Skateboard factory production optimization study

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Abstract:
In order to invest in a new skateboard factory, the customer SK2 & sons wants to be sure about the product manufacturing capacity that can meet the estimated yearly demand. The purpose of this paper is to simulate the manufacturing line under push and pull production strategies by using ExtendSim. The overall simulation analysis is based on the input data provided by a new business plan. The useful data regarding production capacity, machine utilization, work-in-process inventories, and scrap quantities have been obtained through the simulation model. The simulation results indicate that the new plant's capacity cannot meet the expected annual demand using the assumed resources as to machines and workers. parameters under both push and pull strategies. However, there is still room for improvement by investing in more workstations, reducing the scrap rate or increasing working hours or shifts.
To reach expected yearly product demand as provided by SK8 & Sons it is proposed to use either method, depending on their desire and immediate need.

Keywords: Skateboard, Discrete Event, Extendsim, Push Pull, Bottlenecks

1 Introduction

A global manufacturer of sporting goods named SK8 & Sons has a plan to build a new skateboard factory and wants to know the feasibility of the plan based on the evaluation result of the plant capacity and total investment. The purpose of the paper is to provide our capacity assessment results through discrete event simulation modeling. The investment issue will not be treated.

The current information we have got from the manufacturer is that they are going to only produce decks, wheels, and assemble them together to skateboard, other components are bought from their suppliers. The forecasted demand for decks, wheels, and skateboard are assumed. The parameters of production process, working hours, total worker resources, and scrap rates have been noted as well. Some production strategy such as make-to-stock (MTS) and producing in batches have been decided by the manufacturer.

Discrete Event Simulation (DES) is an important technique for analyzing systems and widely used in the manufacturing field. For instance, by simulating the process flow of material handling, it is easy to get understanding the current process situation and solve production issues [1]. In addition, it also has the capability to support the estimations of suggested scenarios in order to get conclusions about whether it is valuable to do investment, in other words it can support decision making [2]. Therefore, this paper prefers to use a DES model the commercial ExtendSim tool (version 10.0.6) to simulate the process situation.

The scope of the simulation results will be included: simulating the production capacity under Pull and Push strategies and comparing the results, finding the bottlenecks of the production process to see the opportunities of improvements and maximize the throughput of the production line.

2 Method

2.1 Conceptual model

A conceptual model is considered essential as to understanding the problem to be analyzed and to define the relevant scope of activities to create a result using DES. In the literature systematic approaches are given [3] [4] using both tables and diagram as important tools for both analysis and understanding. In this paper we shall use tables and figures as well.

2.2 Data collection

Literature was searched limited to only literature papers no older than 2015. Searched where done both for peer reviewed papers and other publications. Specifically, the internet was searched for skateboard manufacturing including videos, which give a very good real time/reality connection.

Also, the preliminary Excel based capacity analyses showed that a steady state productions case with the same amount produced every month (Push) and a maximum monthly production case (Pull) appear to represent the most extreme monthly production capacity cases. These extreme cases are a good bases for the initial extendsim DES modelling.

2.3 Verification & Validation

As to the extendsim model validation and verification the simulation results shall be compared to the mentioned preliminary Excel analysis. For a very complex model it may be necessary to do sub-model testing against the Excel analysis and a simpler model only providing makrodata. For this purpose, the conceptual model has operations allowing to track and communicate data in a simple fashion.

If the extendsim analysis proves the Excel analysis results to be correct, an option list of possible changes to the manufacturing process and its details shall be developed and various options verified by using extendsim. It may be necessary to have different model solutions for Push and Pull production.

2.4 Discrete Event Simulation

DES is a useful technique for analyzing systems, it is based on logic and controlling state sets by triggering events at a discrete time when it is operating, and widely used in the manufacturing field to model, simulate, evaluate, visualize and optimize the production system design, productivity of the production line, as well as logistic operations [5]. It is also an important simulation tool to create knowledge, generate understanding, visualize results, and support decision making within a manufacturing firm [6].

3 Theory

In this section, the key concepts and definitions surrounding this project are described in order to provide readers with more understanding of context on the topic. Theories are formulated through literature review, information from peer-reviewed scientific papers, articles and books will be collected and used in this article to ensure reliability and credibility.

3.1 Pull and Push system strategies comparison

One of the main objectives in a production line is to minimize overproduction as well as reduce excessive inventory, different strategies using a pull system, or a push system can affect results of the inventory quantity. In many companies, the production line is taken “push system” which means the demand or requirement for every workstation depends on the forecast from the external customer, in this case, the current workstation doesn’t concern about the requirement from the next station, finished products are direct sent to the buffer area between workstations [7], thus the buffer quantities will keep a high level. However, “Pull system” means the produced quantities of current station is based on demand or request from the following station, in other words, the following station is the customer of previous station, and it will send out the request when and how many products are needed. Certainly, even under “pull system", it is quite difficult to achieve zero overhead inventory except continuous flow process, but the buffer quantities between the stations and in the warehouse will decline largely [8].

3.2 Eliminate waste in the production process/Optimization

Waste can be regarded as non-value-added activities from a customer perspective. Toyota has identified eight main non-value-added wastes on the production line, which include [8] e.g., overproduction, excess inventory, defects. It is important to take them into account when we construct the model and simulate the process.

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3.3 Identifying Bottlenecks on the production line and detection with Simulation

Identifying and eliminating bottlenecks is a work that needs to continue in order to optimize the productivity of the manufacturing process. The definition of bottleneck is presented in the literature, that is a machine or workstation whose capacity is lower than the demand or it constrains the output of the whole process [9].

After the model has been verified and validated, the methods can be used to detect the bottlenecks based on the output parameters using the utilization method [10].

Utilization method: Utilization is defined as the proportion or percentage of the available time that a device or system is running, a bottleneck can be regarded as the device or system with the highest utilization percentage.

3.4 Machine utilization

Machine utilization can be defined the percentage of time spent on manufacturing equipment, furthermore, it is a fundamental metric for measuring machine usage [11]. The utilization of machines will affect the capacity and efficiency of the whole process and it can be calculated and analyzed by simulation modelling methods [12].

3.5 Key processes when applying DES in production system development

In order to perform successfully DES model in the production system, it is critical to know the key processes. In general, it should include problem formulation, conceptual model, data collection, model building, verification and validation, and evaluation and development [13]. Following a process, it is easy to get a clear understanding of the objective of the project and will support the model building as well. First, obtaining correct and qualified input data of the production line is essential [8]. When building a model, making sure that the computerized model should be in line with the concept model [14]. For the part of verification and validation, the aim of verification is to check and control that the model has been built in assistance with the concept model as well as real situations, which can be tested by observing the animation of the model and its output [15]. The model was simulated and assumed to be valid when the result from the computerized model is in accordance with historical and actual data. The results shall be documented.

4 Results

4.1 Simulation results

The simulation models, both the push and pull were designed for a steady influx of material. This demand was based on the case data provided by SK8 & Sons.

The Figure1 and 2 refers to the optimized version of the model. What this indicates is that the settings have been altered to suit better the performance of the model. The section that has been optimized the most was the quality department. Furthermore, the breakdowns that occurred in the cutting station was reduced in occurrence by a factor four to reduce the time in breakdown state. Shifts are 8 h active work time each day. Lastly, to cope with the high utilization in the pressing station, three more stations were added to the station. The factors that were changed are shown in Table 1, and which stations that the quality aspect was most pressing.

Factors Changed

Breakdown occurance cutting	Four times less
Number of pressing stations	Three more
Shifts	One hour longer
Quality in drilling, finishing, skateboard assembly & maching optimized	Changed to 1% scrap rate

Table 1. Parameters changed for the models

4.1 Push model

The data retrieved from the simulation model showcased that the demand could not be met under the current settings based on the case data. The results from the model showed that there was high amount of scrap in the production system, mainly from the production of decks. Running the simulation for a year provided results showed in Figure 1. Without the optimization settings shown in Table 1, the push model can reach the demand that is expected.

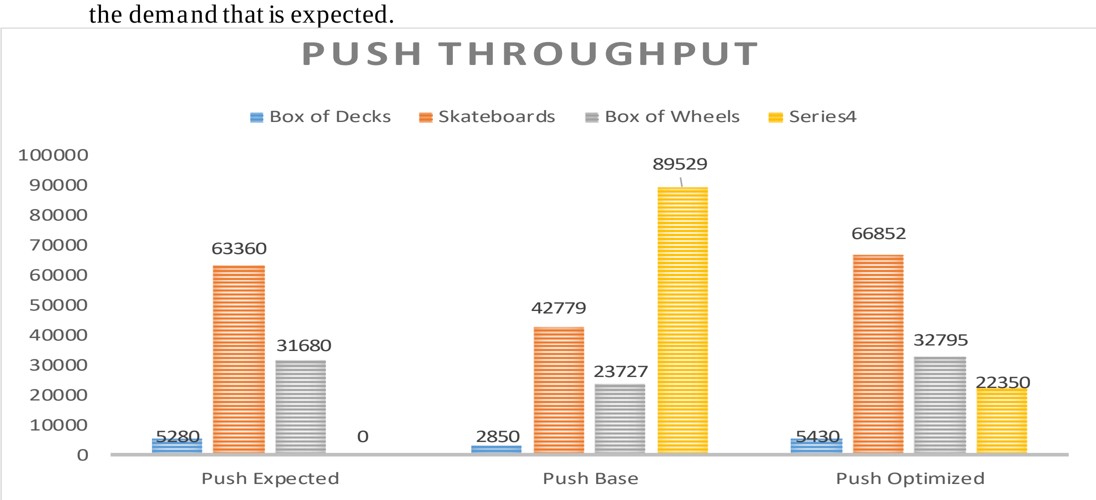

Figure 1. Graphical representation of results

The results indicate that the expected yearly demand could not be met using the case data parameters as provided by customer as shown in Figure 1. Whereas the optimized version could meet the expected demand with reduction of the number of scraps.

4.2 Pull model

The results from the pull model in Figure 2 indicates the expected demand is almost reached throughout the yearlong run, the scrap rate is high when using the base data provided by SK8 & Sons. Figure 2 also showcase the scrap could be reduced substantially compared to the base data.

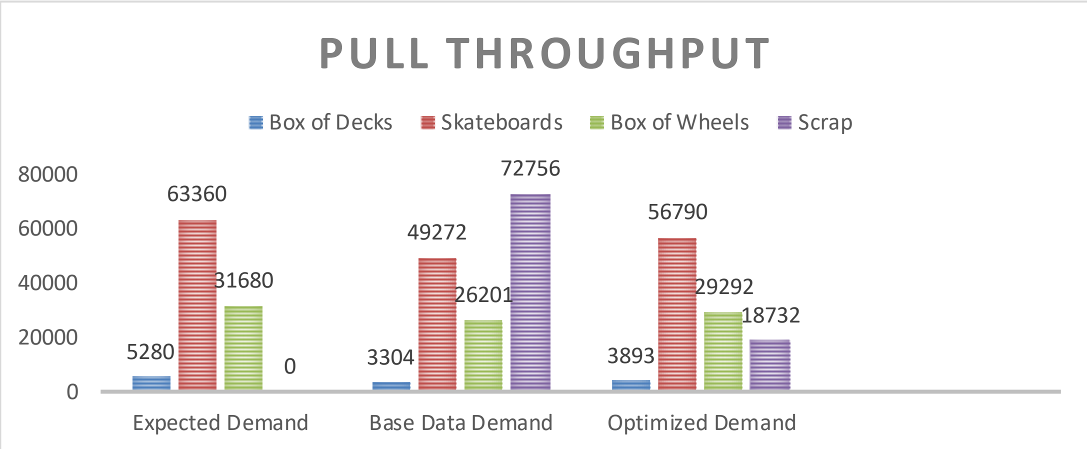

Figure 2. Pull Results from the simulation

4.3 Inventory build-up

The last parameter that is considered is the inventory levels throughout the factory. During a yearlong run the inventory levels are kept in check well apart from a couple of stations. The result from the inventory queue indicated that the inventory build occurred differently from the base data case and optimized version. In Table 4 these two are highlighted.

	Stations / Type of Data	**Current Length Base data**	**Current Length Optimized data**
Push	Wheels to skate-board (base)	5766,0	
	Decks to assembly Skateboard (optimized)		21442,0
Pull	Decks to skateboard (base)	598	3580
	Furnace (base)	158	

Table 2. Highest values of inventory levels and averages

As noticed in the optimized version of the pull-model, there has been an increase in the inventory build-up in the station of decks to skateboard.

5 Analysis & Discussion

We followed the concept of establishing a problem formulation, conceptual model and even verified and validated the model. We also revisited the conceptual model during the course to make sure that it was accurate. This is what is described as a key factor when constructing a simulation model according to [13]. The revisiting aspect is also an important according to [14] as it makes sure that no information is missing in the model. Once the model was done, it was verified and validated to allow for secure experimentation and not having faulty models. Which is an important aspect as well according to [15].

The results indicate that the demand could only be met by using the push strategy. Although, similarly as [7] states that the push produces inventory, so does the model show in Figure 1. The model is overproducing the items to be able to meet the demand. Reducing these inventories could be done by introducing the pull method instead. The pull method model has less inventory which also supported by [8] as an effect of using pull as shown in Table 2. By reducing the number of items in inventory, less capital is bound. The pull model used only the desired quantity of items from the customer with the same parameters as the push-model.

Finding the solution for the optimization factors were to investigate where the bottlenecks were similarly to what [9] describes. Furthermore, the results indicated high utilization which was deemed a bottleneck and needed adjustments The utilization is a one of the most important measuring points according to [11] when trying to find improvements. This method is what [10] describes as being the utilization method which focus on finding bottlenecks through finding the high value of utilization. Which is further emphasized by [12] as being a good method to increase the performance of the process.

The decision on which method to use is up to SK8 & Sons to determine. Whereas the push model could meet the desired amount, but it leaves higher volumes of inventory in certain sections. Contrary, the pull model almost reaches the demand but with much less inventory being in the system. The less inventory, the less capital bound for the company. Furthermore, the investments required leaves SK8 & Sons with the decision in which option does need more investments. The pull method does not meet the demand with the same investments as the push, which leads to the conclusion that the pull method requires more investments. To conclude, if SK8 & Sons deem that the demand is the most important aspect and could have large inventories, choose to push the production. Otherwise, if the level of inventory is crucial, and in the future make more investments, choose to pull.

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