

Improve inspection process in tire manufacturing by using computer simulation

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Abstract. The purity of this research was to study the feasibility of improving the quality inspection in the manufacturing of tire by focusing on the utilization process. The current plant production is continuous and there are four working groups which can be divided into 3 shifts with 24 hours produced a day (Average production capacity is 350 days per year). Improved quality inspection processes will inevitably result in unnecessary production stops. Therefore, the researchers have proposed a feasibility study on how to improve the quality of the test procedures using engineering and technology techniques. These create models that have the same functionality as the current working condition. The result was found that Model 2 could reduce unnecessary processes and also four workers per shift if the worker's wage was calculated. This model shows a cost reduction of approximately 1.68 million baht per year, as well as utilization process

1 Introduction

This factory case study is a big tire production company which has make-to-order manufacturing processes. Job flow is a flow shop which is the same direction from start to finish. The production is carried out by the production department and it employs around 2,000 people. The Maximum tire production capacity is about 35,000 units per day. Work scope is categorized into 4 groups of 3 running cycles for 24 hours excluding 10-15 holidays. In case of engine break down or any improvements will affect the production line greatly especially in high volume. Hence, the machine maintenance should be avoided in the peak period. If the machine needs to be repaired, it has to be done after production is finished. As for the problem mentioned above, the management team recognizes the importance of increasing productivity but not stop working. Due to limitations and conditions of the factory, Researchers propose a feasibility study on the improvement of the performance for the tire quality inspection department by using various tools in industrial engineering, problem solving and simulation to study the feasibility of improvement and find alternative ways for better decision making. To use simulation, each models can be configured to study the consequences of each model. There is efficiency measure for the existing and new working scenarios. To select an effective improvement scenario before starting the actual plan can help the business to be successful.

2 Theories and Research

Situational modelling is one of the best way to solve process problems. At present, the design and development of the system often rely on Modelling for analysis prior to applying to the real system. There are simulation software which can simulate the work system. Computer simulation is in the form of computer programs the principle is to create a systematic decision-making approach troubleshoot the system or improve the existing system is good. It is not without interference in the real process. [1] Simulation is a way to analyse performance of system which is based on interaction the intersection of several random processes. These random processes can be identified by the probability model [2]. The system we are interested in may really exist. For example, if we want to improve the existing system "better" (the criteria for measuring "good") or a situation that does not exist yet. For example, changing the storage layout of a warehouse will use a rack rather than a place on the pallet. The current simulation cannot measure performance directly. In the case the numerical method cannot be determined estimation error. [3] Situational modelling is a model of the real process to learn the behavior of the real process under the conditions laid down in the analysis and evaluation the implementation of the system before the actual. [4] Yonlada Shomya and Udom Jantarajatsuk [5]. present to improved performance of the queuing process by using simulation out-patient services of Lum look Ka Hospital in Pratumthanee province, by modelling the situation and taking into account the dynamic behavior of the patient's arrival time and validation of the model with statistical

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validation techniques. Then presented the revised model in 3 approaches which can be concluded to be the best choices. The result showed that there should have an additional channel for drug dispensing and this would lead a reduction in the average number of service hours per patient by an average of 20.90% and reduced outpatient services by an average of 29.09%.

3 Operation

3.1 Work Study

To study the work process of the audit department (Inspection Department) for inspection of tire quality is to understand the correct work and simulation model which should be very close to the original process. The study found that there are 5 steps in the process.

- Trimming rubber (Trimming)
- Mark and weigh (Balance Section)
- Quality Inspection 100% (100% Section)
- Check the balance (Uniformity Section)
- Quality Inspection 200% (200% Section)

The procedure of the inspection quality department is shown in Figure 1.

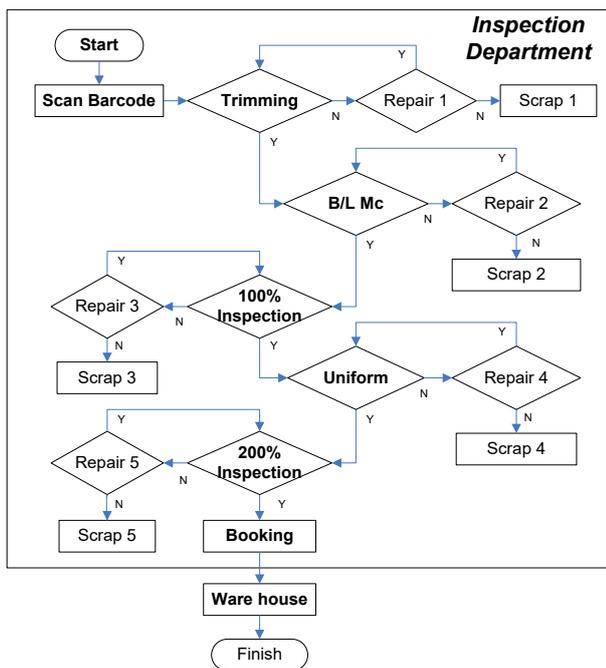


Fig. 1. Procedure of the inspection quality.

3.2 Data collection and Analysis

Tire Quality Inspection Department will use data from working time Monday to Friday in the morning 8 a.m. to 4 p.m. (day shift) with no break time. In day time, the data will have an interruption break period for 15 days. Most of the information is from the monitoring department's timekeeping. Quality and information generated by the machine. In order to provide statistical analysis, every data sets need to have an outlier test. The

outlier will be removed before input into statistical analysis in the next step.

$$n = [Z_{\alpha/2} S/d]^2 \tag{1}$$

d = Margin of error in estimating mean (setting $\alpha = 0.05$)

The appropriate sample size is 22.67, but the data collection must be an integer, so the appropriate amount of Section 100% is 23.

3.3 Modelling the situation

When data is collected as required. The next step is to find the probability distribution of the data by using Chi-square test [6] for one-way discriminant analysis. (Goodness of Fit Test)

$$\chi^2 = \sum_{i=1}^k \frac{(o_i - E_i)^2}{E_i} \tag{2}$$

Table 1. Data distribution model of tire quality inspection process.

Work station	Amount	Pattern of Data
Cut Tentacle	2	Binomial (57,0.948)
Mark and weigh	2	Uniform (26,31)
Quality Inspection100%	2	Binomial (71,0.923)
Check Equation	2	Uniform (27,32)
Quality Inspection200%	2	Binomial (68,0.725)

Situational modelling needs to be closest to the real system. In order to be able to describe the various functions correctly from the analysis. Statistically, the distribution pattern of all data process simulation Modelling [7,8] is used to model the position of the tire quality inspection process.

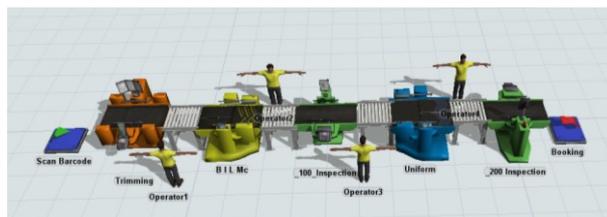


Fig. 2. Current Model Simulation

3.4 Analysis of the accuracy of the situation model

The process of analyzing the accuracy of the procedure is a necessary. It also requires those who understand the system thoroughly to assist in the investigation. If the generated model does not work properly with the diagram design. The improvement will result in errors. Therefore, the generated model must have a valid process flow based on the actual process and statistical tests. Comparison of the results is obtained by Welch Test Confidence Interval, the simulation model of the tire inspection department was created is close to the real

system average at the 95% confidence level, and this model can be used instead of the real system.

3.5 Rounding out the simulation

System design for modelling situations requires multiple tests for accuracy and data variance. This can be calculated by the following equation

$$R \cong R_0 \frac{h_0^2}{h^2} \tag{3}$$

R_0 = Number of preliminary simulation rounds

h_0 = Half width from the simulation cycle.

Introduction at the 95% confidence level,

h = Acceptable 5% half width

The experimental results of the tire quality testing department were 240 hours per cycle in 8 replication experiments.

4 Overall Result

4.1 Solutions of problems

The concept of work improvement for waste reduction in the manufacturing process in the tire quality inspection department is trying to eliminate and reduce unnecessary work. There are many outstanding works from production that is redundant of working procedures. The problem is solved by 5w1H technique to find solutions and then design the production process using ECRS technique. In order to reduce waste from production and increase efficiency, it is necessary to consider tackling quality control process to 100% and quality control process up to 200% quality control process in this section. The analysis can propose ways to improve tire quality inspection system in 2 ways as follows.

4.2 Model Simulation 1

Apply ECRS to improve performance by removing the 100% Inspection section. The newly created models are shown in Figures 3 and 4. Figure 4 shows the procedure for inspecting the tire quality. (Simulation 1)

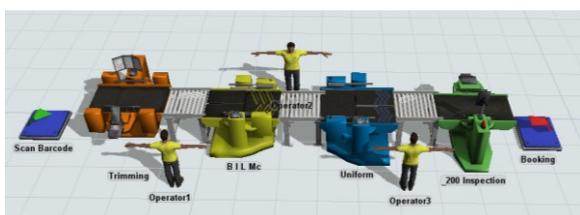


Fig. 3. Model Simulation 1

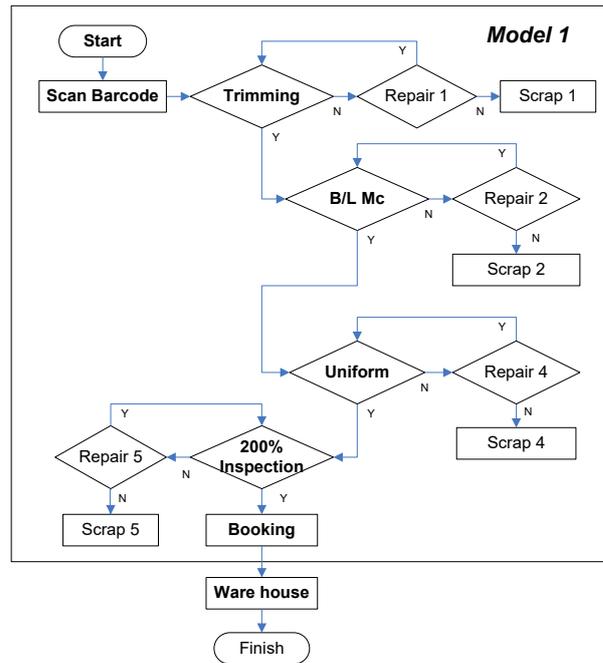


Fig. 4. Procedure for inspecting the tire quality. (Model Simulation 1)

From Tire Quality Inspection Models after improvement, the first test used 240 hours with 8 replications. The average all work sections are over 80% except for rubber cutter which has machine efficiency 75.02%

4.3 Model Simulation 2

Using ECRS principles to improve the original functionality by eliminating the 200% Inspection section. The Model Simulation 2 is shown in Figures 5 and 6.

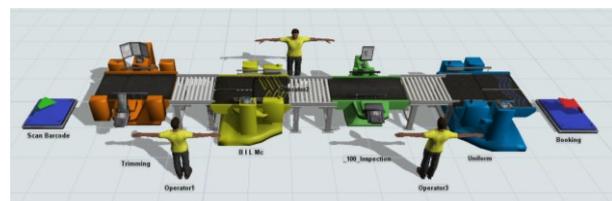


Fig. 5. Model Simulation 2

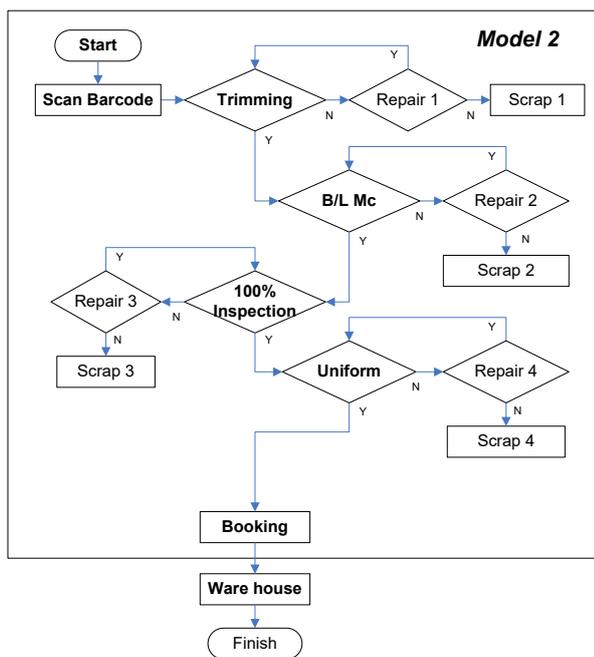


Fig. 6. Procedure for inspecting the tire quality. (Model Simulation 2)

The Model 2 was test by 240 hours of 8 replications. The machine efficiency of all work stations have average percentage more than 80% except for rubber cutter which has machine efficiency 74.89% as show on Table 2.

Table 2. Average performance of each workstation classified by Model type.

Work Station	Machine efficiency (%)		
	Cur	M.1	M.2
Cut Tentacle	74.99	75.02	74.89
Mark and weigh	83.51	83.56	84.25
Quality Inspection 100 %	94.71	-	91.63
Check Equation	85.13	84.64	85.11
Quality Inspection 200 %	91.74	91.24	-
Average	86.02	83.62	83.97

After defining guidelines for improvement and the results are summarized in Table 3.

Table 3. Result of each simulation model.

Situation simulation	Machine efficiency	Number of employees	Amount of waste
Current model Simulation	86.02	6	253
Model Simulation 1	83.62	4	288
Model Simulation 2	83.97	4	279

5 Summary and recommendations

Based on a feasibility study, the Quality Assurance Department found that the Product Inspection Division had a redundant work process between the 100%

Inspection Section and the 200% Inspection Section which will be increasing confidence for quality assurance of customers and the quality of the product slightly. If you want to improve the inspection process, the Model Simulation 2, which can cut 200% Inspection Section out, can be a very good candidate. Using the ECRS principle and simulation model to improve performance is a guideline by creating a model to provide an improved system which cannot be tested on real situation. If we improve the inspection process based on the proposed model, it will be possible to reduce 4 workers per shift (cost reduction is about 1.68 million baht per year). Performance is closed to work situation before improvement. The Factory plant layout is very small and worth the investment.

Acknowledgments

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