IOSR Journal of Business and Management (IOSR-JBM)
e-ISSN: 2278-487X, p-ISSN: 2319-7668. Volume 17, Issue 5.Ver. I (May. 2015), PP 107-115
www.iosrjournals.org

Optimization Overall Performance of Beverage Industry by Total Productive Maintainance

Shelke Pratik Bansi [1], Madhukara Nayak[2], U. Sai Krishna[3]
.[1] [2] [3]Manipal Institute of Technology (A Constituent of Manipal University), Manipal, India

Abstract: *Total productive maintenance (TPM) is approach developed to utilize plant more effectively and extract maximum output from installed capacity by maintaining it with its best performing condition. Increased demand of beverage in market has made industry to think widely to increase their production rate. Total productive maintenance will helps them to see hidden production capacity in existing plant. System dynamic model helps them to see expected rise in production after implementing TPM strategy. Overall equipment effectiveness (OEE) is metric tool to evaluate TPM. Evaluation of OEE of industry with practical approach helps to find scope of improvement in plant with respect to world class standards. TPM pillars helps to achieve greater OEE. System dynamic model will show system in micro world, where manager can see effect of implementing TPM in overall performance. Development of model is important part of this research.*
Analyses of industry taken for study have a world class OEE but there is still scope of improvement in its availability. Office TPM and Autonomous maintenance are pillars will help in these improvements. Steps of implementing these pillars is mentioned in brief and effect of implementing these pillars in system dynamic model have shown significant improvement in availability. Results show that there is significant improvement in performance parameters of industry by implementing TPM pillars. Small amount of initial investment on training workforce and dedicated effort pay huge returns in long run of industry. Data analysis is done with the help of Microsoft Excel 2010 and system dynamic model is developed in Vensim PLE version 6.0b.
Keywords: Total Productive Maintenance, System Dynamics, Maintenance Management.

I. Introduction

Preventive Maintenance comprises of maintenance activities that are undertaken after a specified period of time or amount of machine use. During this phase, the maintenance function is established and time based maintenance activities are generally accepted. This type of maintenance relies on the estimated probability that the equipment will breakdown or experience deterioration in performance in the specified interval. The preventive work undertaken may include equipment lubrication, cleaning, parts replacement, tightening, and adjustment. The production equipment may also be inspected for signs of deterioration during preventive maintenance work [1]. Preventive Maintenance is done by Maintenance department where role of operator is negligible. Nippondenso(Supplier of toyato) required more maintenance staff to maintain their automation line for optimizing workforce company decide to induct training program to their operator to maintain their own machine. This is Autonomous maintenance, one of the features of TPM. After words Maintenance group took up only essential critical maintenance works. Thus Nippondenso, which already followed preventive maintenance, also added Autonomous maintenance done by production operators. The maintenance crew went in the equipment modification for improving reliability.

II. Literature Review

Olayinka S. Ohunakin and Richard O Leramo[2] have done a study on beverage industry in which they encounter various losses in production process. They have calculated OEE for 7 weeks of plant which comes near about 30% which is far less than wold class standard (85%). They have done why-why analysis of all major defect and come with some improvement after imparting these improvements in plant for a week they find out that there is huge rise in OEE up to average 50% and showing continuously increasing trend.

Panagiotis H. Tsarouhas[3] perform evaluation of OEE in one of bottled product drink manufacturing plant where he recorded data for eight month and analyse Time between failure and time to repair and evaluate OEE. He found out performance efficiency and availability is lower than world class standard (95% and 85% respectively). He suggested implementing TPM in focus to improve technician’s skill, manage required spare part inventory and replacement of part during preventive maintenance.

Kamran Shahanaghi andSeyed Ahmad Yazdia[5] gives system dynamic model to analyze effect of implementing TPM in manufacturing industry. They have shown effect of implementing TPM on equipment defect, equipment reliability, breakdown rate and total output which easily convey benefits of implementing TPM in overall performance of organization.

Stephanie Albin, [4][5] from the Massachusetts Institute of Technology, gives basics of system dynamics model making with example which helps to understand model making easily.

Data analysis and suggestion for effectiveness

Collected data from industry can be analysed by manual mathematical calculation or if data is large then it's effective to use any software like Microsoft excel, Minitab, SPSS or SAS. In this project data analysis is done in Microsoft Excel 2010. In which required formula is loaded and taken result [refer appendix to see data with formula used. After analysis compare obtained result with world class standard [5]. It will show area on which improvement is essential. On further study and previous research it will give method to encounter area of improvement. On that basis this thesis gives suggestion to industry and way to implement that. For data collected in industries see annexure-I

Development of model and implement suggestion in model and show effectiveness

Actual implementation of TPM is long way process. System dynamics will help to see long run outcome of this strategy so it's easy to make a micro world of system and see future benefits by implementing in model. Detailed system dynamics model is as explained below.

1. Conceptualization [3]

In this stage basic idea of model defined with purpose, model boundary, model structure with causal loops and some reference modes with respect to time. As per thesis "title optimizing performance of industry by using TPM" gives model purpose to make a production system analogous to studied plant and show effect of implementing TPM in long run.

Causal loop diagram

Causal loop diagrams are the basis on which the SD model is built. They show graphical interactions and cause-and-effect relationships among the different system parameters. During model development, Causal loop diagrams serve as preliminary sketches of causal hypotheses and they can simplify the representation of a model. Figure 4.6 describe causal relationship of industry with its performance parameters such as availability and performance efficiency with respect to plant capacity.

A causal diagram consists of variables connected by arrows denoting the causal influences among the variables. Variables are related by causal links, shown by arrows. Each causal linkis assigned a polarity, either positive (+ and blue colour) or negative (- and red colour) to indicate how thedependent variable changes when the independent variable changes. Arrows with dash will show effect of implementing particular pillar of dependant variable. Model is bounded by only those parameters which are described in causal loops.

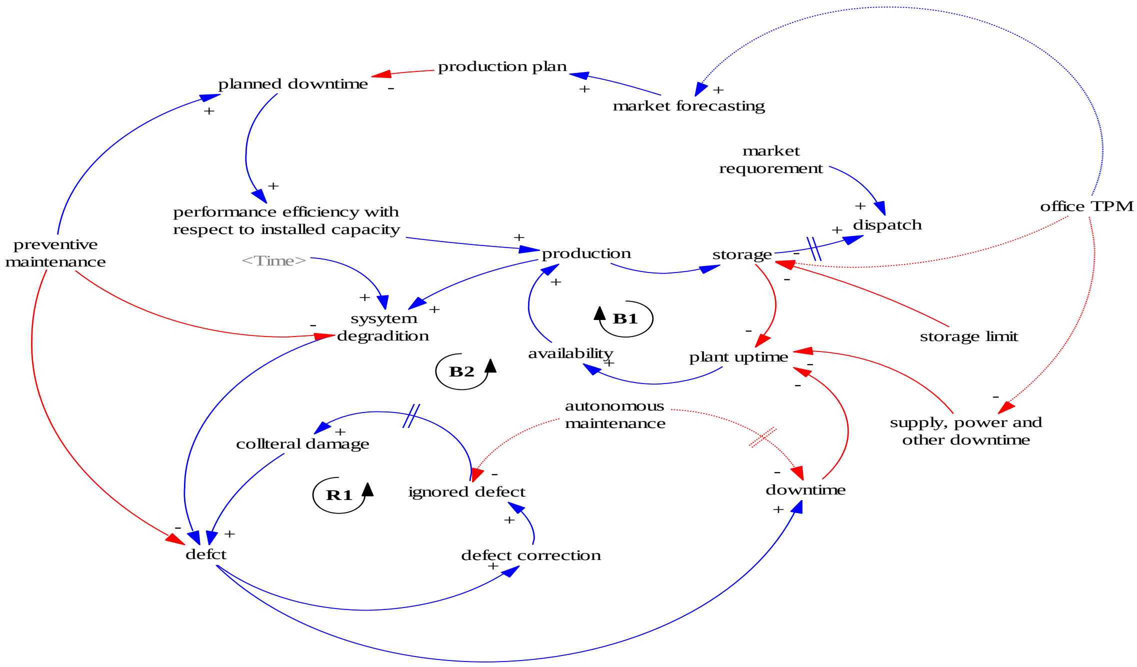

Figure 1.Causal loops

Balancing loop B1 (production – storage-plant uptime-availability) shows effect of insufficient inventory storage on production. Storage limit in finished goods storage restrict plants uptime because there is no space for accommodating new finished product this stop all plant till dispatch. But as dashed arrow from office TPM giving negative influence to storage which indicates that implementing office TPM will help to have proper dispatch plan and help to increase storage capacity if required.

Balancing loop B2 (production-system degradation – defect – downtime-plant uptime - availability) shows effect of cumulative production on system degradation which positively inflicted by it and system degradation will cause defects. Defects lead to downtime and loss of plant uptime.

Reinforcing loop R1 (defect- defect correction- ignored defect- collateral damage) shows effect of ignoring defect on defect generation. This is continuously gone on till ignored defect is not reduced. It can be done by autonomous maintenance which shown in dotted line. It directly reduce ignored defect to 20% of existing ignored defect. Autonomous maintenance is also helpful to reduce downtime through decreasing mean time to defect correction through proper maintenance by operator and standardizing machine.Preventive maintenance will reduce defect creation by maintaining machine with proper planned maintenance but it increase planned downtime.

2. **Formulation of model [5]**

In this step causal loop logic converts into stock and flow diagram. All user defined parameter is taken in formulation of model and equations of dependent variable derived from independent variable and reference lookups.

Stock and Flow diagram

Figure 2 show detail stock and flow diagram of system. Stock and flow diagram extends causal loop diagrams logic with various user defined parameter for model assumptions .

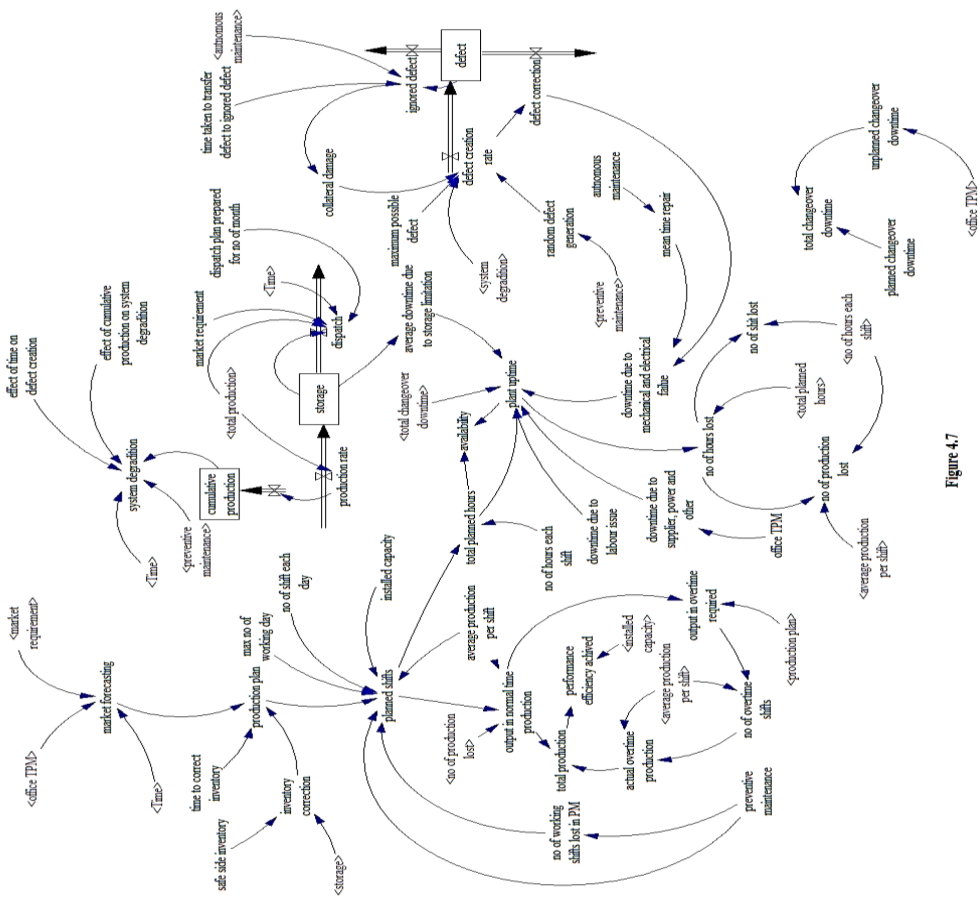

Figure 2: Stock and Flow diagram

Table 1.Important user defined parameter

Parameters	Value with unit	Description
Average production per shift	4000 cases/shift	Its average output calculated for all lines in a shift with respect to installed capacity
Installed capacity	200000 cases/shift	Capacity defined at the time of installation
Maximum working days	26 days	Average working days without Sunday
Maximum possible defect	220 defects/month	Its assumed to be 10 defect per equipment when system will face huge degradation
No of hours each shift	7.5 hours/month	Every day working hour is 15 hours for 2 shifts
No of shit each day	2 shifts/days	As decided by production planning

Model Validation

Of the several validation techniques the behaviour reproduction technique [6] is the most suitable one and is commonly used for validation purpose. Here, a comparison of the actual real data with simulated data is done and its behaviour is analysed. The graph was plotted against the Availability value and performance efficiency with respect to rated output (Actual vs. Simulated) is as shown in Figure 3 and Figure 4. Data of production plan, dispatch plan, downtime due to labour and other issues are given as lookup of actual function because these parameters are out of scope for model making.

It can be observed from the graphs that simulated data follows a similar pattern .Hence it can be said the model is validated.

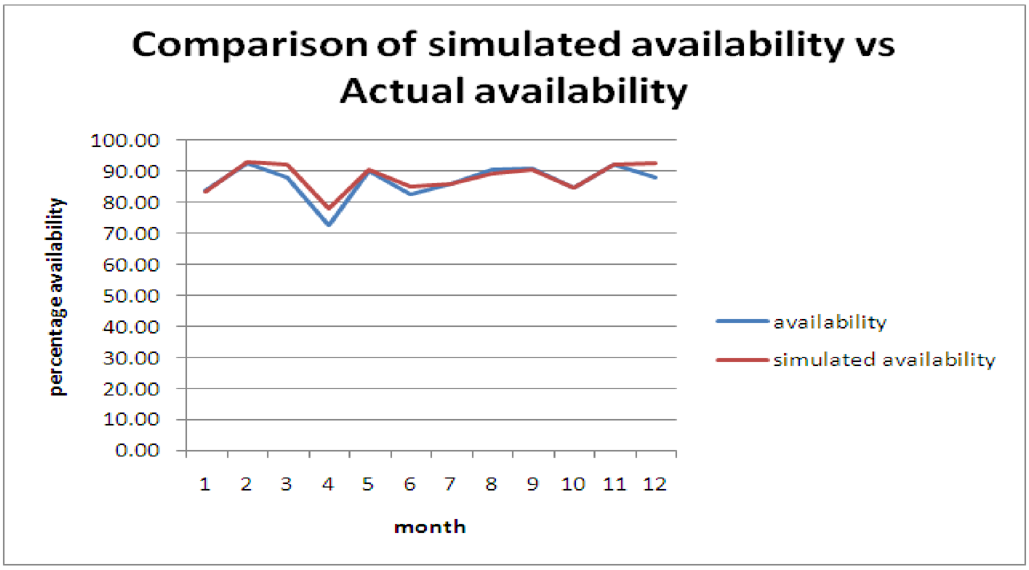

Figure 3: Percentage availability vs. time in month.

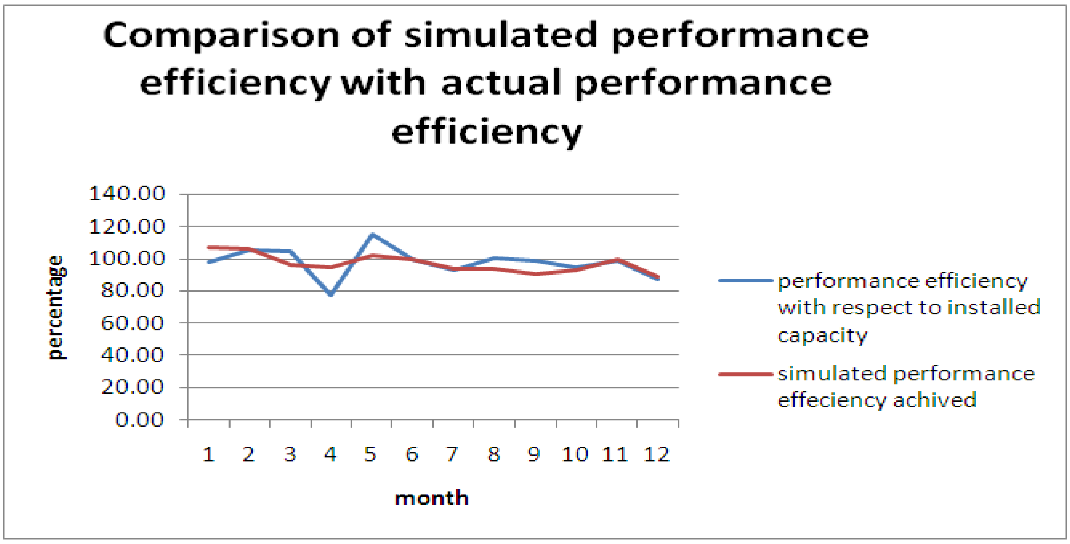

Figure 4: Percentage performance efficiency vs. time month

Simulated results after implementing suggestion in model

Suggestion with respect TPM pillar which are mentioned in table no.1. If we implement in model directly as switching to particular pillar from 0 to 1 will show the effectiveness with respect to existing performance.

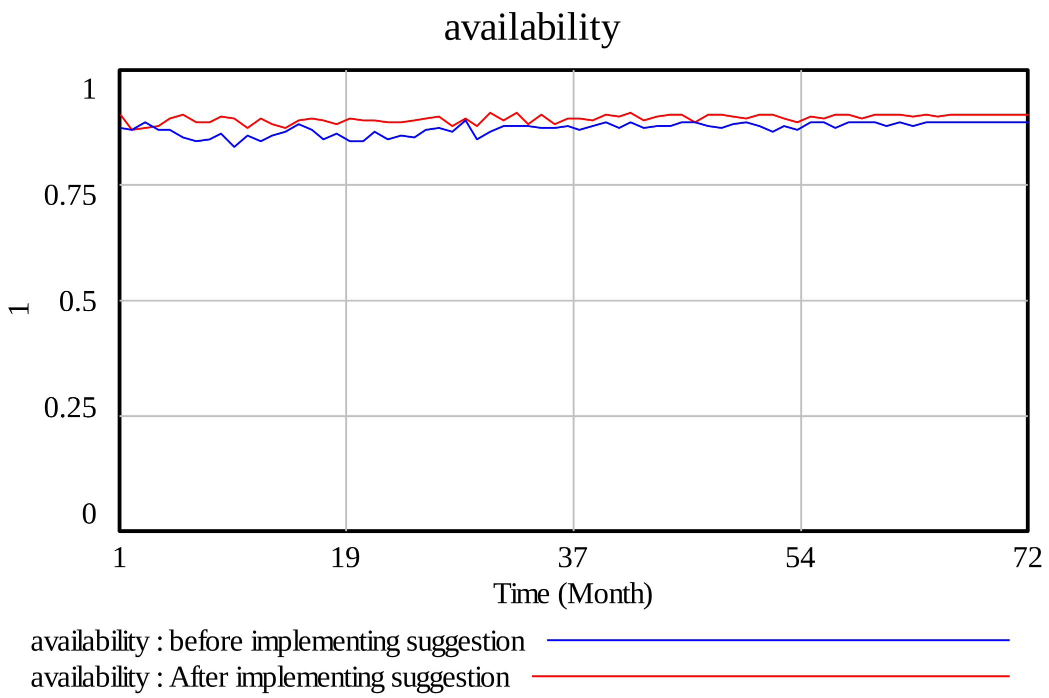

Figure 5: Availability vs. time in month

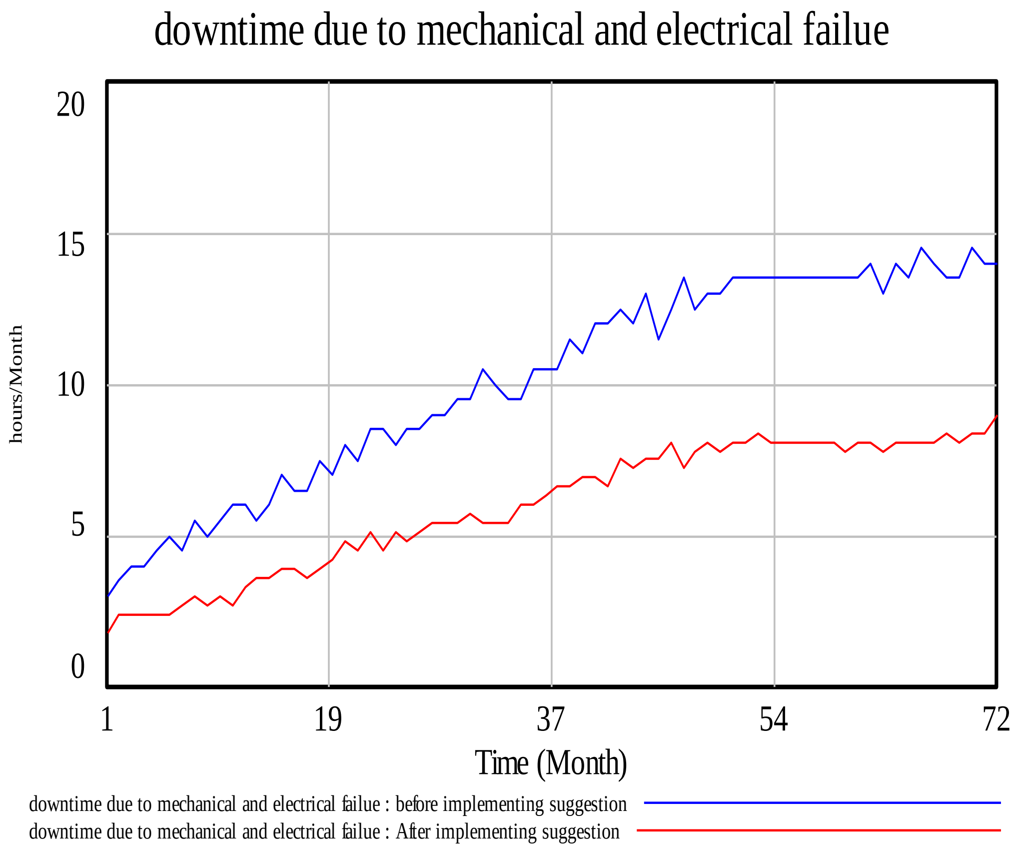

Figure 6: Downtime due to mechanical and electrical failure vs. time in month

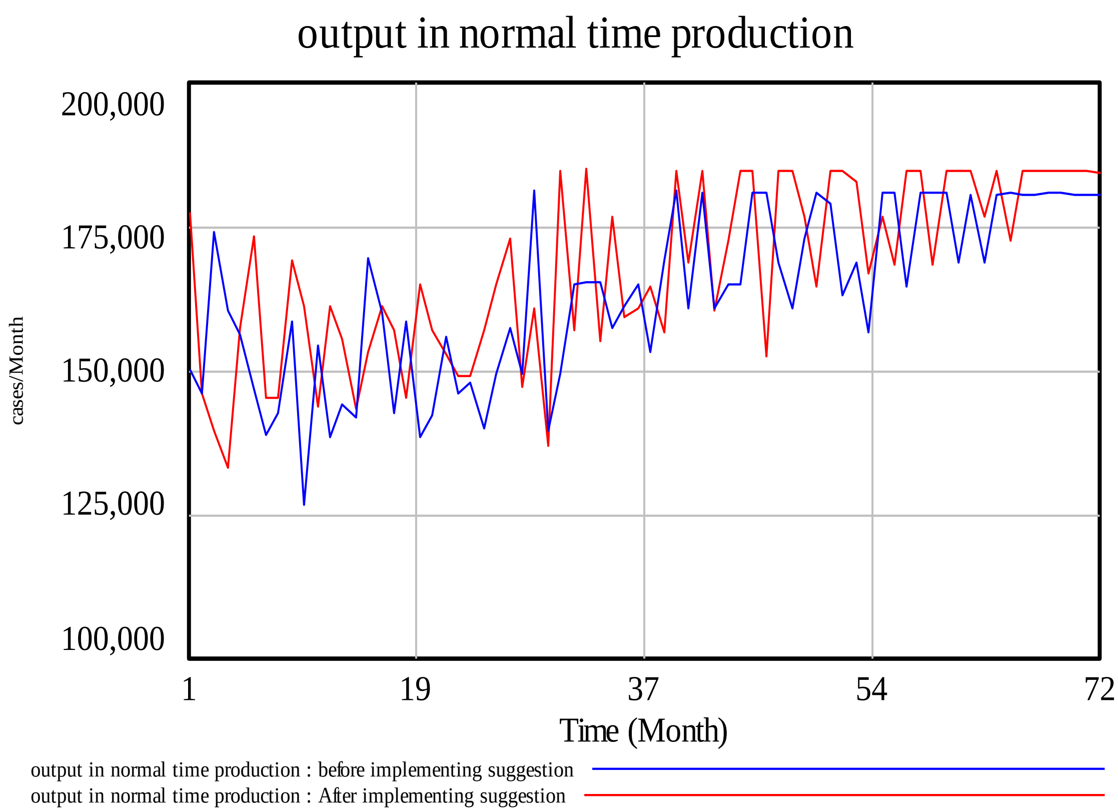

Figure 7: Output in normal time production vs. time in month

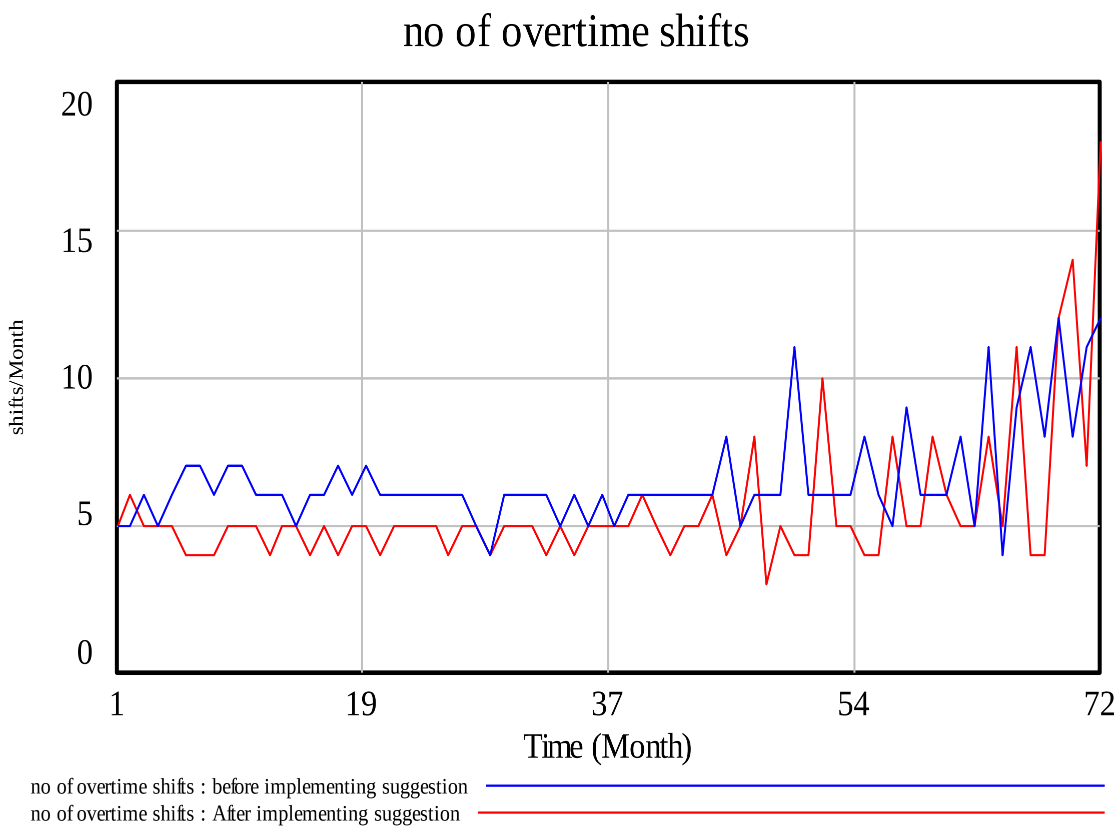

Figure 8: No of overtime shifts vs. time in month

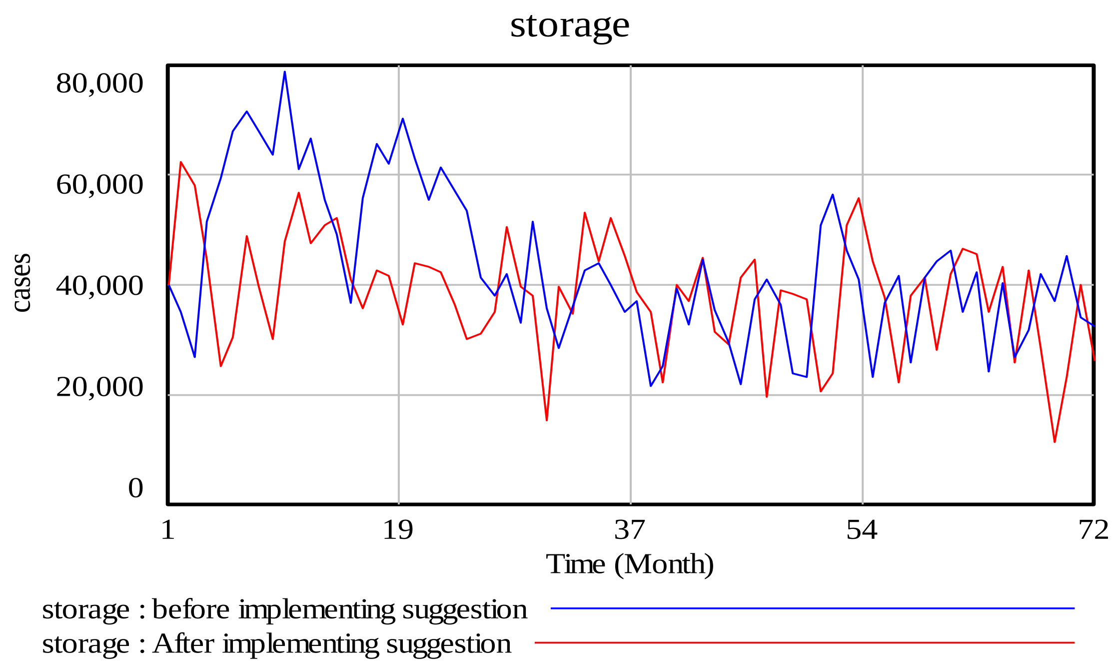

Figure 9: Storage vs. time in month

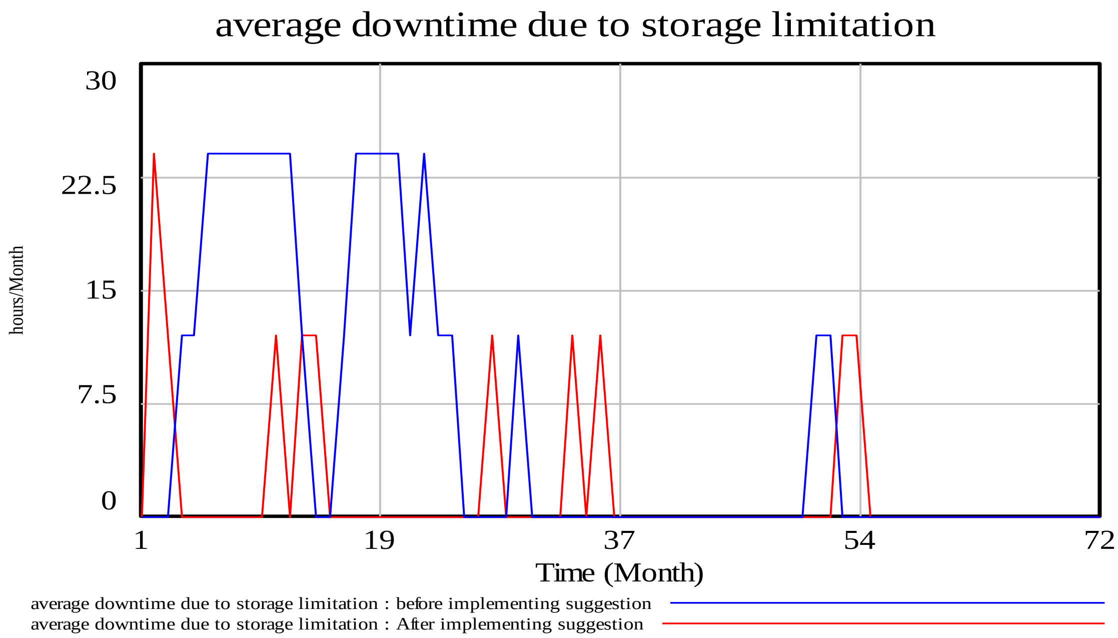

Figure 10 Average downtime due to storage limitations vs. time in month

III. Conclusion

The main objective of present research is to show effect of implementing TPM in organization with system dynamic model. This objective is satisfied by analysing data and developing model to see effectiveness of implementing TPM pillars in organization.

1. After implementing Total Productive Maintenance pillars (Office TPM and Autonomous maintenance) there is significant improvement in main parameters which suggested in scope of improvement, availability. Availability improved with average improvement of 2.25% (previous simulated average availability was 87.28% with implementation is 89.53%)

   There is decrease in average downtime caused due to mechanical defect and electrical defect from 10.125 hours to 5.975 hours. Autonomous maintenance play vital role in this to reduce mean time to repair and reduce ignored defect which caused collateral damage.

2. Average normal production in planned production hour is increased with 2.7% (from 163150 to 167558 cases/month)
   This reduces no of overtime shifts from 6.54 (shifts/month) to 5.51 (shifts/month).
3. Office TPM helps to reduce unnecessary inventory by implementing LEAN policy from average storage 42690 cases to 38548 cases.
   This reduces average downtime due to storage from 4.833 hours to 1.833 hours.

ANNEXURE I

Data collected from industry

	Production (Cases)		Dispatch (Cases)		Overtime (Hrs)			Downtime							
Month	Plan	Acutal	Lifting Plan	Acutal	Production normal hours(C/S)	No of Hours OT Done	Production during OT Hours(C/S)	Changeover	Machine fault	Electrical Fault	Power Failures	Labour issues	Non availability of DG/WG	No space in FG Godown	Others
1	215179	196396	278098	243800	184009	32	12387	42.67	23.5	3	2.67	151.47	23.25	0	21
2	216576	211291	230990	196434	198182	48	13109	42.67	19.5	1.33	3.67	18.5	11.33	0	20.08
3	195097	209497	207203	203667	208615	16	882	29.92	27.25	1	3.67	38.5	12.5	64	6.42
4	191084	154856	219992	179864	140944	36	13912	34.42	8.25	0	31.75	195.25	12.67	76.75	14.83
5	206537	230330	194195	186160	228523	8	1807	55.67	14.75	0.33	1.33	64	18.33	0	7.67
6	205378	199199	219359	214149	194931	16	4268	48.33	9.92	0	4.33	121.17	34	62.5	2.42
7	191629	186586	201931	192901	186586	0	0	49.5	16.92	0.67	9	118.75	5.25	0	11.58
8	190055	200201	213123	203332	200201	0	0	34.25	7.75	0	2	74.83	8.17	8	10.08
9	186000	197197	224434	207000	186297	16	10900	40.17	3.17	0	2.33	65.83	1.5	8	4
10	191234	189189	207545	175175	181051	24	8138	41.58	9.42	0.33	2.67	141.5	11.42	4	3.17
11	201503	198198	196850	191191	192516	16	5682	49.92	21.83	0.5	1	50.67	7.75	2	1.83
12	182017	175175	183176	166092	175175	0	0	38.08	5.83	0.5	4.67	33.17	2.83	88	4.25
total	2372289	2348115	2576896	2359765	2277030	212	71085	507.18	168.09	7.66	69.09	1073.64	149	313.25	107.33

OEE calculations

no of month	actual production	installed capacity	production planned hours	hours lost in downtime	quality loss of production	availability	performance efficiency with respect to installed capacity	oee	world standard OEE	world class standard of availiblity	world class standard of performance efficiency	simulated availability	simulated performance effeciency achived
1	196396	200000	1656	267.56	0	83.84	98.20	82.33	85	90	95	83.7	107
2	211291	200000	1576	117.08	0	92.57	105.65	97.80	85	90	95	93.06	106
3	209497	200000	1552	183.26	0	88.19	104.75	92.38	85	90	95	92.11	96
4	154856	200000	1368	373.92	0	72.67	77.43	56.26	85	90	95	78.19	95
5	230330	200000	1648	162.08	0	90.17	115.17	103.84	85	90	95	90.57	102
6	199199	200000	1640	282.67	0	82.76	99.60	82.43	85	90	95	85.13	100
7	186586	200000	1496	211.67	0	85.85	93.29	80.09	85	90	95	85.87	94
8	200201	200000	1496	145.08	0	90.30	100.10	90.39	85	90	95	89.42	94
9	197197	200000	1384	125	0	90.97	98.60	89.69	85	90	95	90.71	91
10	189189	200000	1392	214.09	0	84.62	94.59	80.05	85	90	95	84.91	93
11	198198	200000	1728	135.5	0	92.16	99.10	91.33	85	90	95	92.43	100
12	175175	200000	1500	177.33	0	88.18	87.59	77.23	85	90	95	92.67	89
Average value						86.86	97.84	85.32	85	90	95	88.23083	97.25
		scope of improvement											

Defect analysis

defect	average hours lost	cumulative %
labour issues	89.47	44.82
changeover	42.27	65.99
no space in FG godown	26.1	79.07
machine fault	14.01	86.09
non availability of DG/WG	12.42	92.31
other	8.94	96.79
Power Failures	5.76	99.67
Electric Failures	0.64	99.99

References

[1]. I.P.S. Ahuja and J.S. Khamba, "Total productive maintenance: literature review and directions", International Journal of Quality & Reliability Management Vol. 25 No. 7, 2008 pp. 709-756.

[2]. Olayinka S. Ohunakin and Richard O. Leramo, "Total Productive Maintenance implementation in a beverage industry: A case study", Journal of engineering and applied sciences, ISSN 1816-949X, version 7 (2), 2012, pp. 128-133.

[3]. Panagiotis H. Tsarouhas, "Evaluation of overall equipment effectiveness in the beverage industry: a case study", International Journal of Production Research Vol. 51, No. 2, 15 January 2013, 515–523.

[4]. Stephanie Albin, "Building a System Dynamics Model Part 1: Conceptualization", Massachusetts Institute of Technology university press, 1997.

[5]. Stephanie Albin, "Building a System Dynamics Model Part II: Formulation", Massachusetts Institute of Technology university press, 1997.

[6]. YamanBarlas, "Model validation in system dynamics", International conference of system dynamics, 1994.