2011 International Conference on Financial Management and Economics
IPEDR vol.11 (2011) © (2011) IACSIT Press, Singapore

Simulation of The Production Line Repair Time Via Dynamic Systems

Professor Mohammad Namazi [1] +, Hamed Forougozar [2] and Navid Reza Namazi [3]
[1] Accounting Department, Shiraz University, Iran
[2] M.A, Department of Industrial Management, "Islamic Azad University, Shiraz Branch", Iran
[3] M.A, student of Accounting, Department of Accounting, "Shiraz University", Iran

Abstract. The major aims of this study are to analyze and study the optimal repair time of the production line of a manufacturing company. The relationship between timing failure, downtime, repair time, machine performance, sales and profit status of a dynamic system is also analyzed. It utilizes simulations ("Vensim Software") and dynamic systems in a vegetable oil manufacturing firm in Iran. At first, the cause and effect diagrams of the model are shown via "Delphi techniques", and then the statistical distribution of different factors affecting various parts of the model is determined by the "Arena Software". Consequently the effect of different parts of the model on other parts is analyzed via the dynamic system. Then, by obtaining financial data relating to a digital generator, the cost- benefit of the model is determined from profit status views. The results of this study exhibit that the designated simulation model is potent and was able to indentify 5 factors influencing the repair time. The power disconnection (C.V=1.48), is indeed the most negative factor affecting the system. In addition, the profitability of the model can be enhanced 8.66% by investing in a digital generator.

Keywords: Repair Time; Timing Failure; Downtime; Simulation; Dynamic Systems; Profitability

1. Introduction

The desire of industries and manufacturing companies for implementing a reliable and efficient repair and maintenance system is enhanced with increasing their activities. In effect, the existence of a modern and well suited repair and maintenance system is crucial because by exerting such a system the control of the company's operations, evaluation of its performance, measuring productivity on building, machinery, equipment, maintenance and profitability would be possible. Consequently providing the best repair services and maintenance and continuation of the services can be attained when a minimum costs and a maximum productivity is exerted [5].

The repair time of the production, due to stopping production line and none completed products, impose significant costs to organizations. Hence, predicting machines repair time is very important in maintenance planning. Furthermore, due to the high cost of repair time, it is really important to adopt a reliable system for predicting such times in order to establish an appropriate maintenance system [2].

The major purpose of this study is to introduce a suitable production repair time model for manufacturing firms. Since a significant obstacle in implementation of an efficient repair and maintenance cost system is identifying various exogenous and endogenous factors affecting the system, the major aims of this study are as follows:

1) To identify the most important factors affecting the production line system in the manufacturing realm

2) To determine how can profitability of the repair time system be enhanced?

Do to the fact that in establishing this model, simulation and dynamic systems are exerted and applied in a real oil manufacturing company in Iran (Shiraz), it is applicable to real cases and hence can be implemented in other situations. Ironically, it will also enhance the frontier of existing knowledge in this area.

+ Corresponding author. Tel.: + 987116460520; fax: +987116460520
E-mail address: mnamazi@rose.shirazu.ac.ir

The organization of this paper is that, first a background of the study will be presented. Second the methodology, simulation results, and profitability status are presented in sections 3, 4 and 5. Finally concluding remarks are summarized in section 6.

2. Research Background

Duffuaa et al. [4] have devised a conceptual model for repair and maintenance systems which is based upon the concept of simulation and facilitates operations of the repair and maintenance systems. Prasertrungruang and Hadikusumo [11] have also introduced a model for identifying significant factors affecting the repair time by exerting the simulation.

Arya et al. [1] in identifying the probability distribution of the repair time concluded that the average timing failure, average outage duration, and average annual downtime are the basic indices whose distribution function is exponential. This leads to justification for assuming constant failure rates and repair rates for each distributor segment. In effect, they suggest analytical methods for a reliable evaluation of a distribution network. Since repair time is much larger than failure times, approximate relations are expensed for obtaining reliability indices of series parallel systems. Average reliability indices are evaluated via analytical techniques, whereas simulation techniques are employed to generate the distribution of these indices.

Jishen and Shaomin [8] mathematically showed that repair time composed of two different time periods: waiting time and real repair time. The waiting time starts from the failure of a component to the start of repair, and the real repair time is the time between the start to repair and the completion of the repair.

Wang and Chen [12] showed that the availability of a repairable system is important in the operations of power plants, production systems, manufacturing systems, parallel, redundant systems, multiprogramming systems, and industrial systems. In addition, maintaining a high or required level of availability is often an essential requisite.

None of these studies, however, are directly related to the subject of our study since we are interested in determining a relevant simulation model for production line repair time and its cost and profitability.

Simulation means showing some phenomenon via numbers and figures to easily study the phenomenon or their sides [6]. Due to interactions between different parts of a system, it is important to demonstrate the behaviour of its elements through a dynamic system. This can be accomplished through the study of all components and communications of the system's interior [9].

3. Methodology

This research is practical and its methodology is based upon a real case study in Iran, named as Narges Shiraz Vegetable Oil Company. It was established in 1954 in Shiraz and with more than 57 years experience in the field of edible oil industry, has the honor of being one of the largest and most well - known companies of its kind in Iran. A great deal of care is taken in selection of the raw materials and components to ensure higher end product quality. The oil is extracted from various types of oil rich plants such as soya beans and sunflower seeds with the total production [7].

The necessary data was gathered through the interviews, Delphi techniques, company's documents and literatures. The cause and effect diagrams [10] were employed for unambiguous understanding of the dynamic systems modelling. Relying on the "Delphi techniques" and gathering opinions of experts and the production managers, the relationships between the cause and effects diagram was extracted. This diagram is shown in Figure 1.

The following definitions were used: Timing failure is the duration of time which machine stops producing due to such factors as power disconnection, dysfunction of electrical system and lack of raw materials [2]. Downtime of a machine is the time between duration of timing failure and the time machines starts normal performance [5]. The sum of the repair time is equal to total failure time and downtime [6].

The amount of timing failure and downtime from the most recent 10 years period (2000 to 2009) were gathered from company's existing formal documents. The data is shown in Table 1. Then the frequency distribution of the data presented in table 1 was determined by exerting Arena Software. The frequency distribution diagram for the gas disconnection, broken parts, operator error and lack of raw materials was normal; However, the frequency distribution diagram for the downtime and power disconnection factors followed by the uniform distribution.

Other variables of the model were determined via the "Delphi technique" and interviewing experts in the company as follows:

- 65% of the power disconnection variable and 40% of the operator error were related to the dysfunction of the electrical system.
- The repair time was equal to total timing failure and downtime.
- According to the obtained documentation, the average factory-term performance was 6360 hours per year, and according to the experts' opinions, the formula for machine performance variable was as follow:

  (6360- Repair time)/6360.
- The factory produced 30,000 tons of oil yearly, hence the formula to determine the production capacity is: (30,000 tons × machine performance).
- Unit value per ton is equivalent to 8,082,000 Rials; thus, the obtained income from sales is:

  (Production capacity × 8,082,000 Rials)
- The cost per hour repair time is 120,000,000 Rials; consequently total cost of the repair time would be: (120,000,000 Rials× total repair time)
- Total profit comes through: (total income from sales – total cost of repair time).

4. Simulation Results

Following the simulation model and utilizing Vensim Software, the experts' opinions about the most important components of timing failure and downtime were obtained. The results are shown in figures 2, 3, 4 and 5. These figures predict simulation results for the next 10 years (2010 - 2019).

The simulation frequency distribution diagram for the broken parts, operator error, power disconnection, gas disconnection and lack of raw materials during 2010 to 2019 followed Beta, Uniform, Weibull, Beta and Uniform distribution respectively.

In determining the profit status of the preceding diagrams, since the distributions were different, hence there was no way other than applying the following "coefficient of variation" formula: [3: 55].

$C.V= \sigma x/\mu x$

C.V=Coefficient of variation

σx=Standard deviation

μx=Mean

Based on the coefficient variation, the importance of the amount of reducing the effects of each factor influencing on repair time (summation of timing failure and downtime) was determined sequentially as follow:

1–Power disconnection (C.V=1.48), 2- Gas disconnection (C.V=0.104), 3-Broken parts,(C.V=0.084) 4- Operator error (C.V=0.0812) and 5- Lack of raw materials (C.V=0.0632).

5. Enhancing Profitability of The System

Since it was identified that power disconnection was the most important factor which negatively affecting the repair time and thus increasing the costs of the company, the factory wanted to solve the power disconnection problem. Thus it was forced to purchase a digital generator to deal with the problem. The cost of purchasing and implementing the digital generator was estimated by company's manager to be 3,000,000,000 Rials. The useful life of the generator would be ten years and no salvage value was considered at the end of its useful life. Given this information, prediction of profit status during 2010 to 2019 was made. The results are shown in figure 6. This figure shows that after purchasing the generator, the profit will be increased from 194,922,000 Rials in 2010 to 179,388,000 Rials in 2019, which is equal to 8.66 percentages increase.

6. Conclusion And Discussion

In this study, an attempt was made to present a dynamic model of the relationship between components of the timing failure, downtime, repair time and determining profit status of a vegetable oil manufacturing company in Iran. Through a simulation techniques and dynamic systems and exerting Vensim Software, the timing failure factors of the production line were obtained for the company. The results of the study can be outlined as follow:

1- Power disconnection (C.V=1.48) is the most negative factor affecting the repair time. It increases the cost and duration of the repair time and thus reduces the profitability of the company significantly. The major reason for this phenomenon could be a lack of sufficient supporting power systems and not receiving enough water (rain) for their operations.

2- Other influential factors affecting the repair time are: gas disconnection, broken parts, operator error and lack of raw materials, respectively.

3- When factory utilizes a digital generator, it will solve power disconnection problem and will also earn a high profit.

4- Timing failure and downtime prediction require a reliable maintenance system.

5- The presented model of this study is able to identify significant factors influencing the repair time.

The significance of this study is that it extends the application of the dynamics systems and simulation techniques to situations in which management is confronted with a complex production line repair time and at the same time desires to enhance its profitability. The presented model is general and does also contain a high reliability and external validity for other manufacturing companies in different countries as well as in various industries.

Future researchers could apply this model to other industries in their countries and could also utilize such a contemporary models as neural networks.

7. References

[1] L.D.Arya, S.C.Choube and R.Arya, Probabilistic reliability indices evaluation of electrical distribution system, accounting outage due to overloading and repair time omission, Electrical Power an Energy Systems Journal ,2011,vol.32, pp. 296-302

[2] A.R.Atefatdoust, Timing failure and downtime of prediction line insulated with fiberglass Isogum Company through artificial neural networks and comparing the results with Monte Carlo simulation method, M.A thesis (Industrial Management), Shiraz University, 2003.

[3] A.Azar and M.Momeny, statistics its application in management, sazeman samt, Tehran, 2008.

[4] S.O.Duffuaa, M.Ben-Daya, K.S.Al-Sultan and A.A.Andijani, A generic conceptual simulation model for maintenance systems, Journal of Quality in Maintenance Engineering,2010, Vol. 7 No. pp.207-219.

[5] N.Faghih, maintenance engineering, Shiraz Navid Publications, 1996.

[6] N.Faghih, Principles of simulation systems, Shiraz Navid Publications, 1999.

[7] http://shirazvegoil.bazarema.com/html/fa/contactus/frontend/index/

[8] J.Jishen and W.Shaomin, Optimizing replacement policy for a cold-standby system with waiting repair times, Applied Mathematics and Computation Journal, 2009, pp. 133–141.

[9] Lai C.L., Lee W.B., Ip W.H.; “A study of system dynamics in just-in-time logistics”; Materials Processing Technology, 2003, No. 135, pp. 265-269.

[10] M.Momeny and A.Morovati Sharif Abadi, queue system dynamics modeling using system dynamics approach, two magazine staff - control Research, 2006.No. 17, pp. 1-14.

[11] Prasertrungruang T and Hadikusumo B.H.W. (2008). System dynamics modelling of machine downtime for small to medium highway contractors, Engineering, Construction and Architectural Management,, 2008, Vol. 15, No. 6, pp. 540-561

[12] Wang Kuo-Hsiung, Chen Yu-Ju, Comparative analysis of availability between three systems with general repair times, reboot delay and switching failures, Applied Mathematics and Computation Journal,2009, pp. 384–394.

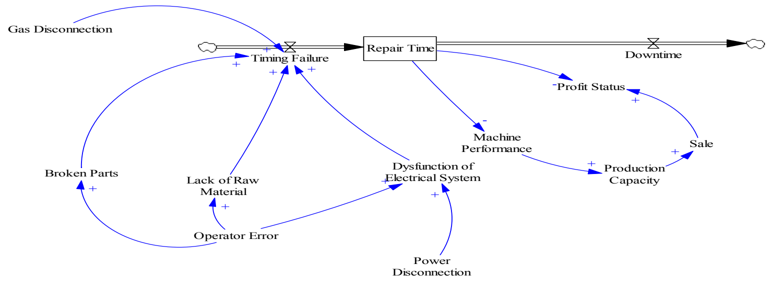

Figure. 1: The Cause and Effect Diagram

Table. 1: Duration of Timing Failure and Downtime from 2000 To 2009

Year	Operator Error	Power Disconnection	Gas Disconnection	Dysfunction of Electrical System	Lack of Raw Material	Brocken Parts	Downtime
2000	252	288	168	301	307	302	144
2001	324	216	168	286	350	317	168
2002	288	432	216	411	269	418	120
2003	180	540	144	432	288	324	108
2004	324	432	144	427	206	281	156
2005	216	504	120	425	298	295	144
2006	180	576	240	455	336	396	120
2007	288	288	168	317	269	345	84
2008	252	216	120	254	259	194	96
2009	324	360	144	380	134	245	108

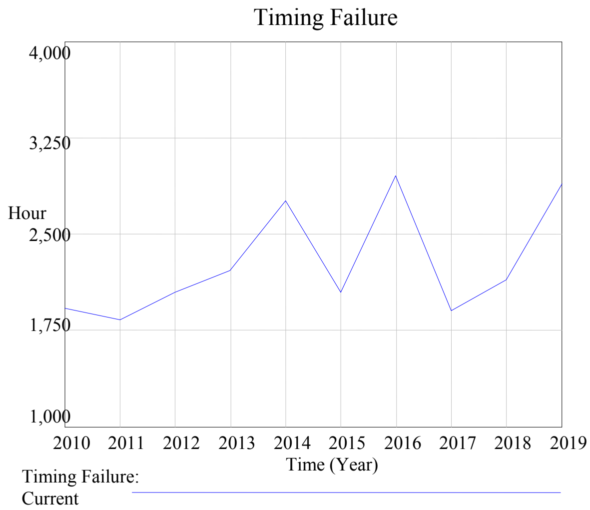

Figure. 2: Timing Failure

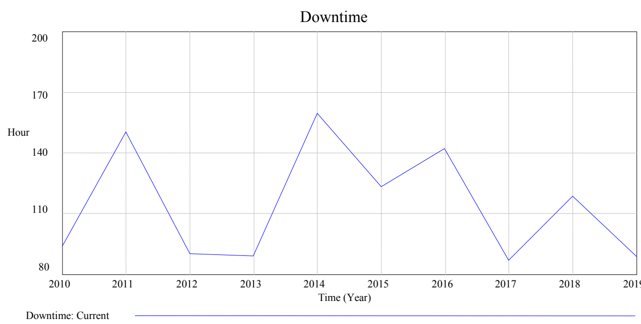

Figure. 3: Downtime

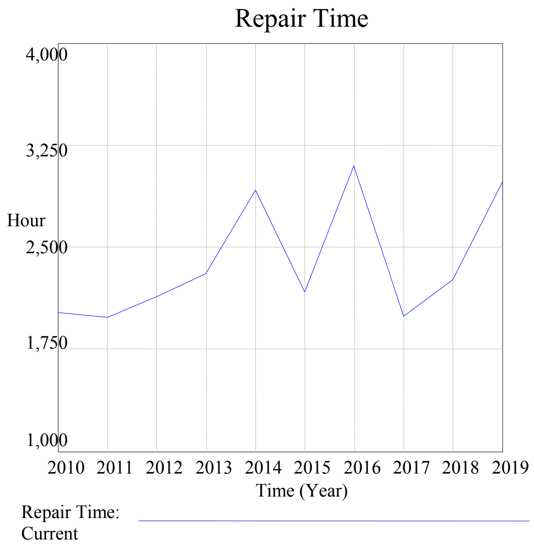

Figure. 4: Repair Time

Profit Status

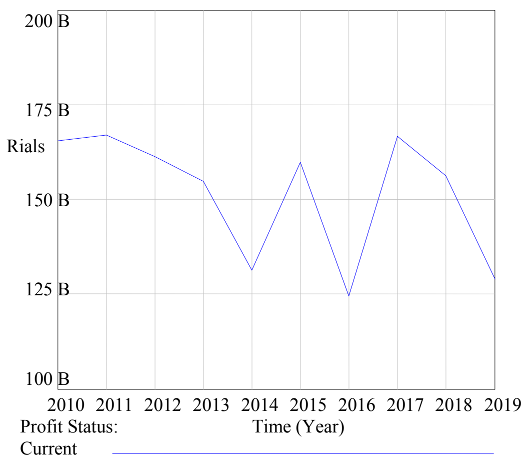

Figure. 5: Profit Status

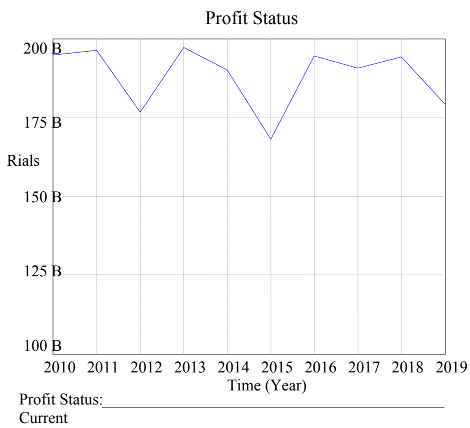

Figure. 6: Profit Status after Purchasing Digital Generator