Availability And Profit Analysis Of A PVC Manufacturing Plant (A Case Study Of Hisar District)

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Abstract: -
For the current investigation, one has selected the Polyvinyl Chloride (PVC) industry located in the Hisar District. PVC plants are only regarded as commercially viable when all four units are in good operating condition. When all four of the system's parts are in good operating order, the system operates at its peak efficiency. When three of the four units are operational, it operates at a reduced capacity. When two or more units fail, the system is said to be in a failed condition. There are separate rates of continuous failure and repair for each of the four units. There is always one repairman available. With the aid of accurate scenarios, it is still necessary to determine how disappointment/repair rates affect the MTSF, accessibility, and server at a busy time.

Keywords: Profit Analysis, RPGT, Availability

1. Introduction

PVC is a popular commercial polymer that is used as a primary raw material in a wide range of chemical and petrochemical applications. The four main sub-units in the PVC business are High Impact PVC, Molecular Oriented PVC, Unplasticized PVC, and Chlorinated PVC. In other words, Unplasticized reduces friction while increasing plasticity or viscosity. Rigid PVC is another name for a PVC-U pipe. Unplasticized PVC (PVC-U) has an amorphous structure that is transformed into a layered structure during the production process to create molecularly orientated PVC (PVC-O). Chlorinated PVC is known as C-PVC. Many of the benefits of PVC-U are also found in C-PVC pipes and fittings. PVC-HI, or High Impact PVC, is a plastic. PVC-U is combined with an impact modifier to increase the pipes' resistance to external hits, resulting in the PVC-HI grade. A variety of elements make up this sector. Even if one or more of its components fails, the framework continues to function for the brief period of time provided. Prior to entering the bombed condition, the subsystems are patched to prevent a substantial separation.

Jieong et al. (2009) addressed multi-objective streamlining issues using GA, or a half-and-half calculation. While Kumar et al. (2017) examined the urea compost sector for system parameters, the primary goal of the paper by Kumar et al. (2019) focuses on the explored investigation of the washing element in the paper company consuming RPGT. Kumar et al.'s 2018 study concentrated on the examination of a bakery and an edible petroleum treatment facility. Malik et al. optimized the mist group of a coal-fired thermal effect shrub in 2022. In Anchal et al.'s analysis of the SRGM classic using variance condition, dual types of deficiencies—simple and hard as for the timing of these for disengagement and expulsion following their recognition—have been reported.

The dependability, availability, and maintainability study gives several techniques to conduct out structure alteration, according to Komal et al. In 2021, Kumari et al. discussed benefit analysis of the stable agricultural harvester plants utilizing RPGT. Researchers Kumar, A., Goel, and Garg (2018) looked into the behaviour of a system that makes bread in their discussion of the reliability technology theory and its applications. Using RPGT, Kumar, A., et al. (2019) looked at the profitability of a cold standby structure with priority for preventative maintenance that comprises of two identical units with server failure. The current paper consists of two units, one of which is accessible online and the other of which is kept in cold standby mode. The only two modes for both online and cold standby units are good and entirely failed.

Bhunia et al. (2010) introduced GA in a series structure with a span portion to address issues with unshakable quality stochastic augmentation. Given the chance imperatives of the series framework, the review was able to find a solution to the issue of streamlining stochastic unshakeable quality. In 2017, Kumar, A., Garg, and Goel examined the mathematical modelling and profit analysis of an edible oil refinery facility. Kumar, A., Garg, D., and Goel (2019) investigated mathematical modelling and behavioural analysis in a paper mill washing unit.

A work by Kumar, A., et al. (2018) looked at the profitability analysis of a 3:4:: outstanding system plant. The system modelling and analysis of the EAEP manufacturing plant was the subject of research by Rajbala et al. in 2019. Behavioural analysis has been studied in the urea fertiliser industry by Kumar, A., Goel, P., Garg, and Sahu (2017). The RPGT technique was used to carry out the mathematical formulation. Different formulas for system parameters are produced by assuming that failure/repair rates are independent and constant. Tables and figures are used to discuss system sensitivity and behavior analysis.

2. Assumptions, Notations & Model Description

- A repairman is available 24*7.
- Failure/repair rates are constant.

f_i/e_i $(2 \leq i \leq 5)$: Constant repair/failure rate of units.

B/B/b : Unit in working / reduced / failed state.

Figure 1 depicts the service's Transition Diagram, which takes into account the above mentioned assumptions as well as notations.

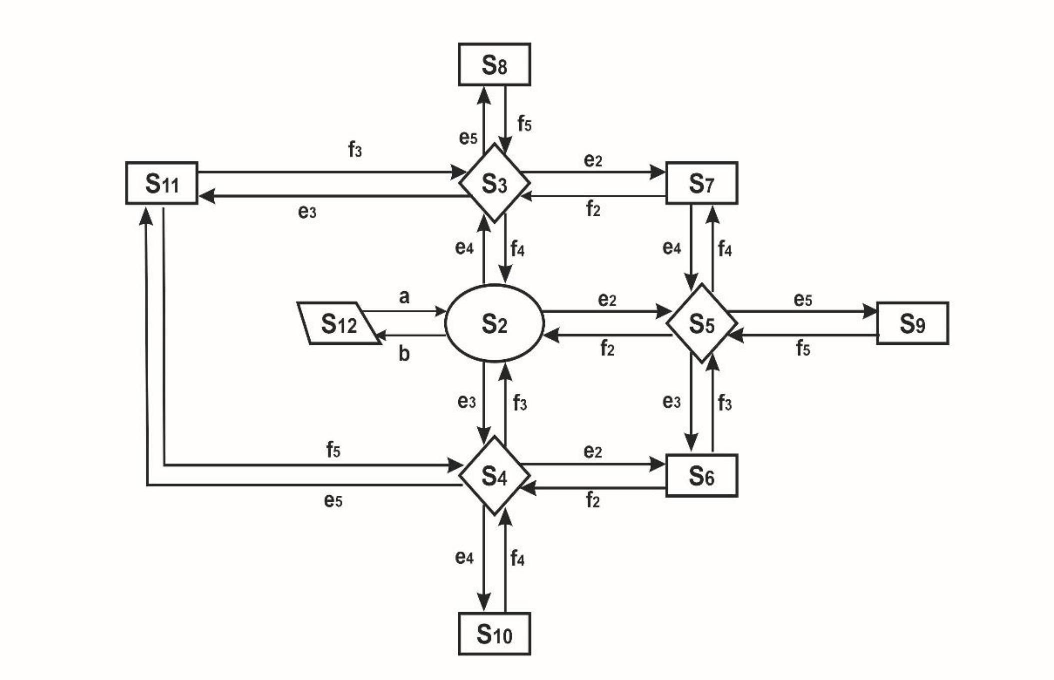

Fig. 1: Transition Diagram of Polyvinyl Chloride Plant

S_2 = ABCD, S_3 = ABCD, S_4 =ABCD,
S_5 = ABCD, S_6= ABCD, S_7 = ABCD,
S_8 = ABCD, S_9 = ABCD, S_{10}= ABCD,
S_{11}= ABCD, S_{12} = ABCD

3. Transition Probabilities & Mean Sojourn Times

Table 1: Transition Probabilities

$q_{i,j}(t)$	$p_{ij} = q^*_{i,j}(t)$
q2,3(t) =e4e-e2+e3+e4+bt q2,4(t) =e3e-e2+e3+e4+bt q2,5(t) =e2e-e2+e3+e4+bt q2,12(t)= be-e2+e3+e4+bt	p2,3= $e_4/(e_1+e_3+e_2+b)$ p2,4= $e_3/(e_1+e_3+e_2+b)$ p2,5= $e_2/(e_1+e_2+e_3+b)$ p2,12= $b/(e_3+e_2+e_1+b)$
q3,2(t) =f4e-f4+e2+e5+e3t q3,8(t) =e5e-f4+e2+e5+e3t q3,7(t) =e2e-f4+e2+e5+e3t q3,11(t) =e3e-f4+e2+e5+e3t	p3,2= f_4/(f4+e2+e5+e3) p3,8= e_5/(f4+e2+e5+e3) p3,7= e_2/(f4+e2+e5+e3) p3,11= e_3/(f4+e2+e5+e3)
q4,2t =f3e-f3+e2+e5+e4t q4,6(t) =e2e-f3+e2+e5+e4t q4,10(t) =e4e-f3+e2+e5+e4t q4,11(t) =e5e-f3+e2+e5+e4t	p4,2= f_3(f3+e2+e5+e4) p4,6= e_2/(f3+e2+e5+e4) p4,10= e_4/(f3+e2+e5+e4) p4,11= e_5/(f3+e2+e5+e4)
q5,2(t) =f2e-f2+e3+e4+e5t q5,7(t) =e4e-f2+e3+e4+e5t	p5,2= f_2/(f2+e3+e4+e5) p5,7= e_4/(f2+e3+e4+e5)

q5,9(t) =e5e-f2+e3+e4+e5t q5,6(t) =e3e-f2+e3+e4+e5t	p5,9= e_5/(f2+e3+e4+e5) p5,6= e_3/(f2+e3+e4+e5)
q6,4(t) =f2e-f3+f2t q6,5(t) =f3e-f3+f2t	p6,4= f_2/(f3+f2) p6,5= f_3/(f3+f2)
q7,3(t) =f2e-f4+f2t q7,5(t) =f4e-f4+f2t	p7,3= f_2/(f4+f2) p7,5= f_4/(f4+f2)
q8,3t= f5e-f5t	p8,3= 1
q9,5t= f5e-f5t	p9,5= 1
q10,4t= f4e-f4t	p10,4= 1
q11,3(t) =f3e-f5+f3t q11,4(t) =f5e-f5+f3t	p11,3= f_3/(f5+f3) p11,4= f_5/(f5+f3)
q12,2t= ae-at	p12,2= 1

Table 2: Mean Sojourn Times

$R_i(t)$	$\mu_i = R_i^*(0)$
R2(t)= e-e2+e3+e4+bt	μ_2 = 1/(e2+e3+e4+ b)
R3(t)= e-f4+e2+e5+e3t	μ_3= 1/(f4+e2+e5+e3)
R4(t)= e-f3+e2+e5+e4t	μ_4= 1/(f3+e2+e5+e4)
R5(t)= e-f2+e3+e4+e5t	μ_5= 1/(f2+e3+e4+e5)
R6(t)= e-f3+f2t	μ_6= 1/(f3+f2)
R7(t)= e-f4+f2t	μ_7= 1/(f4+f2)
R8t= e-f5t	μ_8 = 1/f_5
R9t= e-f5t	μ_9 = 1/f_5
R10t= e-f4t	μ_{10} = 1/f_5
R11(t)= e-f5+f3t	μ_{11} = 1/(f5+f3)
R12t= e-at	μ_{12} = 1/a

4. Parametric evaluation

$V_{2,2} = 1$

$$V_{2,3} = [(2, 3)/(P_1)\{1-\{P_2/(P_{17})\}\}\{1-\{P_3/(P_{21})\}\}][1/1-\{P_5/(P_4)(P_7)(P_6)(P_9)(P_{11})(P_{10})\}]+[(2, 5, 7, 3)/(P_1)\{1-\{P_2/(P_{17})\}\}\{1-\{P_3/(P_2)\}\}(P_{11})\{1-\{P_9/(P_{18})\}\}][1/1-\{P_4/(P_6)(P_5)(P_9)(P_7)(P_{11})(P_{10})\}][1/1-\{P_{12}/(1-P_1)(P_5)(P_3)(P_2)(P_7)(P_6)\}][1/1-\{P_{14}/(P_1)(P_5)(P_5)(P_2)(P_7)(P_9)(P_{11})\}][1/1-\{P_{10}/(P_{16})\}]+[(2,4,6,5,7,3)/(P_1)\{1-\{P_2/(P_{17})\}\}\{1-\{P_3/(P_{21})\}\}\{1-\{P_6/(P_{20})\}\}(P_5)][1/\{1-\{P_7/(P_{19})\}\}\{1-\{P_9/(P_{18})\}\}\{1-\{P_{10}/s(P_{16}\}(P_{11})])\}\}][1/1-\{P_4/(P_5)(P_7)(P_6)(P_{10})(P_9)(1-P_{11})\}][1/1-\{P_8/(P_1)(P_2)(P_3)(P_9)(P_{10})(P_{11})\}][1/1-\{P_{12}/(P_1)(1-P_2)(P_3)(P_6)(P_5)(P_7)\}][1/1-\{P_{13}/(P_1)(P_5)(P_3)(P_2)(P_6)(1-P_{10})(P_{11})\}][1/1-\{P_{14}/(P_1)(P_3)(P_5)(P_6)(P_7)(P_9)(P_{11})\}] + [(2, 4, 11, 3)/(P_1)\{1-\{P_2/(P_{17})\}\{1-\{P_3/(P_{21})\}\}(P_5)][1/\{1-\{P_6/(P_{20})\}\}\{1-\{P_7/(P_{19})\}\}][1/1-\{P_{15}/(P_1)(P_2)(P_9)(P_{11})(P_5)(P_7)(P_{10})\}][1/1-\{P_8/(P_1)(P_2)(P_9)(P_{10})(P_{10})(P_{11})\}] + [(2, 5, 6, 4, 11,3)/(P_1)\{1-\{P_2/(P_{17})\}\}\{1-\{P_3/(P_{21})\}\}(P_5)\{1-\{P_6/(P_{20})\}\}][1/\{1-\{P_7/(P_{19})\}\}\{1-\{P_9/(P_{18})\}\}(P_{11})][1/1-\{P_4/(P_9)(P_7)(P_6)(P_5)(P_{10})(P_{11})\}][1/1-\{P_8/(P_1)(P_2)(P_3)(P_9)(P_{10})(P_{11})\}][1/1-\{P_{12}/(P_1)(P_2)(P_5)(P_5)(P_4)(P_7)\}][1/1-\{P_{13}/(P_1)(P_5)(P_3)(P_2)(P_6)(P_{10})(P_{11})\}][1/1-\{P_{15}/(P_1)(P_2)(P_9)(P_5)(P_7)(P_9)(P_{10})(P_{11})\}]$$

$V_{2,4}$ =…….Continuous

5. Methodology

MTSF (T_0): Reformative un-fizzled states in which framework can transit from early state '2', Earlier any failed state are: 'i' = 2, 4, 3, 5, 12 taking 'ξ' = 2.

$$\text{MTSF}\ (T_0) = \left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(\xi \xrightarrow{s_r(sff)} i\right)\right\}.\mu_i}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1,m_1}}\}}\right\}\right] \div \left[1-\sum_{s_r}\left\{\frac{\left\{pr\left(\xi \xrightarrow{s_r(sff)} \xi\right)\right\}}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2,m_2}}\}}\right\}\right]$$ i,srprξsr(sff)iμiΠm1≠ξ1-Vm1m1 ÷

$$\left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(\xi \xrightarrow{s_r(sff)} i\right)\right\}.\mu_i}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1,m_1}}\}}\right\}\right] \div \left[1-\sum_{s_r}\left\{\frac{\left\{pr\left(\xi \xrightarrow{s_r(sff)} \xi\right)\right\}}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2,m_2}}\}}\right\}\right]$$ 1-srprξsr(sff)ξΠm2≠ξ1-Vm2m2

AOS (A_0): The reformative states in which outline is reachable are 'j' = 2, 5, 4, 3, 12 and states are 'i' = 2 ≤ i ≤ 12 attractive 'ξ' = '2'

$$A_0=\left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}i\right)\right\}.\mu_i}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1,m_1}}\}}\right\}\right]\div\left[1-\sum_{s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}\xi\right)\right\}}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2,m_2}}\}}\right\}\right]$$ j,srprξsr→jfj,μjΠm1≠ξ1-Vm1m1 ÷

$$\left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}i\right)\right\}.\mu_i}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1,m_1}}\}}\right\}\right]\div\left[1-\sum_{s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}\xi\right)\right\}}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2,m_2}}\}}\right\}\right]$$ i,srprξsr→iμi1Πm2≠ξ1-Vm2m2

SOBP (B_0): The states in which attendant is hectic are ‘j’ = $3 \le j \le 12$ after base state ξ = ‘2’

$$B_0=\left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}i\right)\right\}.\mu_i}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1,m_1}}\}}\right\}\right]\div\left[1-\sum_{s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}\xi\right)\right\}}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2,m_2}}\}}\right\}\right]$$ j,srprξsr→j,njΠm1≠ξ1-Vm1m1 ÷

$$\left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}i\right)\right\}.\mu_i}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1,m_1}}\}}\right\}\right]\div\left[1-\sum_{s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}\xi\right)\right\}}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2,m_2}}\}}\right\}\right]$$ i,srprξsr→iμi1Πm2≠ξ1-Vm2m2

ENIR (V_0): Reformative states everyplace repairmen do this job ‘j’ = 3, 4, 5, 12; reformative states are ‘i’ = $2 \le i \le 12$,

$$V_0=\left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}i\right)\right\}.\mu_i}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1,m_1}}\}}\right\}\right]\div\left[1-\sum_{s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}\xi\right)\right\}}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2,m_2}}\}}\right\}\right]$$ j,srprξsr→jΠk1≠ξ1-Vk1k1 ÷

$$\left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}i\right)\right\}.\mu_i}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1,m_1}}\}}\right\}\right]\div\left[1-\sum_{s_r}\left\{\frac{\left\{pr\left(\xi\xrightarrow{s_r(sff)}\xi\right)\right\}}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2,m_2}}\}}\right\}\right]$$ i,srprξsr→iμi1Πk2≠ξ1-Vk2k2

6. Results

Availability of the System (A_0):

Table 3: Availability of the System (A_0)

e \ f	0.55	0.65	0.75
0.15	0.785	0.891	0.929
0.25	0.534	0.689	0.841
0.35	0.378	0.452	0.539

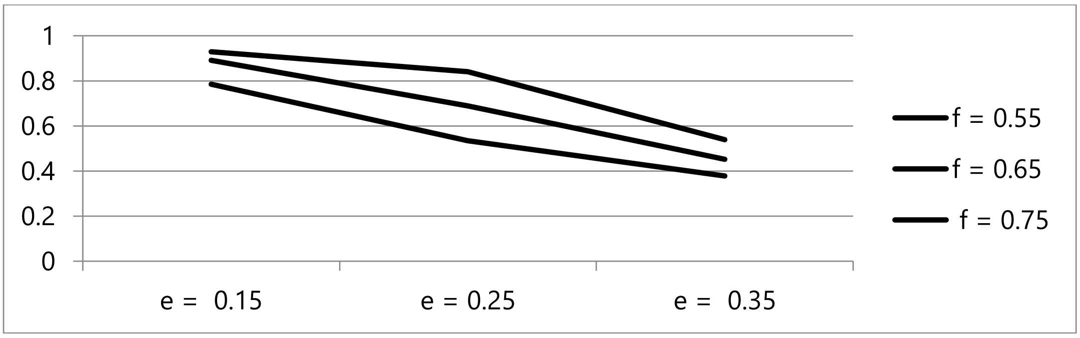

Fig. 2: Availability of the System

According to fig. 2 and Table 3, availability rises with higher repair rates, and declines with higher failure rates, which is consistent with current market trends.

Profit Function: The system can be done by utilizing profit function

$P_0 = D_1A_0 – (D_2B_0 + D_3V_0) = D_1A_0 – D_2B_0 - D_3V_0$

Where: $D_1 = 1000$; $D_2 = 500$; $D_3 = 300$

Table 4: Profit Function (P_0)

e \ f	F= 0.55	f = 0.65	f = 0.75
e = 0.15	415.6	544.5	602.1
e = 0.25	180.8	312.5	483.3

e = 0.35	16.1	56.4	158.6

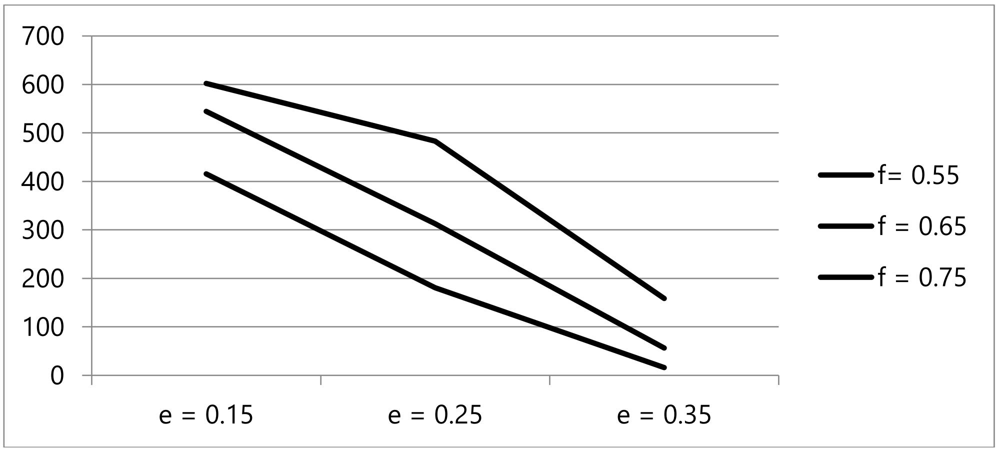

Fig. 3: Profit Function

Figure 3 and Table 4 show that profit rises with an increase in repair rates, for instance, and declines with an increase in estimates of unit failure rates. As a result, the profit function is inversely proportional to disappointment/failure rates, so for the best profit function estimates, repairmen should be as efficient as is reasonably possible with regard to repairs.

7. Conclusion

From the analytical and graphical discussion, it is noted that the values for P_0, profit table above and graph above may besides be set and conclusion with respect to repair and disappointment rates of units. Maximum value of profit is **602.1,** when disappointment rates of units are minimum and repair rates maximum.

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