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On Expected Profit of Four Compressor Units Standby System with Priority to Recently Failed Unit

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Abstract: **The paper présents profit analysis of working standby system from Verka milk plant which operate a refrigeration sytem by using four compressor units where two are in operating state and other two compressor units are taken as standby. System functioning based upon proper operation of atleast two units out of given four compressor units .Various measures of system have been evaluated numerically as well as graphically such as MTSF, Availability ,Busy periods and Cost benefit analysis by using regenerative point technique and semi – Markov process .**

Keywords: **Regeneration point technique, Refrigeration system, semi-Markov process, Compressor unit.**

1. INTRODUCTION

Many researchers [1-7] have done work on real life existing standby systems from various industries for useful and meaningful interpretations. Here in the present paper we have considered four compressor units standby system where two compressor units are in operating state and two are in standby state initially. On the failure of operating unit the standby unit starts its operation. This system actually exists in Verka Milk plant refrigeration system. Compressor unit failures can be categorized into three categories that is serviceable , repairable and replaceable .Here model has been studied with the concept of priority given to recent failed unit for service, repair and replacement.

The model is analyzed by making use of semi-Markov process and regenerative point technique and the expressions for various measures of system effectiveness and such as mean time to system failure, steady state availability, total fraction of busy time of repairman (for service, repair and replacement) per unit time and expected number of visits by repairman per unit time are determined .Profit for model is calculated using above measures. The mean to system failure and profit for a particular case are also calculating where repair time distribution are exponential .Graphs pertaining to this particular case are also plotted.

2. NOTATIONS

$O_I, O_{II}, O_{III}, O_{IV}$	First , second ,third and fourth compressor units are in operative State
S_{II}, S_{III}	Second and third compressors units are in standby state
$\lambda_{i1}, \lambda_{i2}, \lambda_{i3}, \lambda_{i4}$	Failure rate when failure is of serviceable , repairable and replaceable for first ,second, third and fourth compressor unit respectively (i= 1,2,3,4 and i symbol used for compressor unit)
$\alpha_{i1}, \alpha_{i2}, \alpha_{i3}, \alpha_{i4}$	Repair rates when failure is of serviceable , repairable and replaceable type for first, second, third and fourth compressor unit respectively (i=1,2,3,4)
$G_{i1}(t)$, $g_{i1}(t)$	c.d.f and p.d.f of time for service when failure is of serviceable type for first, second, third and fourth compressor unit respectively (i=1,2,3,4)

$G_{i2}(t)$, $g_{i2}(t)$	c.d.f and p.d.f of time for repair when failure is of repairable type for first, second, third and fourth compressor unit respectively (i=1,2,3,4)
$G_{i3}(t)$, $g_{i3}(t)$	c.d.f and p.d.f of time for replacement when failure is of replaceable type for first , second, third and fourth compressor unit respectively(i=1,2,3,4)
FsI , FsII ,FsIII ,FsIV	Serviceable type of failure for compressor first, second, third and fourth compressor unit respectively
FrI,FrII,FrIII,FrIV	Repairable type of failure for compressor first ,second, third and fourth compressor unit respectively
FrepI, FrepII, FrepIII,FrepIV	Replaceable type of failure for first, second, third and fourth compressor unit respectively
FwrI,FwsI,FwrepI	First compressor unit is waiting for repair, service, replacement at the first time respectively
F_{WRI}, F_{WSI}, F_{WREPI}	First compressor unit is waiting for repair,service, replacement respectively at second time

Assumption of Models:

1. All failure times have exponential distribution .
2. After each repair , the unit works as good as new.
3. The repairman visits immediately as the unit fails.
4. System will stop functioning If a unit is under service , repair and replacement.
5. Failure of a unit is detected immediately and perfectly .
6. Arrival of repairman decides about the failure category of compressor unit and after service and replacement unit will work as good as new.

State No.	Status			State No.	Status
S_0	$O_I, O_{II}, S_{III}, S_{IV}$	S_{26}	$F_{WSI}, F_{wrepII}, F_{rIII}, O_{IV}$	S_{52}	$F_{WRI}, F_{wsII}, O_{III}, F_{sIV}$
S_1	$F_{sI}, O_{II}, O_{III}, S_{IV}$	S_{27}	$F_{WSI}, F_{wrepII}, F_{repIII}, O_{IV}$	S_{53}	$F_{WRI}, F_{wsII}, O_{III}, F_{rIV}$
S_2	$F_{rI}, O_{II}, O_{III}, S_{IV}$	S_{28}	$F_{WSI}, F_{wrepII}, O_{III}, F_{sIV}$	S_{54}	$F_{WRI}, F_{wsII}, O_{III}, F_{repIV}$
S_3	$F_{repI}, O_{II}, O_{III}, S_{IV}$	S_{29}	$F_{WSI}, F_{wrepII}, O_{III}, F_{rIV}$	S_{55}	$F_{WRI}, F_{wrII}, F_{sIII}, O_{IV}$
S_4	$F_{wsI}, F_{sII}, O_{III}, O_{IV}$	S_{30}	$F_{WSI}, F_{wrepII}, O_{III}, F_{repIV}$	S_{56}	$F_{WRI}, F_{wrII}, F_{rIII}, O_{IV}$
S_5	$F_{wsI}, F_{rII}, O_{III}, O_{IV}$	S_{31}	$F_{WREPI}, F_{wsII}, F_{sIII}, O_{IV}$	S_{57}	$F_{WRI}, F_{wrII}, F_{repIII}, O_{IV}$
S_6	$F_{wsI}, F_{repII}, O_{III}, O_{IV}$	S_{32}	$F_{WREPI}, F_{wsII}, F_{rIII}, O_{IV}$	S_{58}	$F_{WRI}, F_{wrII}, O_{III}, F_{sIV}$
S_7	$F_{wrepI}, F_{sII}, O_{III}, O_{IV}$	S_{33}	$F_{WREPI}, F_{wsII}, F_{repIII}, O_{IV}$	S_{59}	$F_{WRI}, F_{wrII}, O_{III}, F_{rIV}$
S_8	$F_{wrepI}, F_{rII}, O_{III}, O_{IV}$	S_{34}	$F_{WREPI}, F_{wsII}, O_{III}, F_{sIV}$	S_{60}	$F_{WRI}, F_{wrII}, O_{III}, F_{repIV}$
S_9	$F_{wrepI}, F_{repII}, O_{III}, O_{IV}$	S_{35}	$F_{WREPI}, F_{wsII}, O_{III}, F_{rIV}$	S_{61}	$F_{WRI}, F_{wrepII}, F_{sIII}, O_{IV}$
S_{10}	$F_{wrI}, F_{sII}, O_{III}, O_{IV}$	S_{36}	$F_{WREPI}, F_{wsII}, O_{III}, F_{repIV}$	S_{62}	$F_{WRI}, F_{wrepII}, F_{rIII}, O_{IV}$
S_{11}	$F_{wrI}, F_{rII}, O_{III}, O_{IV}$	S_{37}	$F_{WREPI}, F_{wrII}, F_{sIII}, O_{IV}$	S_{63}	$F_{WRI}, F_{wrepII}, F_{repIII}, O_{IV}$
S_{12}	$F_{wrI}, F_{repII}, O_{III}, O_{IV}$	S_{38}	$F_{WREPI}, F_{wrII}, F_{rIII}, O_{IV}$	S_{64}	$F_{WRI}, F_{wrepII}, O_{III}, F_{sIV}$
S_{13}	$F_{WSI}, F_{wsII}, F_{sIII}, O_{IV}$	S_{39}	$F_{WREPI}, F_{wrII}, F_{repIII}, O_{IV}$	S_{65}	$F_{WRI}, F_{wrepII}, O_{III}, F_{riv}$
S_{14}	$F_{WSI}, F_{wsII}, F_{rIII}, O_{IV}$	S_{40}	$F_{WREPI}, F_{wrII}, O_{III}, F_{sIV}$	S_{66}	$F_{WRI}, F_{wrepII}, O_{III}, F_{repIV}$
S_{15}	$F_{WSI}, F_{wsII}, F_{repIII}, O_{IV}$	S_{41}	$F_{WREPI}, F_{wrII}, O_{III}, F_{rIV}$		
S_{16}	$F_{WSI}, F_{wsII}, O_{III}, F_{sIV}$	S_{42}	$F_{WREPI}, F_{wrII}, O_{III}, F_{repIV}$		
S_{17}	$F_{WSI}, F_{wsII}, O_{III}, F_{rIV}$	S_{43}	$F_{WREPI}, F_{wrepII}, F_{sIII}, O_{IV}$		
S_{18}	$F_{WSI}, F_{wsII}, O_{III}, F_{repIV}$	S_{44}	$F_{WREPI}, F_{wrepII}, F_{rIII}, O_{IV}$		
S_{19}	$F_{WSI}, F_{wrII}, F_{sIII}, O_{IV}$	S_{45}	$F_{WREPI}, F_{wrepII}, F_{repIII}, O_{IV}$		
S_{20}	$F_{WSI}, F_{wrII}, F_{rIII}, O_{IV}$	S_{46}	$F_{WREPI}, F_{wrepII}, O_{III}, F_{sIV}$		
S_{21}	$F_{WSI}, F_{wrII}, F_{repIII}, O_{IV}$	S_{47}	$F_{WREPI}, F_{wrepII}, O_{III}, F_{rIV}$		
S_{22}	$F_{WSI}, F_{wrII}, O_{III}, F_{sIV}$	S_{48}	$F_{WREPI}, F_{wrepII}, O_{III}, F_{repIV}$		
S_{23}	$F_{WSI}, F_{wrII}, O_{III}, F_{rIV}$	S_{49}	$F_{WRI}, F_{wsII}, F_{sIII}, O_{IV}$		
S_{24}	$F_{WSI}, F_{wrII}, O_{III}, F_{repIV}$	S_{50}	$F_{WRI}, F_{wsII}, F_{rIII}, O_{IV}$		
S_{25}	$F_{WSI}, F_{wrepII}, F_{sIII}, O_{IV}$	S_{51}	$F_{WRI}, F_{wsII}, F_{repIII}, O_{IV}$		

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The possible states of transition $S_0,S_1,S_2,S_3,S_4,S_5,S_6,S_7,S_8,S_9,S_{10}$, S_{11},S_{12} are regenerative state where as $S_0,S_1,S_2,S_3,S_4,S_5,S_6,S_7,S_8,S_9,S_{10},S_{11},S_{12}$ are operating states $S_{13},S_{14},S_{15},S_{16},S_{17},S_{18},S_{19},S_{20},S_{21},S_{22},S_{23},S_{24},S_{25},S_{26},S_{27},S_{28},S_{29},S_{30},S_{31},S_{32},S_{33},S_{34},S_{35},S_{36},S_{37},S_{38},S_{39},S_4,S_{41},S_{42},S_{43},S_{44},S_{45}$ $,S_{46},S_{47},S_{48},S_{49},S_{50},S_{51},S_{52},S_{53},S_{54},S_{55},S_{56},S_{57},S_{58},S_{59},S_{60},S_{61},S_{62}$, $S_{63},S_{64},S_{65},S_{66}$ are failed state.

3. TRANSITION PROBABILITIES

Table 1: Possible states with status

Sr No	From State	To State	Rate	Sr No	From State	To State	Rate	Sr No	From State	To State	Rate	Sr No	From State	To State	Rate
1	S_4	S_{13}	λ_{31}	32	S_9	S_{44}	λ_{32}	63	S_{21}	S_5	$g_{33}(t)$	93	S_{51}	S_{10}	$g_{33}(t)$
2	S_4	S_{14}	λ_{32}	33	S_9	S_{45}	λ_{33}	64	S_{22}	S_5	$g_{41}(t)$	94	S_{52}	S_{10}	$g_{41}(t)$
3	S_4	S_{15}	λ_{33}	34	S_9	S_{46}	λ_{41}	65	S_{23}	S_5	$g_{42}(t)$	95	S_{53}	S_{10}	$g_{42}(t)$
4	S_4	S_{16}	λ_{41}	35	S_9	S_{47}	λ_{42}	66	S_{24}	S_5	$g_{43}(t)$	96	S_{54}	S_{10}	$g_{43}(t)$
5	S_4	S_{17}	λ_{42}	36	S_9	S_{48}	λ_{43}	67	S_{25}	S_6	$g_{31}(t)$	97	S_{55}	S_{11}	$g_{31}(t)$
6	S_4	S_{18}	λ_{43}	37	S_{10}	S_{49}	λ_{31}	68	S_{26}	S_6	$g_{32}(t)$	98	S_{56}	S_{11}	$g_{32}(t)$
7	S_5	S_{19}	λ_{31}	38	S_{10}	S_{50}	λ_{32}	69	S_{27}	S_6	$g_{33}(t)$	99	S_{57}	S_{11}	$g_{33}(t)$
8	S_5	S_{20}	λ_{32}	39	S_{10}	S_{51}	λ_{33}	70	S_{28}	S_6	$g_{41}(t)$	100	S_{58}	S_{11}	$g_{41}(t)$
9	S_5	S_{21}	λ_{33}	40	S_{10}	S_{52}	λ_{41}	71	S_{29}	S_6	$g_{42}(t)$	101	S_{59}	S_{11}	$g_{42}(t)$
10	S_5	S_{22}	λ_{41}	41	S_{10}	S_{53}	λ_{42}	72	S_{30}	S_6	$g_{43}(t)$	102	S_{60}	S_{11}	$g_{43}(t)$
11	S_5	S_{23}	λ_{42}	42	S_{10}	S_{54}	λ_{43}	73	S_{31}	S_7	$g_{31}(t)$	103	S_{61}	S_{12}	$g_{31}(t)$
12	S_5	S_{24}	λ_{43}	43	S_{11}	S_{55}	λ_{31}	74	S_{32}	S_7	$g_{32}(t)$	104	S_{62}	S_{12}	$g_{32}(t)$
13	S_6	S_{25}	λ_{31}	44	S_{11}	S_{56}	λ_{32}	75	S_{33}	S_7	$g_{33}(t)$	105	S_{63}	S_{12}	$g_{33}(t)$
14	S_6	S_{26}	λ_{32}	45	S_{11}	S_{57}	λ_{33}	76	S_{34}	S_7	$g_{41}(t)$	106	S_{64}	S_{12}	$g_{41}(t)$
15	S_6	S_{27}	λ_{33}	46	S_{11}	S_{58}	λ_{41}	77	S_{35}	S_7	$g_{42}(t)$	107	S_{65}	S_{12}	$g_{42}(t)$
16	S_6	S_{28}	λ_{41}	47	S_{11}	S_{59}	λ_{42}	78	S_{36}	S_7	$g_{43}(t)$	108	S_{66}	S_{12}	$g_{43}(t)$
17	S_6	S_{29}	λ_{42}	48	S_{11}	S_{60}	λ_{43}	79	S_{37}	S_8	$g_{31}(t)$				
18	S_6	S_{30}	λ_{43}	49	S_{12}	S_{61}	λ_{31}	80	S_{38}	S_8	$g_{32}(t)$				
19	S_7	S_{31}	λ_{31}	50	S_{12}	S_{62}	λ_{32}	81	S_{39}	S_8	$g_{33}(t)$				
20	S_7	S_{32}	λ_{32}	51	S_{12}	S_{63}	λ_{33}	82	S_{40}	S_8	$g_{41}(t)$				
21	S_7	S_{33}	λ_{33}	52	S_{12}	S_{64}	λ_{41}	83	S_{41}	S_8	$g_{42}(t)$				
22	S_7	S_{34}	λ_{41}	53	S_{12}	S_{65}	λ_{42}	84	S_{42}	S_8	$g_{43}(t)$				
23	S_7	S_{35}	λ_{42}	54	S_{12}	S_{66}	λ_{43}	85	S_{43}	S_9	$g_{31}(t)$				
24	S_7	S_{36}	λ_{43}	55	S_{13}	S_4	$g_{31}(t)$	86	S_{44}	S_9	$g_{32}(t)$				
25	S_8	S_{37}	λ_{31}	56	S_{14}	S_4	$g_{32}(t)$	87	S_{45}	S_9	$g_{33}(t)$				
26	S_8	S_{38}	λ_{32}	57	S_{15}	S_4	$g_{33}(t)$	88	S_{46}	S_9	$g_{41}(t)$				
27	S_8	S_{39}	λ_{33}	58	S_{16}	S_4	$g_{41}(t)$	89	S_{47}	S_9	$g_{42}(t)$				
28	S_8	S_{40}	λ_{41}	59	S_{17}	S_4	$g_{42}(t)$	90	S_{48}	S_9	$g_{43}(t)$				
29	S_8	S_{41}	λ_{42}	60	S_{18}	S_4	$g_{43}(t)$	91	S_{49}	S_{10}	$g_{31}(t)$				
30	S_8	S_{42}	λ_{43}	61	S_{19}	S_5	$g_{31}(t)$	92	S_{50}	S_{10}	$g_{32}(t)$				
31	S_9	S_{43}	λ_{31}	62	S_{20}	S_5	$g_{32}(t)$	93	S_{51}	S_{10}	$g_{33}(t)$				

By transition probabilities it can be verified that

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$$p_{01} + p_{02} + p_{03} = 1$$
$$p_{10} + p_{14} + p_{15} + p_{16} = 1$$
$$p_{41} + p_{4,13} + p_{4,14} + p_{4,15} + p_{4,16} + p_{4,17} + p_{4,18} = 1$$
$$p_{51} + p_{5,19} + p_{5,20} + p_{5,21} + p_{5,22} + p_{5,23} + p_{5,24} = 1$$
$$p_{61} + p_{6,25} + p_{6,26} + p_{6,27} + p_{6,28} + p_{6,29} + p_{6,30} = 1$$
$$p_{73} + p_{7,31} + p_{7,32} + p_{7,33} + p_{7,34} + p_{7,35} + p_{7,36} = 1$$
$$p_{83} + p_{8,37} + p_{8,38} + p_{8,39} + p_{8,40} + p_{8,41} + p_{8,42} = 1$$
$$p_{93} + p_{9,43} + p_{9,44} + p_{9,45} + p_{9,46} + p_{9,47} + p_{9,48} = 1$$
$$p_{10,2} + p_{10,49} + p_{10,50} + p_{10,51} + p_{10,52} + p_{10,53} + p_{10,54} = 1$$
$$p_{11,2} + p_{11,55} + p_{11,56} + p_{11,57} + p_{11,58} + p_{11,59} + p_{11,60} = 1$$
$$p_{12,2} + p_{12,61} + p_{12,62} + p_{12,63} + p_{12,64} + p_{12,65} + p_{12,66} = 1$$
$$p_{41} + p_{4,4}^{13} + p_{4,4}^{14} + p_{4,4}^{15} + p_{4,4}^{16} + p_{4,4}^{17} + p_{4,4}^{18} = 1,$$
$$p_{51} + p_{5,5}^{19} + p_{5,5}^{20} + p_{5,5}^{21} + p_{5,5}^{22} + p_{5,5}^{23} + p_{5,5}^{24} = 1$$
$$p_{61} + p_{6,6}^{25} + p_{6,6}^{26} + p_{6,6}^{27} + p_{6,6}^{28} + p_{6,6}^{29} + p_{6,6}^{30} = 1$$
$$p_{73} + p_{7,7}^{31} + p_{7,7}^{32} + p_{7,7}^{33} + p_{7,7}^{34} + p_{7,7}^{35} + p_{7,7}^{36} = 1$$
$$p_{83} + p_{8,8}^{37} + p_{8,8}^{38} + p_{8,8}^{39} + p_{8,8}^{40} + p_{8,8}^{41} + p_{8,8}^{42} = 1$$
$$p_{93} + p_{9,9}^{43} + p_{9,9}^{44} + p_{9,9}^{45} + p_{9,9}^{46} + p_{9,9}^{47} + p_{9,9}^{48} = 1$$
$$p_{10,2} + p_{10,10}^{49} + p_{10,10}^{50} + p_{10,10}^{51} + p_{10,10}^{52} + p_{10,10}^{53} + p_{10,10}^{54} = 1$$
$$p_{11,2} + p_{11,11}^{55} + p_{11,11}^{56} + p_{11,11}^{57} + p_{11,11}^{58} + p_{11,11}^{59} + p_{11,11}^{60} = 1$$
$$p_{12,2} + p_{12,12}^{61} + p_{12,12}^{62} + p_{12,12}^{63} + p_{12,12}^{64} + p_{12,12}^{65} + p_{12,12}^{66} = 1$$

4. MEAN TIME TO SYSTEM FAILURE

To determine the mean time to system failure (MTSF) of the system, we regard the failed states of the system as absorbing states and the mean time to system failure (MTSF)when the system starts from the state S_0.

$$\text{MTSF}=T_0 = \lim_{s\to 0}\frac{1-\phi_0^{**}(s)}{s}$$

Using L ' Hospital rule and putting the value of $ø_0^{**}$(s) we have

$$T_0 = N / D$$

$$N = \mu_0(-(p_{10} + p_{20} + p_{30}) + (1-(p_{14}p_{41} + p_{15}p_{51} + p_{16}p_{61}))(1-(p_{2,10}p_{10,2} + p_{2,11}p_{11,2} + p_{2,12}p_{12,2}))$$
$$(1-(p_{37}p_{73} + p_{38}p_{83} + p_{39}p_{93})) + p_{01}(\mu_1(1-g_{11}(\lambda)) + p_{14}\mu_4(1-g_{21}(\lambda)) + p_{15}\mu_5(1-g_{22}(\lambda)) + p_{16}\mu_6(1-g_{23}(\lambda))$$
$$(1-(p_{2,10}p_{10,2} + p_{2,11}p_{11,2} + p_{2,12}p_{12,2}))(1-(p_{37}p_{73} + p_{38}p_{83} + p_{39}p_{93})) + p_{02}(\mu_2(1-g_{12}(\lambda)) + p_{2,10}\mu_{10}(1-g_{21}(\lambda))$$
$$+p_{2,11}\mu_{11}(1-g_{22}(\lambda)) + p_{2,12}\mu_{12}(1-g_{23}(\lambda))(1-(p_{37}p_{73} + p_{38}p_{83} + p_{39}p_{93}))(1-(p_{14}p_{41} + p_{15}p_{51} + p_{16}p_{61}))$$
$$+p_{03}(\mu_3(1-g_{13}(\lambda)) + \mu_7 p_{3,7}(1-g_{21}(\lambda)) + \mu_8 p_{3,8}(1-g_{22}(\lambda)) + \mu_9 p_{3,9}(1-g_{23}(\lambda)))(1-(p_{14}p_{41} + p_{15}p_{51} + p_{16}p_{61}))$$
$$(1-(p_{2,10}p_{10,2} + p_{2,11}p_{11,2} + p_{2,12}p_{12,2}))$$
$$D = (1-(p_{14}p_{41} + p_{15}p_{51} + p_{16}p_{61}))(1-(p_{2,10}p_{10,2} + p_{2,11}p_{11,2} + p_{2,12}p_{12,2}))(1-(p_{37}p_{73} + p_{38}p_{83} + p_{39}p_{93}))$$
$$-p_{01}p_{10}(1-(p_{37}p_{73} + p_{38}p_{83} + p_{39}p_{93}))(1-(p_{2,10}p_{10,2} + p_{2,11}p_{11,2} + p_{2,12}p_{12,2}))$$
$$-p_{02}p_{20}(1-(p_{37}p_{73} + p_{38}p_{83} + p_{39}p_{93}))(1-(p_{14}p_{41} + p_{15}p_{51} + p_{16}p_{61}))$$
$$-p_{03}p_{30}(1-(p_{14}p_{41} + p_{15}p_{51} + p_{16}p_{61}))(1-(p_{2,10}p_{10,2} + p_{2,11}p_{11,2} + p_{2,12}p_{12,2}))$$

5. AVAILABILITY ANALYSIS

Using the arguments of the theory of regenerative processes in steady state system availability is

$$A_0 = \lim_{s \to 0}(sA_0^*(s)) = \frac{N_1}{D_1}$$

where

$$N_1 = (a-p_{41})(b-p_{51})(c-p_{61})(d-p_{73})(e-p_{83})(f-p_{93})(g-p_{10,2})(h-p_{11,2})(i-p_{12,2})(\mu_0+\mu_1 p_{01})$$
$$-(a-p_{41})(b-p_{51})(c-p_{61})(d-p_{7,3})(e-p_{8,3})(f-p_{93})(g-p_{10,2})(h-p_{11,2})(i-p_{12,2})(\mu_2 p_{02}+\mu_3 p_{03})$$
$$+(c-p_{61})(d-p_{7,3})(e-p_{83})(f-p_{93})((g-p_{10,2})(h-p_{11,2})(i-p_{12,2})p_{01}((b-p_{51})\mu_4 p_{14}+(a-p_{41})\mu_5 p_{15})$$
$$+(a-p_{41})(b-p_{51})(d-p_{73})(e-p_{83})(g-p_{10,2})(h-p_{11,2})(i-p_{12,2})(\mu_6 p_{01}p_{16}+(c-p_{61})\mu_{10}p_{02}p_{2,10})$$
$$+(a-p_{41})(b-p_{51})(c-p_{61})(e-p_{83})(f-p_{93})\mu_7 p_{37}+(d-p_{73})\mu_8 p_{38}+(a-p_{41})(b-p_{51})(c-p_{61})(d-p_{73})$$
$$(e-p_{83})\mu_9 p_{03}$$

Where

$$1-p_{4,4}^{13}+p_{4,4}^{14}+p_{4,4}^{15}+p_{4,4}^{16}+p_{4,4}^{17}+p_{4,4}^{18}=a$$
$$1-p_{5,5}^{19}+p_{5,5}^{20}+p_{5,5}^{21}+p_{5,5}^{22}+p_{5,5}^{23}+p_{5,5}^{24}=b$$
$$1-p_{6,6}^{25}+p_{6,6}^{26}+p_{6,6}^{27}+p_{6,6}^{28}+p_{6,6}^{29}+p_{6,6}^{30}=c$$
$$1-p_{7,7}^{31}+p_{7,7}^{32}+p_{7,7}^{33}+p_{7,7}^{34}+p_{7,7}^{35}+p_{7,7}^{36}=d$$
$$1-p_{8,8}^{37}+p_{8,8}^{38}+p_{8,8}^{39}+p_{8,8}^{40}+p_{8,8}^{41}+p_{8,8}^{42}=e$$
$$1-p_{9,9}^{43}+p_{9,9}^{44}+p_{9,9}^{45}+p_{9,9}^{46}+p_{9,9}^{47}+p_{9,9}^{48}=f$$
$$1-p_{10,10}^{49}+p_{10,10}^{50}+p_{10,10}^{51}+p_{10,10}^{52}+p_{10,10}^{53}+p_{10,10}^{54}=g$$
$$1-p_{11,11}^{55}+p_{11,11}^{56}+p_{11,11}^{57}+p_{11,11}^{58}+p_{11,11}^{59}+p_{11,11}^{60}=h$$
$$1-p_{12,12}^{61}+p_{12,12}^{62}+p_{12,12}^{63}+p_{12,12}^{64}+p_{12,12}^{65}+p_{12,12}^{66}=i$$

$$D_1 = (-1+p_{01}p_{10})(\mu_4(1-g_{21}^*(\lambda))p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+\mu_5(1-g_{22}^*(\lambda))p_{4,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}$$
$$+\mu_6(1-g_{23}^*(\lambda))p_{4,1}p_{5,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+\mu_7(1-g_{21}^*(\lambda))p_{4,1}p_{5,1}p_{6,1}p_{8,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+\mu_8(1-g_{22}^*(\lambda))p_{4,1}$$
$$p_{5,1}p_{6,1}p_{7,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+\mu_9(1-g_{23}^*(\lambda))p_{4,1}p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{10,2}p_{11,2}p_{12,2}+\mu_{10}(1-g_{21}^*(\lambda))p_{4,1}p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{11,2}p_{12,2}$$
$$+\mu_{11}(1-g_{22}^*(\lambda))p_{4,1}p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{12,2}+\mu_{12}(1-g_{23}^*(\lambda))p_{4,1}p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{11,2}+p_{4,1}p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}$$
$$p_{11,2}p_{12,2}+\mu_4(1-g_{21}^*(\lambda))(p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{12,2})(-1+p_{01}p_{10})-((p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+p_{41}(\mu_5(1-g_{22}^*(\lambda))$$
$$p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+\mu_6(1-g_{23}^*(\lambda))p_{5,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{12,2}+\mu_7(1-g_{21}^*(\lambda))p_{5,1}p_{6,1}p_{8,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+$$
$$+\mu_8(1-g_{22}^*(\lambda))p_{5,1}p_{6,1}p_{7,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+\mu_9(1-g_{23}^*(\lambda))p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{10,2}p_{11,2}p_{12,2}+\mu_{10}(1-g_{21}^*(\lambda))p_{5,1}p_{6,1}p_{7,3}p_{8,3}$$
$$p_{9,3}p_{11,2}p_{12,2}+\mu_{11}(1-g_{22}^*(\lambda))p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{12,2}+\mu_{12}(1-g_{23}^*(\lambda))p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{11,2}+\mu_1(1-g_{12}^*(\lambda^{**}))$$
$$p_{10}+\mu_7(1-g_{21}^*(\lambda))p_{8,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+\mu_8(1-g_{22}^*(\lambda))p_{7,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}+\mu_9(1-g_{23}^*(\lambda))p_{7,3}p_{8,3}p_{10,2}p_{11,2}p_{12,2}$$
$$+\mu_{10}(1-g_{21}^*(\lambda))p_{7,3}p_{8,3}p_{9,3}p_{11,2}p_{12,2}+\mu_{11}(1-g_{22}^*(\lambda))p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{12,2}+\mu_{12}(1-g_{23}^*(\lambda))p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{11,2}+\mu_7$$
$$(1-g_{21}^*(\lambda))p_{8,3}p_{9,3}+\mu_8(1-g_{22}^*(\lambda))p_{7,3}p_{9,3}+\mu_9(1-g_{23}^*(\lambda))p_{7,3}p_{8,3}+((p_{7,3}\mu_8(1-g_{22}^*(\lambda))p_{9,3}+\mu_9(1-g_{23}^*(\lambda))$$
$$+\mu_8(1-g_{22}^*(\lambda))+\mu_9(1-g_{23}^*(\lambda))p_{10,2}+p_{9,2}\mu_{10}(1-g_{21}^*(\lambda))p_{02}p_{20}-p_{03}p_{30}((\mu_5(1-g_{22}^*(\lambda))p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{11,2}+$$
$$+\mu_7(1-g_{21}^*(\lambda))p_{8,3}p_{9,3}p_{10,2}p_{11,2}p_{5,1}+\mu_8(1-g_{22}^*(\lambda))p_{7,3}p_{9,3}p_{10,2}p_{11,2}p_{12,2}p_{5,1}+\mu_9(1-g_{23}^*(\lambda))p_{5,1}p_{7,3}p_{8,3}p_{10,2}p_{11,2}$$
$$+\mu_{10}(1-g_{21}^*(\lambda))p_{5,1}p_{7,3}p_{8,3}p_{11,2}+\mu_{11}(1-g_{22}^*(\lambda))p_{5,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{9,3}p_{11,2}p_{12,2}+\mu_{11}(1-g_{22}^*(\lambda))p_{5,1}p_{6,1}p_{7,3}p_{8,3}p_{9,3}p_{10,2}p_{12,2}$$

6. BUSY PERIOD ANALYSIS FOR SERVICE ONLY

$$B_{S0} = \lim_{s\to 0}(sB^*_{S0}(s)) = \frac{N_2}{D_1}$$

where

$$N_2 = -(b-p_{51})(c-p_{61})p_{01}(h-p_{11,2})(i-p_{12,2})(g-p_{10,2})+p_{10,2}p_{2,10}+(g-p_{10,2})p_{11,2}p_{2,11}+(g-p_{10,2})$$
$$(h-p_{11,2})p_{12,2}p_{2,12}(d-p_{73})(e-p_{83})(f-p_{93})+p_{37}p_{73}+(d-p_{73})p_{3,8}p_{8,3})+(d-p_{73})(e-p_{83})p_{3,9}p_{9,3})$$
$$(a-p_{41})(\mu_1-p_{14}k_1)(b-p_{51})(c-p_{61})((a-p_{41})+p_{14}p_{41})+((a-p_{41})p_{15}p_{51})+((a-p_{41})$$
$$(b-p_{51})p_{16}p_{61})(h-p_{11,2})(i-p_{12,2})p_{02}p_{2,10}(d-p_{73})(e-p_{83})(f-p_{93})+p_{37}p_{73})$$
$$+((d-p_{73})p_{38}p_{83})+(d-p_{73})(e-p_{83}))p_{39}p_{93})k_1+(e-p_{83})(f-p_{93})p_{03}(h-p_{11,2})(i-p_{12,2})$$
$$(g-p_{10,2})+p_{2,10}p_{10,2})+(g-p_{10,2})+p_{2,10}p_{10,2})+((g-p_{10,2})p_{2,11}p_{11,2})+((g-p_{10,2})(h-p_{11,2})$$
$$p_{2,12}p_{12,2})p_{37}k_1$$

7. BUSY PERIOD ANALYSIS FOR REPAIR ONLY

$$B_{RP0} = \lim_{s\to 0}(sB^*_{RP0}(s)) = \frac{N_3}{D_1}$$

where

$$N_3 = (g-p_{10,2})(i-p_{12,2})p_{02}(a-p_{41})(b-p_{51})(c-p_{61})+p_{14}p_{41}(a-p_{41})p_{15}p_{51})+(a-p_{41})(b-p_{51})p_{16}p_{61}$$
$$(d-p_{73})(e-p_{83})(f-p_{93})+p_{37}p_{73})+(d-p_{73})p_{38}p_{83}+(d-p_{73}))(e-p_{83})p_{39}p_{93}(p_{2,11}k_2+\mu_2-(h-p_{11,2})\mu_2)$$
$$+(g-p_{10,2})(h-p_{11,2})(i-p_{12,2})+p_{2,10}p_{10,2})+(g-p_{10,2})p_{2,11}p_{11,2})+(g-p_{10,2})(h-p_{11,2})p_{2,12}p_{12,2})$$
$$(a-p_{41})(c-p_{61})p_{01}p_{15}(f-p_{93})((e-p_{83})+p_{37}p_{73})+(d-p_{73})p_{38}p_{83})+(d-p_{73})(e-p_{83})p_{39}p_{93})k_2$$
$$+(d-p_{73})(f-p_{93})p_{03}p_{38}(b-p_{51})(a-p_{41})(c-p_{61})p_{14}p_{41}+(a-p_{41})p_{15}p_{51}+(a-p_{41})(b-p_{51})p_{16}p_{61})k_2$$

8. BUSY PERIOD ANALYSIS FOR REPLACEMENT ONLY

$$B_{REP0} = \lim_{s\to 0}(sB^*_{REP0}(s)) = \frac{N_4}{D_1}$$

where

$$N_4 = (g-p_{10,2})(h-p_{11,2})p_{02}p_{2,12}(a-p_{41})(b-p_{51})(c-p_{61})+p_{14}p_{41}+(a-p_{41})p_{15}p_{51})$$
$$+(a-p_{41})(b-p_{51})p_{16}p_{61}(1-(p^{43}_{9,9}+p^{44}_{9,9}+p^{45}_{9,9}+p^{46}_{9,9}+p^{47}_{9,9}+p^{48}_{9,9}))(1-(p^{37}_{8,8}+p^{38}_{8,8}+p^{39}_{8,8}$$
$$+p^{40}_{8,8}+p^{41}_{8,8}+p^{42}_{8,8}))(1-(p^{31}_{7,7}+p^{32}_{7,7}+p^{33}_{7,7}+p^{34}_{7,7}+p^{35}_{7,7}+p^{36}_{7,7}))p_{37}p_{73}+(1-(p^{31}_{7,7}+p^{32}_{7,7}+p^{33}_{7,7}$$
$$+p^{34}_{7,7}+p^{35}_{7,7}+p^{36}_{7,7}))p_{38}p_{83})+(d-p_{73})(e-p_{83})p_{39}p_{93})k_3-(h-p_{11,2})(i-p_{12,2})(g-p_{10,2})+p_{10,2}p_{2,10}$$
$$+(g-p_{10,2})p_{11,2}p_{2,11})+(g-p_{10,2})(h-p_{11,2})p_{12,2}p_{2,12}))-(a-p_{41})(b-p_{51})p_{01}p_{16}(d-p_{73})(e-p_{83})$$
$$(f-p_{93})+p_{37}p_{73})+(d-p_{73})p_{38}p_{83})+(d-p_{73})(e-p_{83})p_{39}p_{93})k_3+(d-p_{73})(e-p_{83})$$
$$p_{03}(b-p_{51})(c-p_{61})(a-p_{41})+p_{14}p_{41})+(a-p_{41})p_{15}p_{51})+(a-p_{41})(b-p_{51})p_{16}p_{61}))(f-p_{93})\mu_3-p_{39}k_3$$

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9. EXPECTED NUMBER OF SERVICES IN SYSTEM

$$S_0 = \lim_{s\to 0}(sS_0^{**}(s)) = \frac{N_5}{D_1}$$

where

$$N_5 = -p_{01}(g-p_{10,2})(h-p_{11,2})(i-p_{12,2}) + p_{2,10}p_{10,2}) + (g-p_{10,2}) + p_{2,11}p_{11,2})(g-p_{10,2})(h-p_{11,2})p_{2,12}p_{12,2})$$
$$(d-p_{73})(e-p_{83})(f-p_{93}) + p_{37}p_{73} + (d-p_{73})p_{38}p_{83} + (d-p_{73})(e-p_{83})p_{39}p_{93}(a-p_{41})(b-p_{51})$$
$$(c-p_{61})p_{10} - p_{14}(p_{4,4}^{13} + p_{4,4}^{16}) - (a-p_{41})p_{10} - p_{15}(p_{5,5}^{19} + p_{5,5}^{22}) - (a-p_{41})(b-p_{51})p_{16}(p_{6,6}^{25} + p_{6,6}^{28}) +$$
$$(c-p_{61})(a-p_{41})(b-p_{51})p_{10} + p_{14}p_{41} - (a-p_{41})p_{15}p_{51} + (a-p_{41})(b-p_{51})p_{16}p_{61})(p_{02}(e-p_{83})(f-p_{93})$$
$$(d-p_{73}) + p_{37}p_{73}) + (d-p_{73}) + p_{38}p_{83})(d-p_{73})(e-p_{83})p_{39}p_{93})(i-p_{12,2})(h-p_{11,2})p_{2,10}(p_{10,10}^{49} + p_{10,10}^{52})$$
$$+(g-p_{10,2})p_{2,11}(p_{11,11}^{55} + p_{11,11}^{58}) + (g-p_{10,2})(h-p_{11,2})p_{2,12}(p_{12,12}^{61} + p_{12,12}^{64}) + (p_{03}(i-p_{12,2})(g-p_{10,2})(h-p_{11,2})$$
$$+p_{2,10}p_{10,2}) + (g-p_{10,2})p_{2,11}p_{11,2}) + (g-p_{10,2})(h-p_{11,2})p_{2,12}p_{12,2})(e-p_{83})(f-p_{93})p_{37}(p_{7,7}^{31} + p_{7,7}^{34})$$
$$+(e-p_{83})p_{38}(p_{8,8}^{37} + p_{8,8}^{40}) + (d-p_{73})(e-p_{83}))p_{39}(p_{9,9}^{43} + p_{9,9}^{46}))$$

10. EXPECTED NUMBER OF REPAIRS IN SYSTEM

$$R_0 = \lim_{s\to 0}(sR_0^{**}(s)) = \frac{N_6}{D_1}$$

where

$$N_6 = -p_{02}(a-p_{41})(b-p_{51})(c-p_{61}) + p_{14}p_{41}) + (a-p_{41})p_{15}p_{51}) + (a-p_{41})(b-p_{51})p_{16}p_{61})$$
$$(d-p_{73})(e-p_{83})(f-p_{93}) + p_{37}p_{73})(d-p_{73})p_{38}p_{83}) + (d-p_{73})(e-p_{83})p_{39}p_{93})(i-p_{12,2})$$
$$(g-p_{10,2})(h-p_{11,2}) + p_{2,10}p_{10,2})(g-p_{10,2}) + p_{2,11}p_{11,2}) + (g-p_{10,2}) + p_{2,12}p_{12,2})(p_{01}(d-p_{73})$$
$$(e-p_{83})(f-p_{93}) + p_{3,7}p_{7,3}) + (d-p_{73}) + p_{3,8}p_{8,3}) + (d-p_{73})(e-p_{83})p_{3,9}p_{9,3})(b-p_{51})(c-p_{61})$$
$$p_{14}(p_{4,4}^{14} + p_{4,4}^{17}) + (a-p_{41})p_{15}(p_{5,5}^{20} + p_{5,5}^{23}) + (a-p_{41})(b-p_{51})p_{16}(p_{6,6}^{26} + p_{6,6}^{29}) + (p_{03}((c-p_{61})(b-p_{51}))$$
$$(a-p_{41}) + p_{1,4}p_{4,1}) + (a-p_{41}) + p_{1,5}p_{5,1}) + (a-p_{41})(b-p_{51})p_{1,6}p_{6,1}(f-p_{93})(e-p_{83})p_{3,7}(p_{7,7}^{32} + p_{7,7}^{35})$$
$$+(e-p_{83})p_{3,8}(p_{7,7}^{32} + p_{7,7}^{35})$$

11. EXPECTED NUMBER OF REPLACEMENTS IN SYSTEM

$$REP_0 = \lim_{s\to 0}(sREP_0^{**}(s)) = \frac{N_7}{D_1}$$

where

$$N_7 = (p_{03}(g-p_{10,2})(h-p_{11,2})(i-p_{12,2}) + p_{2,10}p_{10,2}) + (g-p_{10,2})p_{2,11}p_{11,2}) + (g-p_{10,2})(h-p_{11,2})p_{2,12}p_{12,2})$$
$$(e-p_{83})(f-p_{93}))p_{37}(p_{7,7}^{31} + p_{7,7}^{34}) + (e-p_{83})p_{38}(p_{8,8}^{37} + p_{8,8}^{40}) + (d-p_{73})(e-p_{83})p_{39}(p_{9,9}^{43} + p_{9,9}^{46}))(p_{01}(f-p_{93})$$
$$(d-p_{73})(e-p_{83}) + p_{3,7}p_{7,3}) + (d-p_{73})p_{3,8}p_{8,3}) + (d-p_{73})(e-p_{83})p_{3,9}p_{9,3})(b-p_{51})(c-p_{61})p_{14}(p_{4,4}^{14} + p_{4,4}^{17})$$
$$+(a-p_{41})p_{15}(p_{5,5}^{20} + p_{5,5}^{23}) + (a-p_{41})(b-p_{51})p_{16}(p_{6,6}^{26} + p_{6,6}^{29})$$

12. EXPECTED NUMBER OF VISITS BY REPAIRMAN

$$V_0 = \lim_{s \to 0}(sV_0^{**}(s)) = N_8 / D_1$$

where

$$N_8 = (p_{01} + p_{02} + p_{03})(g - p_{10,2})(h - p_{11,2})(i - p_{12,2}) + p_{2,10}p_{10,2}) - (g - p_{10,2})p_{2,11}p_{11,2}) + (g - p_{10,2}))$$
$$+(h - p_{11,2}) - (g - p_{10,2})(h - p_{11,2})p_{2,12}p_{12,2})(a - p_{41})(b - p_{51})(c - p_{61}) + p_{14}p_{41}) - (a - p_{41})p_{15}p_{51})$$
$$+(a - p_{41}) + (b - p_{51}) - (a - p_{41})(b - p_{51})p_{16}p_{61})(d - p_{73})(e - p_{83})(f - p_{93})(d - p_{73})(e - p_{83})$$
$$(f - p_{93}) + p_{37}p_{73}) - (d - p_{73})p_{38}p_{83}) + (d - p_{73}) + (e - p_{83}) - (d - p_{73})(e - p_{83})p_{39}p_{93})$$

13. COST BENEFIT ANALYSIS

The expected total profit incurred to the system in steady state is given by

P = $C_0A_0 - C_1B_{S0} - C\,B_{RP0} - C_3\,B_{REP0} - C_4V_0 - C_5S_0 - C_6R_0 - C_7REP_0$,

Where

C_0 = Revenue per unit up time for system

C_1 = Cost per unit time when repairman is busy for service

C_2 = Cost per unit time when repairman is busy for repair

C_3 = Cost per unit time when repairman is busy for replacement

C_4 = Cost per visit of repairman

C_5 = Cost per unit service

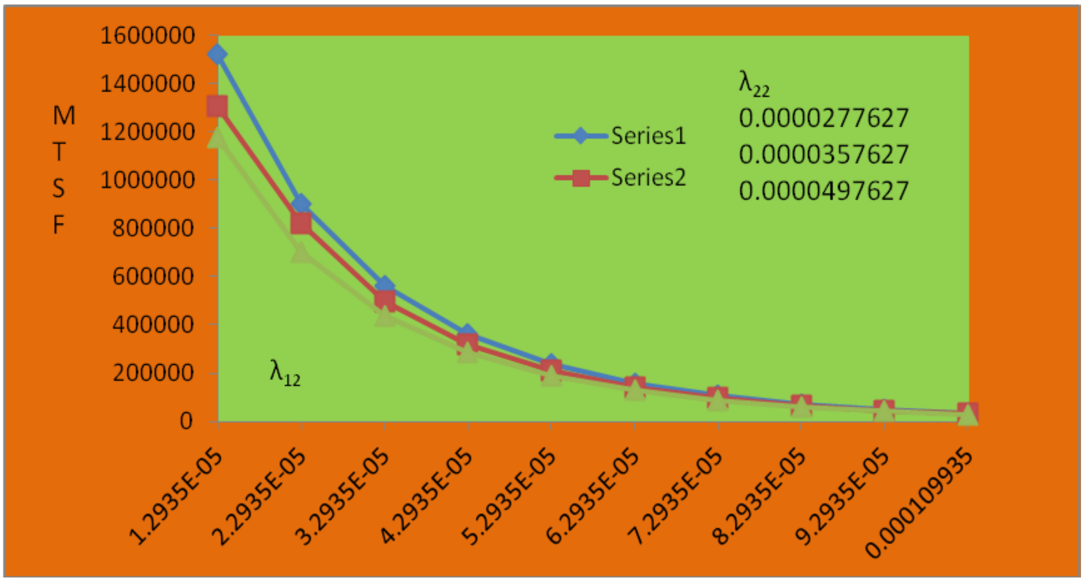
C_6 = Cost per unit repair

C_7 = Cost per unit replacement

Failure rate of first compressor unit when failure is of serviceable type	λ_{11}	0.000042935/hr
Failure rate of first compressor unit when failure is of repairable type	λ_{12}	0.000022935/hr
Failure rate of first compressor unit when failure is of replaceable type	λ_{13}	0.000012935/hr
Failure rate of second compressor unit when failure is of serviceable type	λ_{21}	0.0000477627/hr
Failure rate of second compressor unit when failure is of repairable type	λ_{22}	0.0000277627/hr
Failure rate of second compressor unit when failure is of replaceable type	λ_{23}	0.0000177627/hr
Failure rate of third compressor unit when failure is of serviceable type	λ_{31}	0.001020147/hr
Failure rate of third compressor unit when failure is of repairable type	λ_{32}	0.000920147/hr
Failure rate of third compressor unit when failure is of replaceable type	λ_{33}	0.000820147/hr
Failure rate of fourth compressor unit when failure is of serviceable type	λ_{41}	0.0010056/hr
Failure rate of fourth compressor unit when failure is of repairable type	λ_{42}	0.0009056/hr
Failure rate of fourth compressor unit when failure is of replaceable type	λ_{43}	0.0008056/hr
Repair rate of first compressor unit when failure is of serviceable type	α_{11}	0.00297619/hr
Repair rate of first compressor unit when failure is of repairable type	α_{12}	0.000586/hr
Repair rate of first compressor unit when failure is of replaceable type	α_{13}	0.04166/hr
Repair rate of second compressor unit when failure is of serviceable type	α_{21}	0.0018939394/hr
Repair rate of second compressor unit when failure is of repairable type	α_{22}	0.0003822629/hr
Repair rate of second compressor unit when failure is of replaceable type	α_{23}	0.0010162602/hr
Repair rate of third compressor unit when failure is of serviceable type	α_{31}	0.010416666/hr
Repair rate of third compressor unit when failure is of repairable type	α_{32}	0.004416666/hr
Repair rate of third compressor unit when failure is of replaceable type	α_{33}	0.002416666/hr
Repair rate of fourth compressor unit when failure is of serviceable type	α_{41}	0.0010416666/hr
Repair rate of fourth compressor unit when failure is of repairable type	α_{42}	0.002166666/hr
Repair rate of fourth compressor unit when failure is of replaceable type	α_{43}	0.001166666/hr
Revenue per unit up time	C_0	Rs. 60100
Cost per unit time(service) when repairman is busy for service	C_1	Rs.28600

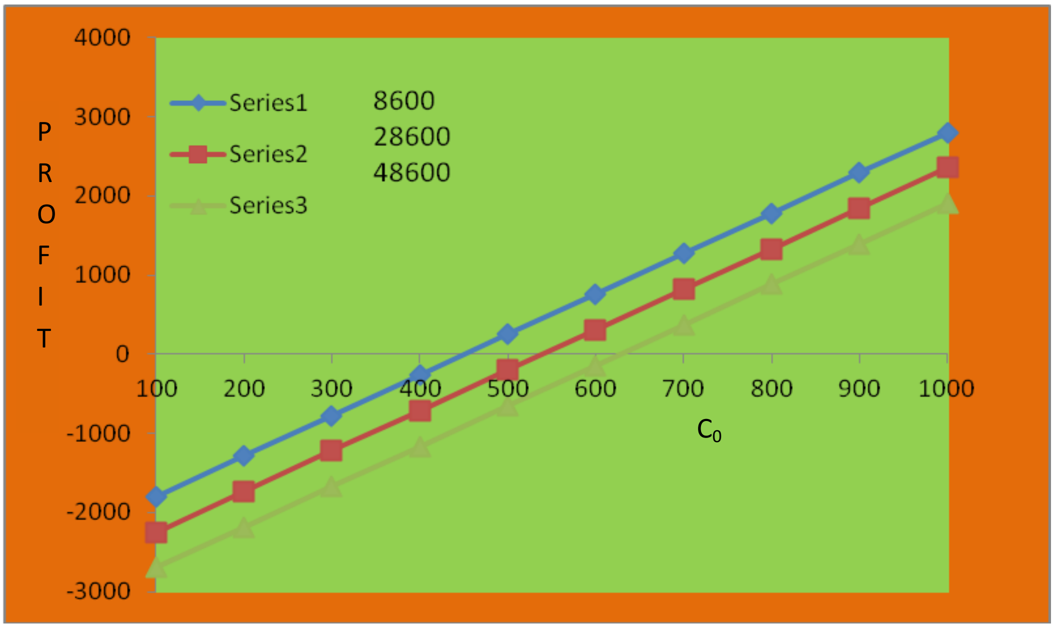
Cost per unit time(repair) when repairman is busy for service	C_2	Rs.7600
Cost per unit time(replacement) when repairman is busy for service	C_3	Rs. 7975
Cost per visit of repairman	C_4	Rs.800
Cost per unit time(service)	C_5	Rs.1500
Cost per unit time(repair)	C_6	Rs. 1000
Cost per unit time(replacement)	C_7	Rs.550

Graph between MTSF and Failure rate λ_{12} (variation in λ_{22})Fig1



Graph in Fig 1 represents the behaviour of MTSF vs failure rate λ_{12} with variation in λ_{22}.It is clear that as failure rate λ_{12} increases MTSF decreases. As variation is taken in failure rate λ_{22} for MTSF, It can be concluded as the failure rate λ_{22} increases MTSF decreases

Graph between Profit and Revenue C_0 (variation in C_1) Fig 2



It can be interpreted from graph in Fig 2 that profit increases with increase in values of revenue per unit up time (C_0).It can also be seen that if C_1=8600 , then P>or=or<0 according as C_0 >or =or< 452.467. So for C_1=8600, revenue per unit up time should be fixed greater than 18.Similarly for C_1=28600 and 48600, the revenue per unit up time should be greater than 5.23and 615.78 respectively

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