UTBM
Exam Corrections: R.M.A.S of energy hydrogen systems ER59
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Exercice n°1

MTBF (A) = 14500 h ; MTBF (B) = 13200 h; MTBF (C) = 16000 h; MTBF (D) = ?

1.1) $\lambda_T = \frac{1}{MTBF_A} + \frac{1}{MTBF_B} + \frac{1}{MTBF_C} + \frac{1}{MTBF_D}$

$\lambda_T = \frac{1}{14500} + \frac{1}{13200} + \frac{1}{16000} + \frac{1}{MTBFD}$ = 2.2 e-04 /heure

$MTBF_D = \frac{1}{\lambda_T - \frac{1}{MTBF_A} - \frac{1}{MTBF_B} - \frac{1}{MTBF_C}}$ =78266 heures

1.3) exp(-2.2e-04*1500) = 72%

1.4) exp(-2.2e-04*5000) =33.3%

Exercice n°2

2.1)

$R(t) = \exp - \left(\frac{t-\gamma}{\eta}\right)^{\beta}$

β (beta) is the "shape" parameter (slope),
η (eta) is the "scale" parameter (characteristic life),
γ (gamma): "location" parameter (or failure free life)

2.2) Failure density function: f(t)= - $\frac{dR(t)}{dt} = \frac{\beta}{\eta^{\beta}}(t-\gamma)^{\beta-1}\exp - \left(\frac{t-\gamma}{\eta}\right)^{\beta}$

2.3) Failure rate λ(t) = $\frac{f(t)}{R(t)} = \frac{\beta}{\eta^{\beta}}(t-\gamma)^{\beta-1}$

after one year the reliability is :$R(1) = \exp - \left(\frac{1}{5}\right)^{2.6}$

2.4) $\exp - \left(\frac{t}{5}\right)^{2.6}$ = 98,49%

2.5) $\lambda(1) = \frac{2.6}{5^{2.6}}(1)^{1.6}$ = 0.039 failure/year

2.6) Ln(Ln[$\exp - \left(\frac{t}{5}\right)^{2.6}$]= Ln (Ln(0.95))

1) $t = 5.\exp(\frac{(\text{Ln}(-\text{Ln}\ (0.95))}{2.6})$ = 1.59 years

Exercice n°3A

The binomial low of (1oo3) is expressed as:

$R(t) = \sum_{j=1}^{j=3} C_n^j \,.R(t)^j(1-R(t))^{n-j}$

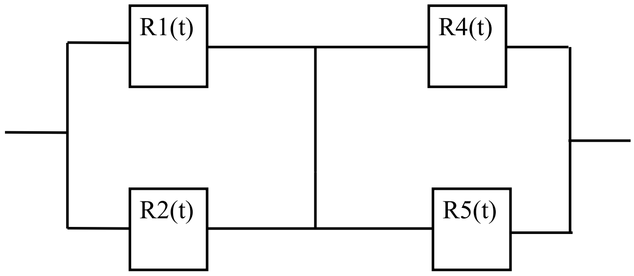
$R(t) = C_3^1 R(t)^1(1-R(t))^2 + C_3^2 R(t)^2(1-R(t))^1 + C_3^3 R(t)^3$

$R(t) = 3.R(t)^1(1-R(t))^2 + 3.R(t)^2(1-R(t))^1 + R(t)^3$

$R(t) = 3 * 0.85(1-0.85)^2 + 3 * 0.85^2(1-0,85)^1 + 0,85^3$ = 99,66%

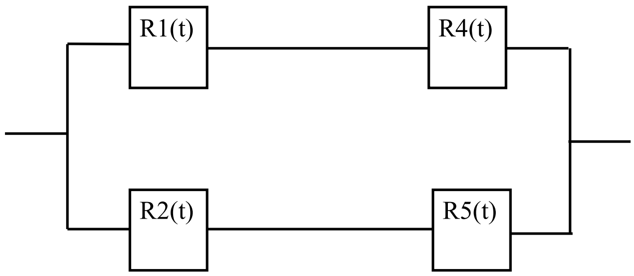
Exercice n°3B

If R3(t) =1



$RA(t)= (1-(1-R(t))^2)^2 = 4R(t)^2-4R(t)^3+R(t)^4$

If R3(t)=0



$RB(t)= 1-(1-R^2)^2 = 2R^2-R^4$

Rs(t)= R(t).RA(t)+ (1-R(t))*RB(t)

$Rs(t)= 2R^5(t) -5R^4(t) +2R^3(t) +2 R^2(t)$

Exercice4

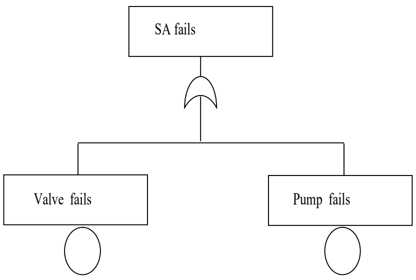
4.1) $R_A(t) = R_P(t).R_V(t)$

$R_A(t) = exp - (\lambda_P.t).exp - (\lambda_V.t)$

$R_A(t) = exp - (\lambda_p + \lambda_V).t$

4.2) $MTBF_A = \int_0^{+\infty} R_A(t)\,dt = \frac{1}{\lambda_P+\lambda_V}$

4.3)



Logic function P+V

The fault tree has two minimal cuts of first order

4.4) $R_B(t) = 1 - \left(1 - R_{P1}(t).R_{V1}(t)\right).(1 - R_{P2}(t).R_{V2}(t))$

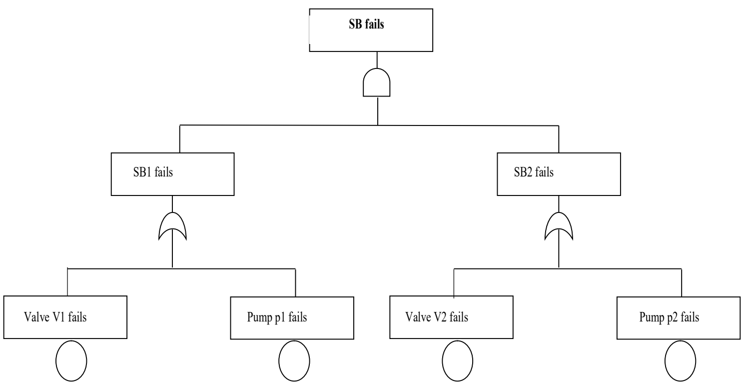
$R_B(t) = 1 - (1 - 2.R_P(t).R_V(t) + R_P(t)^2.R_V(t)^2)$

$R_B(t) = R_{P1}(t).R_{V1}(t) + R_{P2}(t).R_{V2}(t) - R_{P1}(t).R_{V1}(t).R_{P2}(t).R_{V2}(t)$

$R_B(t) = exp - (\lambda_{P_1} + \lambda_{V1}).t + exp - (\lambda_{P_2} + \lambda_{V2}).t - exp - (\lambda_{P_1} + \lambda_{V1} + \lambda_{P2} + \lambda_{V2}).t$

4.5 $MTBF_B = \int_0^{+\infty} R_B(t)\,dt = \frac{1}{(\lambda_{P_1}+\lambda_{V1})} + \frac{1}{(\lambda_{P_1}+\lambda_{V1})} - \frac{1}{(\lambda_{P_1}+\lambda_{P2}+\lambda_{V1}+\lambda_{V_2})}$

4.6)



Logic equation (P1+V1).(P2+V2)

= EB(P1).EB(P2) + EB(P1).EB(V2)+ EB(V1).EB(P2)+ EB(V1).EB(V2)

The fault tree has four minimal cuts of second order

4-7) $R_C(t) = \left[1-\left(1-R_P1(t)\right)\left(1-R_P2(t)\right)\right]\left[1-\left(1-R_{V1}(t)\right)\left(1-R_{V2}(t)\right)\right]$

$$R_C(t) = [R_P1(t) + R_P2(t) - R_{P1}(t)R_{P2}(t)][R_V1(t) + R_V2(t) - R_{V1}(t)R_{V2}(t)]$$

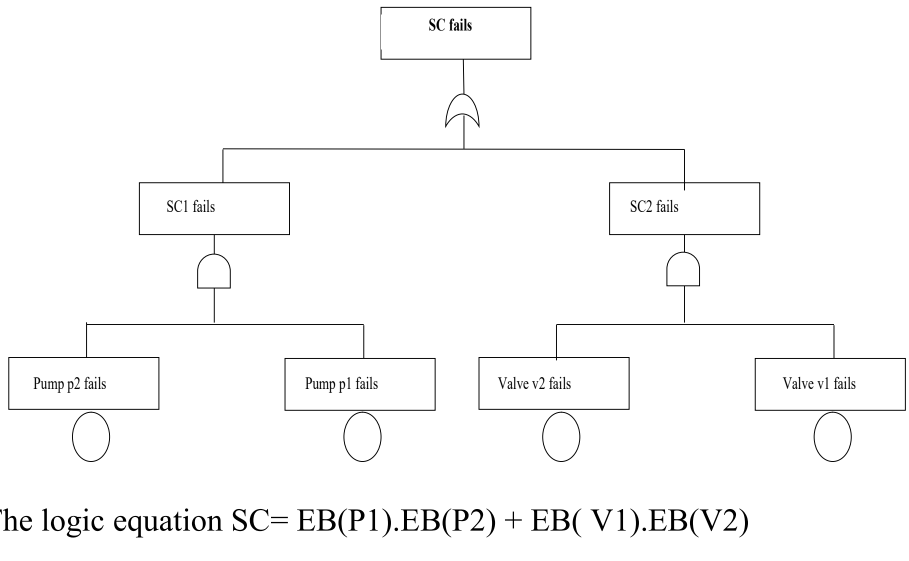
$$\begin{aligned} R_C(t) = [&R_P1(t).R_V1(t) + R_P1(t).R_{V2}(t) - R_V1(t).R_V2(t).R_P1(t) \\ &+ R_P2(t).R_{V1}(t) + R_P2(t).R_{V2}(t) - R_V1(t).R_V2(t).R_P2(t) \\ &- R_{P1}(t)R_{P2}(t).R_{V1}(t) - R_{P1}(t)R_{P2}(t).R_{V2}(t) \\ &- R_{P1}(t)R_{P2}(t).R_{V1}(t).R_{V2}(t)] \end{aligned}$$

4.8) $MTBF_C = \int_0^{+\infty} R_C(t)\, dt =$

$$\frac{1}{\lambda_{P1}+\lambda_{V1}} + \frac{1}{\lambda_{P1}+\lambda_{V2}} + \frac{1}{\lambda_{P2}+\lambda_{V1}} + \frac{1}{\lambda_{P2}+\lambda_{V2}} - \frac{1}{\lambda_{V2}+\lambda_{P1}+\lambda_{V2}} - \frac{1}{\lambda_{V1}+\lambda_{P2}+\lambda_{V2}}$$

$$- \frac{1}{\lambda_{P2}+\lambda_{P1}+\lambda_{V1}} - \frac{1}{\lambda_{P2}+\lambda_{P1}+\lambda_{V2}} - \frac{1}{\lambda_{P2}+\lambda_{P1}+\lambda_{V1}+\lambda_{V2}}$$

4.9)



The logic equation SC= EB(P1).EB(P2) + EB(V1).EB(V2)

The fault tree has two minimal cuts of second order