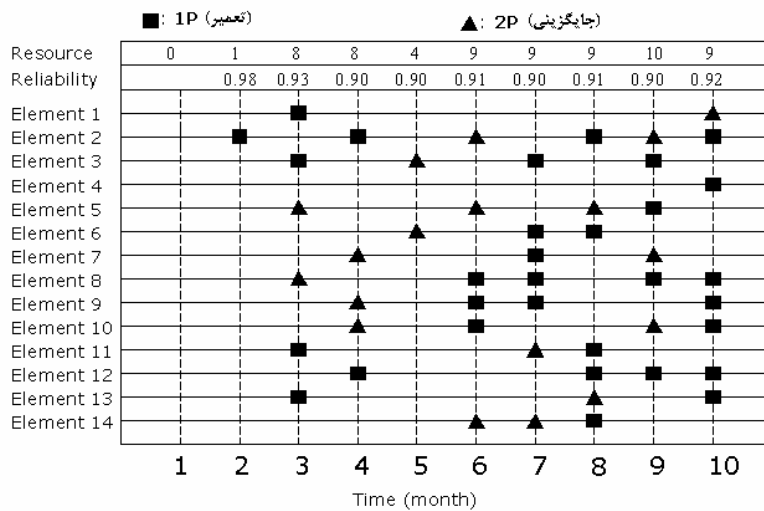
TS

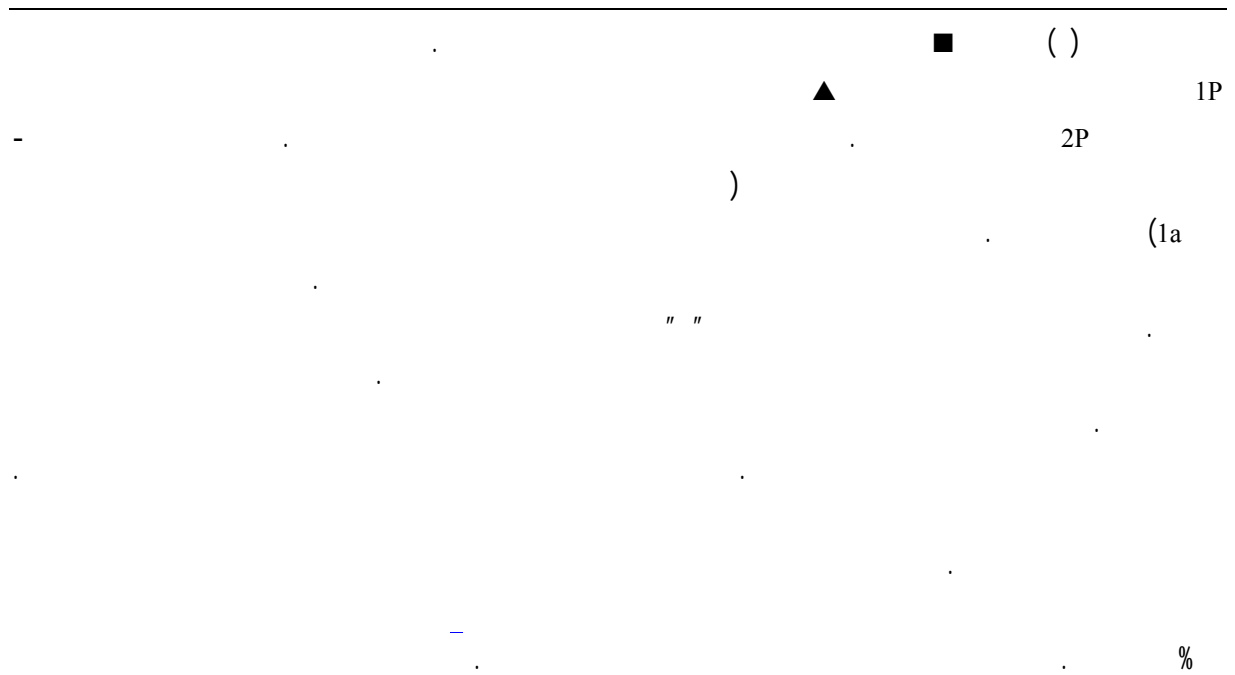
TS SA

SA

.TS SA

TS





- 1 - Ramakumar, R. (1993). *Reliability Engineering: Fundamentals and Applications*, Prentice Hall, ISBN 0-13-276759-7.
 - 2 - Tsai, Y. T., Wang, K. S. and Teng, H. Y. (2001). "Optimizing preventive maintenance for mechanical components using genetic algorithms." *Reliability Engineering System Safety*, Vol. 74, PP. 89-97.
 - 3 - Lie, C. H. and Chun, Y. H. (1986). "An algorithm for preventive maintenance policy." *IEEE Trans Reliab* Vol. 35, No. 1, PP.71-5.
 - 4 - Wang, H. (2002). "A survey of maintenance policies of deteriorating systems." *European Journal of Operational Research*, Vol. 139, PP. 469-489.
-

5 - Barlow, R. E. and Hunter, L. C. (1960). "Optimum preventive maintenance policies." *Operation Research*, Vol. 8, PP. 90-100.

6 - Bris, R., Chatelet, E. and Yalaoui, F. (2003). "New method to minimize the preventive maintenance cost of series-parallel systems." *Reliability Engineering and System Safety*, Vol. 82, PP. 247-255.

7 - Samrout, M., Yalaoui, F., Chatelet, E. and Chebbo, N. (2005). "New methods to minimize the preventive maintenance cost of series-parallel systems using ant colony optimization." *Reliability Engineering and System Safety*, Vol. 89, PP. 346-354.

8 - Lapa, C., Pereira, C. and Mol, A. C. (2000). "Maximization of a nuclear system availability through maintenance scheduling optimization using a genetic algorithm." *Nuclear Engineering and Design*, Vol. 196, PP.219-231.

9 - Mercier, S. (2002). "A preventive maintenance policy with sequential checking procedure for a Markov deteriorating system." *European Journal of Operational Research*, Vol. 147, PP. 548-576.

10- Kolahan F. and Doostparat M. (2006). *Application of simulated annealing algorithm in optimal preventive maintenance planning, 3rd Technical Conference in Maintenance*, Tehran, Iran. (In Persian).

11 - Lapa, C., Pereira, C. and Frutuoso, P. F. (2003). "Surveillance test policy optimization through genetic algorithms using non periodic intervention frequencies and considering seasonal constraints." *Reliability Engineering System Safety*, Vol. 81, PP. 103-109.

12- Haj Shirmohamadi, A. (1998). *Maintenance and repair planning (Technical management in industry)*, Azle Esfehan Publication Inc. (In Persian).

13 - Tsai, Y. T., Wang, K. S. and Tsai, L. C. (2004). "A study of availability-centered preventive maintenance for multi-component systems." *Reliability Engineering and System Safety*, Vol. 84, PP. 261-270.

14 - Jones, D. F., Mirrazavi, S. K. and Tamiz, M. (2002). "Multi-objective meta- heuristic: An overview of the current state-of-the-art." *European Journal of Operational Research*, Vol. 137, PP. 1-9.

15 - Eshraghnia R., Modir Shanehchy S. and Rajabi Mashhadi H. (2006). *Maintenance scheduling of manufacturing companies in a competitive environment using genetic algorithm., 3rd Technical Conference in Maintenance*, Tehran, Iran. (In Persian).

16 - Kirkpatrick, Gelatt, J. and Vecchi, D. D. (1983). "Optimization by simulated annealing." *Science*, PP.220, 671.

17 - Laarhoven, P. J. M. and Aarts, E. H. L. (1998). *Simulated annealing: Theory and applications*, Kluwer Academic Publishers.

18 - Glover, F. (1990). *Tabu search: A tutorial, Interfaces*, Vol. 20, PP. 74-94.

19 - Kolahan, F. and Liang, M. (1998). "An adaptive TS approach to JIT sequencing with variable processing times and sequence-dependent setups." *European Journal of Operational Research*, Vol. 109, PP. 142-159.

20 - Gopalakrishnan, M. (2001). "A tabu search heuristic for preventive maintenance scheduling." *Computers & Industrial Engineering*, Vol. 40, PP.149-160.

- | | | |
|----------------------------|-------------------------------|-----------------------------------|
| 1 - Reliability | 2 - Corrective Maintenance | 3 - Preventive Maintenance |
| 4 - Minimal Repair | 5 - Corrective Replacement | 6 - Simple Préventive Maintenance |
| 7 - Preventive Replacement | 8 - Down time | 9 - Availability |
| 10 - Genetic Algorithm | 11 - Hazard Rate | 12 - Tabu Search |
| 13 - Simulated Annealing | 14 - Boltezman Distribution | 15 - Partition Function |
| 16 - Boltezman Factor | 17 - Annealing | 18 - Transition Probability |
| 19 - Pairwise Interchange | 20 - Extraction and Insertion | |