Maintenance Management
II – Test (16/4/2017)
VI Semester, Mechanical Engineering

Time-1 Hr. **M.M.- 10**

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1. The failure density function for a class of component is given by

$$f(t) = 0.25 - \left(\frac{0.25}{8}\right)t \qquad \textit{where t is in years}$$

a) Find failure distribution, reliability and hazard rate function. (2)
b) Sketch the four functions. (2)
c) Find *MTTF*. (2)

Solution: Given, $f(t) = 0.25 - \left(\frac{0.25}{8}\right)t$

Failure distribution function is given by

$$F(t) = \int_0^t f(t)\,dt$$

$$\therefore \quad F(t) = \int_o^t \left(0.25 - \left(\frac{0.25}{8}\right)t\right)dt$$

$$\therefore \quad F(t) = 0.25\,t - \left(\frac{0.25}{16}\right)t^2$$

We know $R(t) = 1 - F(t)$

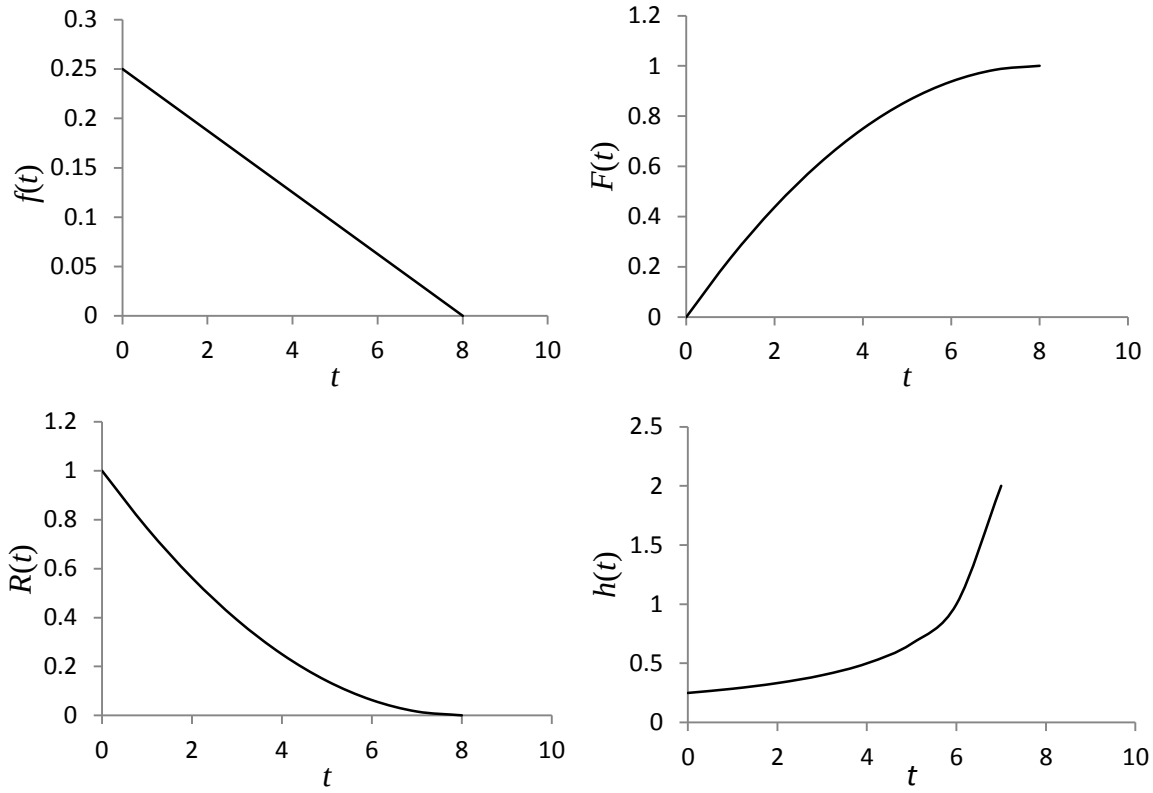
$$\therefore \quad R(t) = 1 - 0.25\,t + \left(\frac{0.25}{16}\right)t^2$$

Since, the hazard rate function is the ratio of the probability density function to the reliability function, that is

$$h(t) = \frac{f(t)}{R(t)} = \frac{0.25 - \left(\frac{0.25}{8}\right)t}{1 - 0.25\,t + \left(\frac{0.25}{16}\right)t^2}$$

$$\therefore \quad h(t) = \frac{2 - 0.25t}{8 - 2t + 0.125t^2}$$

To sketch above functions, we vary time to failure *t* at three-four levels such as 0, 2, 6 and 8 to find values of functions. Then, we can plot these functions as shown in Figure 19.



Figures Lifetime functions for Problem

Here, we integrate reliability function from 0 to 8 to get MTTF as it is equal to the area under the reliability function, that is

$$\text{MTTF}=\int_0^8\left(1-0.25\,t+\left(\frac{0.25}{16}\right)t^2\right)dt$$

$$\text{MTTF}=\left[t-\frac{0.25}{2}t^2+\frac{0.25}{48}t^3\right]_0^8=2.667 \text{ years.}$$

2. A car has four identical and independent tyres and failure rate of each tyre is 0.0002 failures/hr. If any one of the tyre is punctured, the car can not be driven. Calculate the following:

a) Car reliability for 15 hours mission time with respect to tyres. (2)

b) Car failure rate with respect to tyres. (1)

c) Car *MTTF* with respect to tyres. (1)

Solution: This is a case of series reliability system as the car cannot be driven if any one of the tyre is punctured.

(i) Car reliability for a 50 hours mission time with respect to tyres is given by

$$R_s(t) = e^{-\lambda_1 t} * e^{-\lambda_2 t} * \ldots * e^{-\lambda_n t} = e^{-\left(\sum_{i=1}^{n} \lambda_i t\right)}$$

For given problem, we have

$$R_s(t) = e^{-(0.0002+0.0002+0.0002+0.0002)t} = e^{-0.0008t}$$

At t = 50 hours, we have

$$R_s(t) = e^{-0.0008t} = e^{-0.0008*50} = 0.9608$$

(ii) Car failure rate with respect to tyres

The failure rate of a series system is the sum of the component failure rates, that is

$$\lambda_s = \sum_{i=1}^{n} \lambda_i$$

$\therefore \quad \lambda_s = 0.0002 + 0.0002 + 0.0002 + 0.0002 = 0.0008$ failures per hour

(iii) Car MTTF with respect to tyres

The mean time to failure (MTTF) of a series system is given by the reciprocal of the sum of the failure rates of the components in the system.

$$\text{MTTF}_s = \frac{1}{\sum_{i=1}^{n} \lambda_i}$$

$$\text{MTTF}_s = \frac{1}{0.0008} = 1250 \text{ hours}$$

Maintenance Management
I – Test (18/2/2016)
VI Semester, Mechanical Engineering

1. **If linear hazard rate function is**

$$h(t) = 5 \times 10^{-6} t$$

where *t* is measured in hours. What is the design life for a desired reliability of 0.98? (6)

Solution: Following equation is used to derive the reliability function from a known hazard rate function.

$$R(t) = \exp\left(-\int_0^t h(t)dt \right) = e^{-\int_0^t h(t)dt}$$

$$\therefore \quad R(t) = \exp\left(-\int_0^t 5 \times 10^{-6} t \right)$$

As desired reliability is 0.98

$$\therefore \quad 0.98 = \exp\left(-\frac{5 \times 10^{-6}}{2} t^2 \right)$$

$$\therefore \quad -5 \times 10^{-6} t^2 = \ln(0.98) = -0.02020$$

$$\therefore \quad t^2 = 8080$$

$$\therefore \quad t = 90 \text{ hours}$$

Therefore, the design life for a desired reliability of 0.98 is 90 hours.

2 **Differentiate between:**
(i) MTTF and MTTB
(ii) Reliability and Quality **(4)**

Solution:

(i) The average time to failure of the non-repairable system after entering into service is known as mean time to failure (MTTF).

The mean operating time between failures (abbreviated as MTBF) is the expected length of time between successive failures of a repairable component or system.

In general, while MTTF is reserved for a non-repairable component or system, MTBF is used as a reliability measure for the study of repairable systems.

(ii) Reliability is one of the most important characteristics of a product. In general, it is said that reliability is quality over time. If a product performs well at the time of buying it, you would consider the product to have good quality. However, if over a period of time parts of the product wear-out before you expect them and its functionality deteriorates, then this would be termed as unreliable product. The same product would be considered reliable one if it performs well during its lifetime without failure. In other words, while quality is conformance of customer requirement only at a given point of time, the reliability is conformance of customer requirement over a period of time. Therefore, the difference between quality and reliability is concerned with time and more specifically product lifetime. Reliability can only be determined after an elapsed time, but can be predicted at any time.

Maintenance Management
II – Test (12/4/2016)
VI Semester, Mechanical Engineering

1. Define maintenance management. Enumerate the objectives of maintenance. (5)

Solution:

- All activities of the management that determines the maintenance objectives, strategies, and responsibilities and implement them by means such as maintenance planning, scheduling and control of methods in the organization including economic aspects.
- Maintenance management generally consists of the following basic concepts:
  - Setting aims and objectives
  - Providing the means of attaining those aims and objectives
  - Decision making

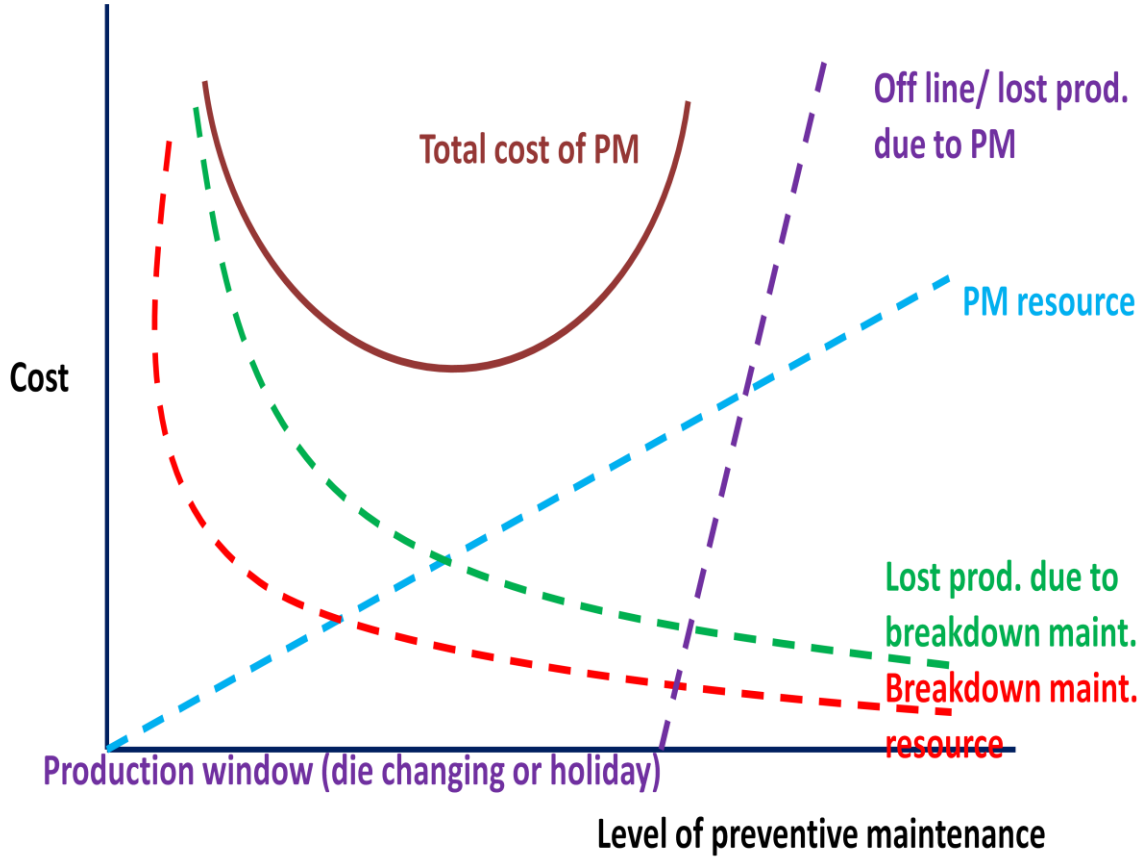
Objectives of Maintenance

- To enhance overall plant/equipment effectiveness (OEE).
  - OEE = Availability * Performance rate * Quality rate
- To achieve acceptable safety of manpower and nearby surrounding.
- To ensure operational readiness of all equipment at all the time and for emergency duty.
- To minimize cost.

2. Explain how an optimal maintenance strategy is selected for the given item/equipment. (5)

Solution:

- The preventive maintenance cost increases when the inspection and maintenance interval is shortened by maintenance at the higher reliability level.
- On the other hand, risk or loss caused by failure will increase when the inspection and maintenance interval is lengthened.


Total cost of PM
Off line/ lost prod. due to PM
PM resource
Cost
Lost prod. due to breakdown maint.
Breakdown maint. resource
Production window (die changing or holiday)
Level of preventive maintenance