# OPTIMAL OF BUFFER SIZE ALLOCATION ON DISK DRIVE SUSPENSION BY USING SIMULATION

Naphat Saensuk
Engineering Management Program, Department of Industrial Engineering, Faculty of Engineering
Kasetsart University Bangkok 10900
Naphat.sae07@gmail.com

Roongrat Pisuchpen
Department of Industrial Engineering Faculty of Engineering Kasetsart University Bangkok 10900
fengros@ku.ac.th

## Introduction:

Nowadays, the hard disk drive industry has been expanding and been growing fast for many years and Thailand is one of the countries of production for this industry. Manufacturers produce their products for serving both local and export customers. They also improve their production system by using new technology to be consistent with current situation in the market that has high competition, such as pricing, delivery's lead time, and the products' quality to meet conditions required for customers satisfaction. The suspension is a part of the hard disk drives product. It is used to read the disk in the hard drive. So, accuracy of every step in the production system is very important. To produce quality products, a quality control system is also important. Manufacturers have to maintain a strict quid in every step of production to guarantee the customers satisfaction.

### Literature review

The production system has the many approaches for improvement and management of the methods; see the examples, Azadeh et al [1] studied about designing CONWIP system and JIT system by creating simulation with ANOVA for improving the optimization of the JIT system. Huang et al [2] presented a simulation model for analyzing constant production system and push & pull production system. It is used for finding optimal number of Kanban card in each station to maximize efficiency and suitability with the production system. Pettersen J.A and A. Segerstedt [3] studied supply chain model in restricted areas that has connections between Kanban and Non-Kanban production to control constant work in process (CONWIP) and work in process (WIP) for inventory efficiency. Deanmu J. and K. Taaffe [4] presented using simulation of LimWip and takt time to analyze relationship between work in process (WIP) and the buffer size, by the design simulation model to make smooth continuous production and to improve output of each station to optimal levels. These researches present a simulation model that use Arena 13.5 program to simulate production systems while we use the data from manufacturers to create fundamental models and studies to integrate queuing systems and constant simulation models to compare a key performance index of optimal buffer size in the system.

## Simulation model

### *The Current production model.*

This research studied the process approach on the data used in the production and analyzing the data has created model Arena13.5 [5] for finding the buffer size to each station. The buffer sizes are used to control work in process in each station to meet production demand. This research has taken the produced information to be the variable used for creating the simulation model by Input Analyzer tools [6] from (1) Material input information (2) processing time information (3) conveyor information (4) Input Analyzer for production as below;

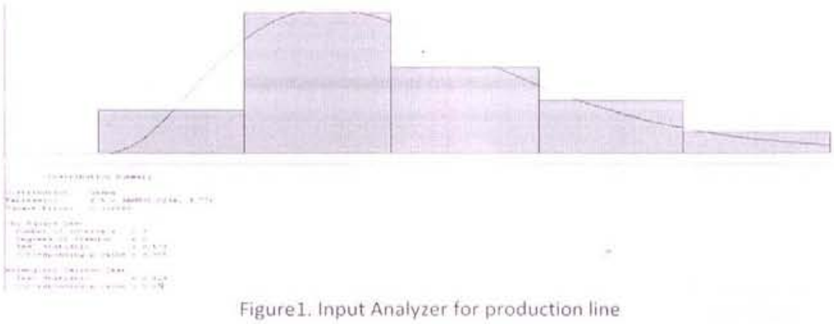


Figure1. Input Analyzer for production line

Figure 1 shows the input analyzer being used in order to measure the statistical dispersion of data. The input data is conducted under 95% confidence interval (significant level = 0.05), by the input analyzer in Arena program.

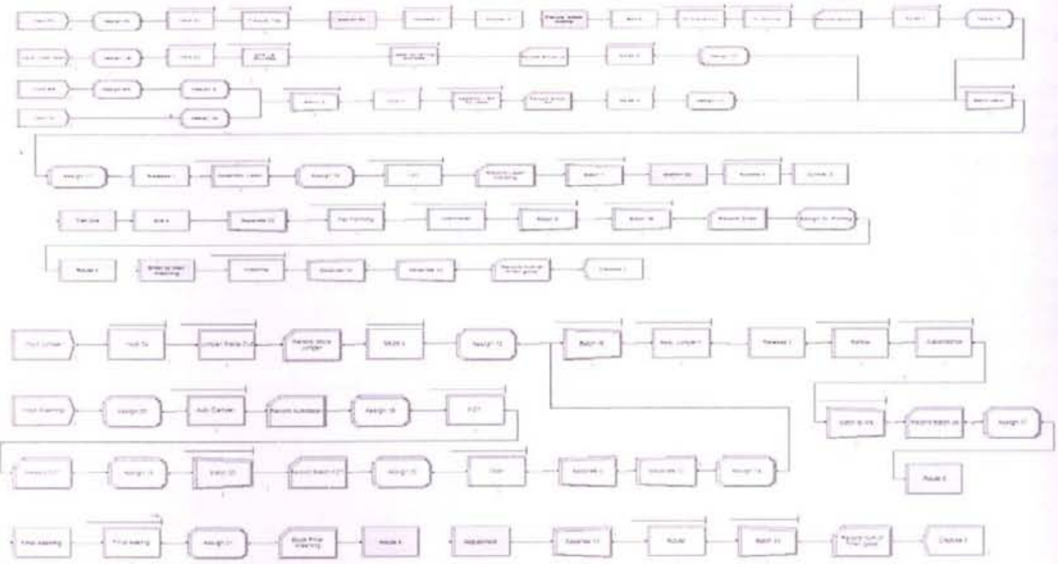


Figure2 The simulation model of the production line.

Figure 2 shows the simulation model of the production line. The batch module is used to allocate the buffer size in each work station. The process module is used to represent the machine processing time in each work station. Conveyor rate and Conveyor length are determined by the simulation model. The simulation model was run for 6 replications and 15 days for the warm up period and has verified its correctness through T-test.

## Verification and validation

Modeling of a plant production system for studying the operation of the production has been processed carefully and the model has been checked about verification of the model. It was compared between real information and the calculated information from simulation models which used the hypothesis analyze to from a relationship of the two systems as follows;

Table 1 Comparing the quantity data.

| Station | Results |
|---|---|
| Average ($d_i$) | -1704 |
| Variance | 10,304,111 |
| $t_0$ | 1.76 |
| $t_{\alpha/2,K-1}$ | 2.63 |

Table 1 These models are able to test that if $|t_0| > t_{\alpha/2,K-1}$ rejects the null hypothesis $H_0$ and if $|t_0| \le t_{\alpha/2,K-1}$ does not reject the null hypothesis, the simulation results conclude that $|t_0| \le t_{\alpha/2,K-1}$ which this models do not reject the null hypothesis, so the actual production and the simulation model are not different.

Table 2 The results of the buffer size compared model.

| Station | Results |
|---|---|
| Average ($d_i$) | 1.64 |
| Variance | 18.77 |
| $t_0$ | 1.138 |
| $t_{\alpha/2,K-1}$ | 2.751 |

Table2 these models are able to test the models which these models do not reject the null hypothesis, so the actual production and the simulation model are not different.

In conclusion, in comparing to the actual design simulation found that the system are not different, therefore the simulation model are able to design the experiment to improve the buffer size in the production line.

## Experimental design

### *Experimental approach.*

This research uses multiple methods to evaluate and compare the results of new experiments and the current production system. We mainly focus on two techniques which are Optquest Arena system, and Process Analyzer Arena system.

#### OptQuest system.

This research conducts mathematical modeling by utilizing Arena OptQuest program. The buffer size are considered between variable 1,variable 2 and variable 3 from laser welding station to final washing station. Arena program can be set the verity of all buffer sizes which can use ± 20 by setting objective equation and give conditions required at the beginning and ending of the process.

Table 3 Objective of equation Simulation Model

| Function | Equation |
|---|---|
| Objective equation | Maximize (Number out) |
| Restriction | [GL Forming WIP] ≤ 7 Lot |
| | [Fx Forming WIP] ≤ 163 Lot |
| | [Washing Machine WIP] ≤ 7.8 Lot |

| Function | Equation |
|---|---|
| Objective equation | Maximize (Number out) |
| Restriction | [Input Oven ] <= 1600 Pcs. |
| | [Capacitance WIP] <= 111 Lot. |
| | [PZT.WIP] <= 6070 Pcs. |

After getting objective equation and restriction of the model, the equation is run in the Arena OptQuest program in order to find output of production process.

#### Process Analyzer system.

Process analyzer system provides the system selection in order to compare the result of the traditional system and another one. The result assists an analyzer for making decision.

| Name | Control | | Responses | | | | |
|---|---|---|---|---|---|---|---|
| | Variable 1 | Variable 2 | Batch 36 | Batch 7 | System Number Out | Stock GL | Laser Welding |
| Scenario 7 | 60 | 5 | 1.998 | 29.159 | 5700 | 19 | 5440 |
| Scenario 1 | 60 | 3 | 0.982 | 29.159 | 5580 | 31 | 5440 |
| Scenario 5 | 60 | 7 | 3.015 | 29.159 | 5460 | 13 | 5440 |
| Scenario 4 | 60 | 6 | 2.501 | 29.159 | 5400 | 15 | 5440 |
| Scenario 6 | 55 | 4 | 1.504 | 27.062 | 5280 | 24 | 5404 |
| Scenario 2 | 66 | 6 | 2.543 | 32.227 | 5148 | 13 | 5359 |
| Scenario 3 | 50 | 6 | 2.535 | 24.366 | 5100 | 17 | 5346 |

Figure 3(a) Results of the process from Laser Welding to Washing.

Figure 3(a) the control variables are variable1 and variable 2.Variable 1 represents the buffer size of batch 7 and Laser welding. Variable 2 represents the buffer size of Stock GL.

| Name | Control | | | Responses | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Variable 1 | Variable 2 | Variable 3 | Stock Capa | Batch 30 | Batch to Ws | Batch 14 | System Number Out | Stock Jumper | Autodam per | Record Ws |
| Scenario 3 | 50 | 4 | 40 | 212 | 1.51 | 19.503 | 19.936 | 169 | 8489 | 12069 | 212 |
| Scenario 8 | 55 | 3.5 | 35 | 242 | 1.014 | 16.931 | 25.099 | 154 | 8461 | 12325 | 242 |
| Scenario 1 | 60 | 4 | 40 | 212 | 1.51 | 19.503 | 19.931 | 142 | 8489 | 12069 | 212 |
| Scenario 7 | 60 | 4 | 30 | 284 | 1.506 | 14.361 | 15.044 | 142 | 8497 | 11952 | 284 |
| Scenario 4 | 60 | 3.3 | 40 | 208 | 1.004 | 19.448 | 20.025 | 139 | 8327 | 12007 | 208 |
| Scenario 5 | 60 | 6 | 40 | 209 | 2.51 | 19.331 | 20.154 | 139 | 8380 | 11988 | 209 |
| Scenario 6 | 60 | 4 | 66 | 127 | 1.504 | 32.707 | 27.849 | 139 | 8440 | 11938 | 127 |
| Scenario 2 | 66 | 4 | 40 | 212 | 1.51 | 19.503 | 31.945 | 129 | 8489 | 12069 | 212 |

Figure 3(b) Results of the process from Jumper to Final Washing.

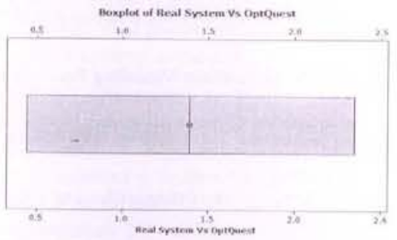
Figure 3(b) the control variables are variable1, variable 2 and variable3. Variable 1 represents the buffer size of batch 14, variable 2 is batch 30 and variable 3 is batch to washing.

## Results and Review

After the results of the experiments were completed, this research was compared between the buffer size of each station for finding the optimum buffer size as below;

Table 4 & Figure 4 Comparing the buffer size between real systems to OptQuest system and real system to Process Analyzer

| Station | Real | OptQuest | $(\bar{d})$ | Real | Process Analyzer | $(\bar{d})$ |
|---|---|---|---|---|---|---|
| Sum | 31.64 | 20.49 | - | 31.64 | 27.57 | - |
| Average | - | - | 1.394 | - | - | 0.5075 |
| Sample variance | | 1.297 | | | 1.915 | |
| standard deviation, | | 1.138 | | | 1.383 | |
| Standard error | | 0.403 | | | 0.489 | |
| $t_{\alpha/2,\nu}$ | | 2.364 | | | 2.364 | |



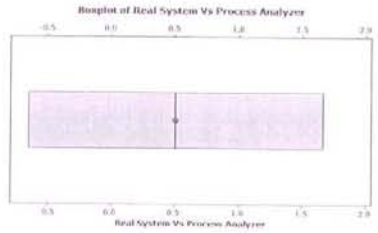




Table 4 and Figure4 Calculation on acceptable reliability of 5% error in the range (0.442, 2.346) shows that the model was compared between real system and OptQuest system of the buffer size. It is found that OptQuest system was better than the actual performance. And real system with Process analyzer calculation on acceptable reliability of 5% error in the range (-0.649, 1.664) shows that the models were compared between real system and Process analyzer of the buffer size. It is found that the result of 2 models were similar. By the buffer size of process analyzer system was the buffer size is 27.57 lots which was less than the buffer size of real system 31.64 Lots. So the process analyzer was able to be use for finding the buffer size, but it was not the optimal buffer size.

Table 5 Comparing the buffer size between OptQuest systems to Process analyzer

| Station | OptQuest | Process Analyzer | $(\bar{d})$ |
|---|---|---|---|
| Sum | 20.49 | 27.57 | |
| Average | - | - | -0.886 |
| Sample variance | | 0.861 | |
| standard deviation, | | 0.928 | |
| Standard error | | 0.328 | |

Table 5. Calculation on acceptable reliability of 5% error in the range (-1.662, -0.110) shows that the model was compared between OptQuest and process of the buffer size; found that OptQuest system was better than the Process analyzer. In summary, the OptQuest system as 20.49 lots is the good approach for finding the optimum buffer size.

## Conclusion

The results were evaluated to use simulation model for comparing the properly buffer by these experiment as below;

### *The optimization buffer size*

The process analyzer system was able to increase the production be 8,450 pcs. Total buffer of system be 27.27 lots which the buffer sizes decrease from the present system be 12.86%. However, to consider the conclusion OptQuest system could increase production to 5,116 pcs. which is more than 2,846 pcs. The total buffer size of system is 20.49 lots these decreasing from a real system 61.59%. Consequently of optimum this system could choose OptQuest system to find the optimization buffer size of process line.

### *Comparison of production costs*

This research analyzed about production costs of the system, found that work-in-process (WIP) of the present system had the total costs in system of 6;834,240 baht. The process analyzing system had the total costs of 5,955,030 baht while the OptQuest system had the total costs of 4,425,840 baht. After that comparison the three systems were found that costs of OptQuest system had the least costs. This system could decrease work-in-process (WIP) and the cost of production is 35.24%.

## Reference


1. Azadeh, A., B. Bidokhi S.M.R and Sakkaki. 2005. Design of practical optimum JIT systems by integration of computer Simulation and analysis of variance. **Computer & Industrial Engineering**. 49: 504-519
2. Huang, M., W.H. Ip, K.L. Yung, X.Wang and D.Wang. 2007. Simulation study using dynamics for a CONWIP-controlled lamp supply. **Journal of advanced manufacturing technology**. 32(1-2): 184-193
3. Pettersen, J.A. and A.Segerstedt. 2009. Restricted work-in-process: A study of differences between Kanban and CONWIP. **Introduction Journal Production Economics**. 118: 199-207
4. Deanmu, J. and T. Kevi. 2007. Measuring Manufacturing throughput using takt time analysis and simulation. **In Simulation Conference 2007 Winter**: 1633-1640
5. Greasley, A. 2008. Using simulation for facility design: A Case study. **Simulation Modeling Practice and Theory** 16: 670–677
6. Hu, S. and W. Yi. 2009. Simulation and Optimization of Kanban System for Steel Rolling. **IEEE Xplore Digital Library**, 1-4
7. Nabhendra, B., Alhussein and A. Abouzeid. 2009. Queuing network models for delay analysis of multihop wireless ad hoc networks. **Advance Hoc Networks** 7:79-97
8. Songchitruksa, P. and N.H. Edwin. 2008. Queuing simulation of roadside survey station: Blocked traffic lane. **Transportation Research Part A**. 42:857–873.


* * * * *