World Academy of Science, Engineering and Technology
International Journal of Industrial and Manufacturing Engineering
Vol:7, No:9, 2013

The Evaluation of Production Line Performance by Using ARENA – A Case Study

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Abstract**—**The purpose of this paper is to simulate the production process of a metal stamping industry and to evaluate the utilization of the production line by using ARENA simulation software. The process time and the standard time for each process of the production line is obtained from data given by the company management. Other data are collected through direct observation of the line. There are three work stations performing ten different types of processes in order to produce a single product type. Arena simulation model is then developed based on the collected data. Verification and validation are done to the Arena model, and finally the result of Arena simulation can be analyzed. It is found that utilization at each workstation will increase if batch size is increased although throughput rate remains/is kept constant. This study is very useful for the company because the company needs to improve the efficiency and utilization of its production lines.

Keywords**—**Arena software, case study, production line, utilization.

I. Introduction

A Simulation is the imitation of the operation of a real world process or system over time. Whether done by hand or a computer, simulation involves the generation of an artificial history of a system, and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system [1].

The behavior of a system as it evolves over time is studied by developing a simulation model. Once developed and validated, a model can be used to investigate a wide variety of "what-if" questions about the real-world system [1].

Potential changes to the system can first be simulated in order to predict their impact on system performance [2]. Simulation can also be used to study system in the design stage, before such systems are built. Thus, simulation modeling can be used both as an analysis tool for predicting the effect of changes to existing systems, and as design tool to predict the performance of new systems under varying sets of circumstance.

Manufacturing and material handling system provide one of the most important applications of simulation. One of the important performance parameters of manufacturing system is utilization. Utilization refers to the amount of output of a production facility relative to its capacity. This expression often defined as the proportion of time that the facility is operating, relative to the time available under the definition of capacity, and usually the result is expressed as a percentage (%). Utilization is useful measures of performance in a manufacturing plant especially in providing a measure of how well production facilities are being used. If the utilization is low, the facility has not operated nearly to its capacity. Otherwise if utilization is very high (near 100%), it mean that the facilities are being fully utilized.

The main objective of this study is to apply ARENA software in order to simulate and evaluate the utilization of a production line for a complete production process of a certain manufacturing industry based on stamping operation. ARENA is a discrete-event simulation product developed by Rockwell Software, and has been used in wide variety of application areas such as call centers, business processes and manufacturing. In this paper, the study will be emphasized on the complete production process for the product, which is from an early stage (input) until end product (output). The study will also focus on the related facilities/work station involved in the production flow for selected part/product and attention is given only for discrete part flow. The study will not involve other elements that influence utilization such as plant layout, human factors/errors, facilities and product design and others. The focus of study is to examine the effect of entities per arrival or batch size and throughput rate to the utilization parameter.

II. Problem Definition

Nowadays product varieties are rapidly being introduced into the market. In this situation, the philosophy needed by a company to survive is by constantly changing from the old product to a new one, or by improving an existing product [3]. Newly developed products will need machines and other production resources to process raw material to become finished goods. On the other hand, the procurement of these machines and resources requires a substantial amount of cost as well as time from design to production. Procurement, production and marketing of a new product will certainly lead to a longer time to market thus affecting competitiveness of the company. It could be that the existing facilities are already in place for new product but the problem is whether the utilization of the existing manufacturing system is capable of producing a product mix (the existing product as well as the new one). That is why it is very important to evaluate the utilization of an existing production facility in relation to product varieties produced by a manufacturing industry.

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III. Related Work

Production line consists of series of workstations. The workstations are arranged so that product moves from one workstation to the next. At each workstation certain process is carried out on the product. The production rate of the line is determined by its slowest station. Workstations whose pace is faster than the slowest will ultimately be limited by that bottleneck station. Transfer of the product along the line is usually accomplished by a mechanical transfer device or conveyor system, although some manual lines simply pass the product by hand between stations. Production lines are associated with mass production. If product quantities are very high and the work can be divided into separate tasks that can be assigned to individual workstations, then production line is the most appropriate manufacturing system [4].

Simulation has been used to investigate a wide variety of problematic areas in manufacturing [5]-[7]. A simulation model is a descriptive model of a process a system and usually includes parameters that allow the model to be configurable [1]. The model will then be used to estimate the effects of various actions. The idea behind simulation is to imitate a real world situation mathematically, then to fitly its properties and operating characteristics and finally to draw conclusions and make action decision based on the results of the simulation. In this way the real life system is not touched until the advantages and disadvantages of what may be major policy decision are first measured on the systems model.

While by analyzing the impact of new, "what-if" business ideas, rules, and strategies before implementation on live customers-offline, Arena simulation software helps protect business without causing disruptions in service.

According to Sara Hewitt, stochastic system use random-number generators, so the output of the simulation is an estimate of the true system behavior [8].

Sending and receiving messages is a way for simulation model to interact with directly with a shop floor execution system. From external database that are updated by a process planning system and coordinated via an external business system, the process plans and master production order can be reads by control simulation model [9]. Using the Arena software as an analysis tools, the utilization and cycle time for production process can be simulated.

Boginski et al. [10] used Arena in their research because Arena module can show the real environment of a hospital, a factory, or a bank, etc. and animates the process while it is running. Arena produces a detailed report after running the model, which includes useful information such as average waiting time for specific resources in certain components of the system. In their work, they used it to determine the distribution of the patient arrival interval and the time each patient stays in a particular area.

Nagarajan et al. [11] had to familiarize with SNMPv3 and its characteristic for network management which are usually seen as a complex task. But Arena simulation software could become a useful tool to understand the basics of any network management. A simulation model had been created to represent SNMPv3 Traffic Flow Meter characteristics. This simple model can be used to estimate traffic flow characteristics like packet arrivals, availability of network resources and authentication and privacy of users. This definitely was a new and simple alternative approach to study network management protocols. It is also possible to verify simulation results by using simple queuing theory principles and therefore the validity of the results achieved is extremely reliable [12]-[15]. The developed simulation model also helps to understand the importance of policies which determine who will have access to network resources and when those resources will be available.

Vieira [16] had presented first ideas of a research project proposing to use computer simulation, in this case is Arena, in modeling and evaluation of supply chain performance.

The efforts to improve performances of manufacturing system have never ended. And utilization is one of the performance parameters which need to be improved. Some of the previous studies to improve the resource utilization of manufacturing system have been conducted [17]-[20].

The issue of utilization and improvement in a multi-product unreliable production line with finite buffers had been analyzed by using an analytical approach [19].

One of scenarios to improve productivity of production line in a food processing industry was by adjusting the number of resources (such as machine) and distance between workstations. And then Arena software was used to analyze the effects of that adjustment [17].

A few previous studies that related to resource utilization and Arena simulation have been discussed. Anyway, only a few of these studies have discussed directly on the effect of batch size and throughput parameters to improve resource utilization.

IV. Methodology

The methodology for this study can be illustrated as shown in Fig. 1. The following paragraphs describe the individual element of the methodology flow chart.

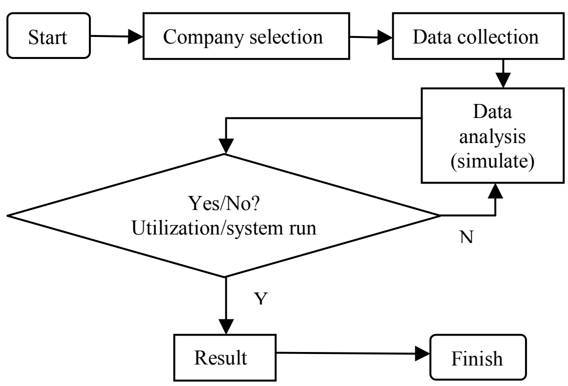

Fig. 1 Flowchart of methodology

A. Company and Production Line Selection

Selecting the company and production line which correlates with the objective of the study is one of the important aspects in conducting the study. To conduct this study, a production line that creates queuing was selected. A production line that creates queuing is an imbalance line.

B. Data Collection

Actual operational data are needed for simulation and verification. The data was collected through observation on the line. The collected data were entities per arrival, configuration of the line, and types of machine processes. The processes time and the standards time for each processes of the line were gained from management of the industry. A constant meeting with the engineer of the centre is held to discuss the model build in ARENA software.

TABLE I
THE PRODUCT PRODUCTION PROCESS PLAN

Work Station (Machine)	Process Number	Process Name
80T	1	Blanking
80T	2	Inspection 1
80T	7	Bending
80T	8	Inspection 4
110T	3	Forming
110T	4	Inspection 2
60T	5	Piercing
60T	6	Inspection 3
60T	9	Cam Piercing
60T	10	Inspection 5

C. Data Analysis

The first step is to model the existing line by using ARENA software. This step was done by utilizing the build function in the software. There were 3 work stations with 10 difference types of processes were studied. The data collected from the each processes of production line is entered in the model. After the developed model has got verification, the validation of model is done by comparing the result resulted from the model to the results based on the real situation. The product production processes plans is shown in Table I, and the standard time and parameters used in this simulation is shown in Table II.

TABLE II
STANDARD TIME AND PARAMETERS

Process Name	Work Station (Machine)	Standard Time (minutes)	Entites per Arrival (unit)	Throughput (unit/hour)
Blanking	80T	1	1, 3, 7, 9, 13	109
Bending	80T	7.3	1, 3, 7, 9, 13	109
Forming	110T	14.8	1, 3, 7, 9, 13	109
Piercing	60T	4.2	1, 3, 7, 9, 13	109
Cam Piercing	60T	9.4	1, 3, 7, 9, 13	109

V. RESULT AND DISCUSSION

A. Product Output versus Arrival Entities

Fig. 2 shows the numbers of difference entities per arrival versus throughputs. Based on the graph plotted, the numbers of products out are increased when entities per arrival or batch size are increased.

B. Product In, Product Out, and Utilization

Figs. 3-5 show the numbers of 'products in' (product quantities coming into a certain workstation), the numbers of 'products out' (product quantities coming out from a certain workstation), and utilizations percentages for each processes for difference entities per arrival. There are 5 difference entities per arrival which are used. These quantities of entities per arrival are 1, 3, 7, 9 and 13. All these quantities have the same throughputs which are 109 units/hour.

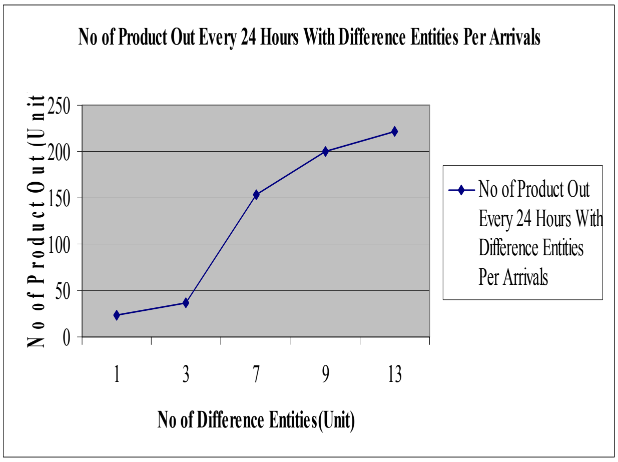

Fig. 2 Numbers of 'product out' for difference entities per arrival

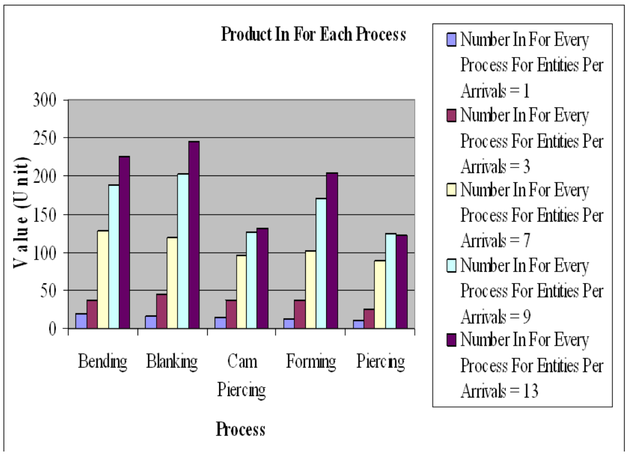

Fig. 3 Results for numbers of 'products in' for each processes

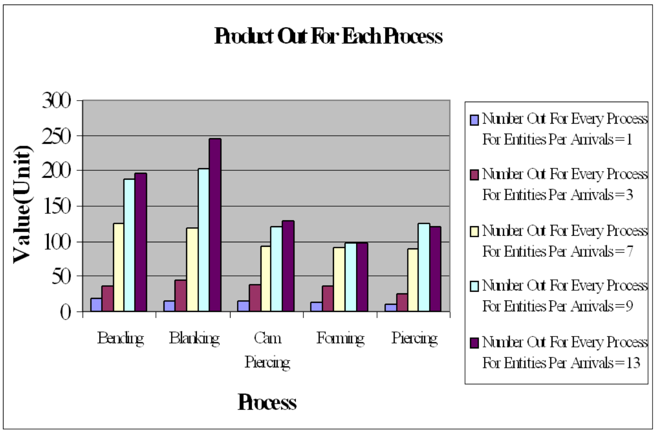

Fig. 4 Results for numbers of ‘products out’ for each processes

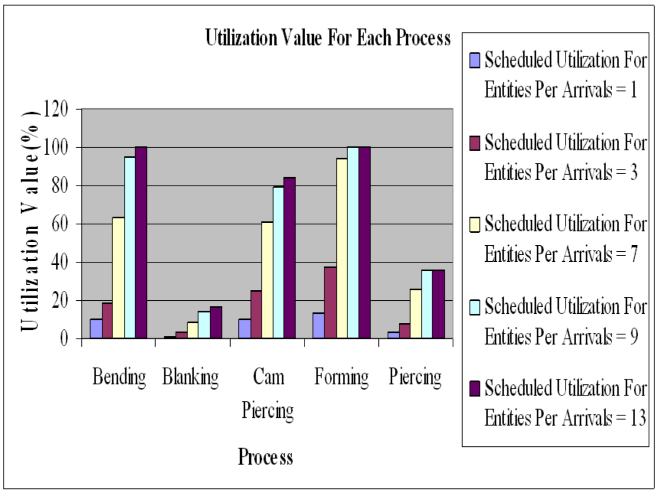

Fig. 5 Result for ‘utilization percentages’ for each processes

C. Utilization versus Product In, Product Out, Wait Time

Figs. 6-8 show the utilization percentages versus numbers of products in, numbers of products out and wait time for each process with the difference entities per arrival.

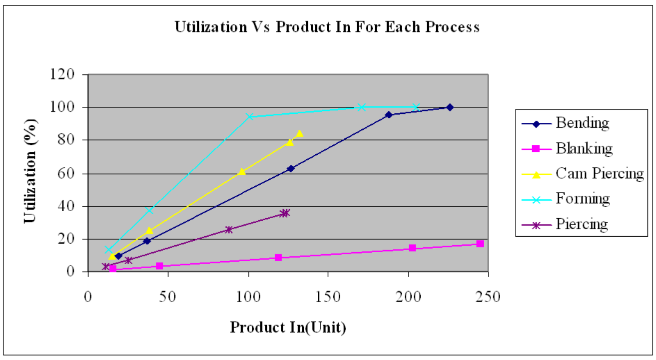

Fig. 6 Utilization Vs Products In

Based on the graphs plotted on these figures, numbers of products out, numbers of products in and wait times for each processes increased when entities per arrivals increased. This clearly showed that a utilization percentage is linear with products out, products in and wait times.

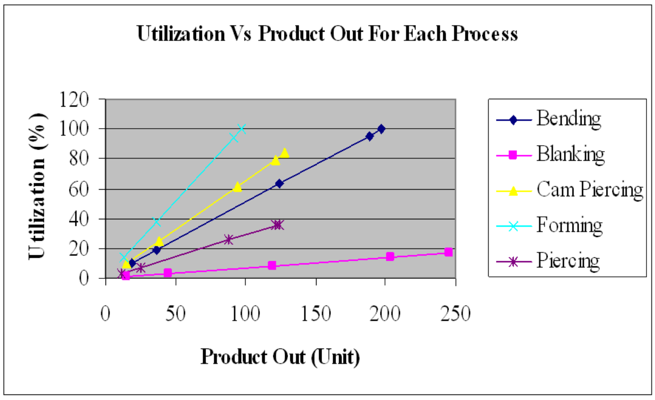

Fig. 7 Utilization Vs Products Out

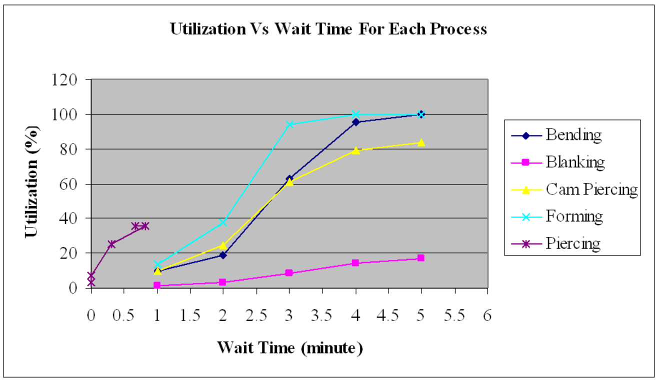

Fig. 8 Utilization Vs Wait Time

VI. Conclusion and Recommendation

Based on the results of this study, it can be concluded that the parameters of ‘product in’, ‘product out’, ‘utilization’, and ‘wait time’ have positive relationship to processing time at each workstation. By increasing batch size, higher quantity of products will be processed at any workstation, and this causes more time to process them. As a result, ‘product in’, ‘product out’, ‘utilization’, and ‘wait time’ parameters will also increase.

For further study, it is recommended to investigate the effect of changes in throughput rate to utilization parameter at the constant condition of batch size.

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