Reducing Disturbance in Manufacturing System with Discrete-event Simulation

Norhanom binti Awang , Fazeeda binti Mohamad
Razman bin Mat Tahar

Faculty of Technology Management, Universiti Malaysia Pahang

Email: anumjp@yahoo.com **and** adeezaf@gmail.com

Tel. No : 0199837383 and 0137031224

ABSTRACT

This study aims to present a modelling of production flow in HICOM automotive industry in Malaysian using discrete-event simulation (DES). The purpose of the study is to reduce disturbance or constraints in a manufacturing plant operation problem using discrete-event simulation (DES) model. This was based on data collection in Painting Shop (PS) in production manufacturing plant. Case experiences indicate that combining data analysis with DES is beneficial in identifying and reducing disturbance or constraints in manufacturing system. The computer-based integrated approach successfully reduces the risk of inefficiency cause of these problems in operation. The computer simulation enables the reduction of disturbance and constraint in existing capacity suggested improvement in productivity than existing production operation. The study makes a business case that process improvement through reduction of disturbance and constraint can be effectively accomplished with the integrated approach of using widely available inexpensive and user-friendly computer-based tools

Keywords - Manufacturing system, Production Operation, Simulation, Disturbance.

1. INTRODUCTION

The capabilities of an organisation can be effectively improved by indentifying its critical operations or constraints affected productivity, quality and delivery performance of the organisation. After identifying such operations, each of them can be individually examined closely. A systematic is useful to understand the important characteristic of an operation and generating useful analytical data for carrying out data analysis (Aldowaisan and Gaafar, 1999).

Manufacturing systems tend to become more and more complex and the need to take more scientific approach to overcome production disturbance (Arne Ingemansson, 2003). Elimination of constraints or disturbances in manufacturing system is one of the ways to increase efficiency. Production is the key performance in manufacturing system. The failure of production to perform the expected outcomes affected the financial performance and non performance of the organisation.

Studies from several researchers have shown that identifying constraints or disturbance in any operation is the source of improving productivity and efficiency. Recent example of papers reporting reducing disturbance by Arne Ingemansson (2004), C. Carl Pegels and Craig Watrous (2004) stated that disturbance may affect product quality as well as work safety, work environment and satisfaction of the workers.

System improvement is important in terms of increased productivity in manufacturing. The analytical formalization showed that the manufacturing improvement process will reduce uncertainty in decision making. The improvement system will benefit the performance of the organisation.

The objective of this paper is to present a case study of reducing disturbances in manufacturing system with combination of discrete-event simulation (DES). DES model is suggested method used as means to change different conditions and see the result in the model. The potential of DES for analysis of the production improvement is an interest.

The main purpose of the performed the case study is to show that the disturbance in manufacturing system lead to unproductively. The finding indicates that the potential of DES can be applied to validate the effectiveness. This analysis is one way to achieve desired performance in manufacturing system.

2. DISCRETE-EVENT SIMULATION

Computer simulation has been widely used in manufacturing system to validate the effectiveness of decisions, plan or schedule. It provides a means to validate the information theoretic from model developed and to study the impact on the performance. The used of DES in this case permits the evaluation of operating performance prior to the implementation of the work flow in production.

DES utilizes a mathematical/logical model of a physical systems is used as a interactive tool decision-making. It enables companies to perform what-if analyses leading them to better planning decision because with the simulation tools, comparison of various operational alternatives without interrupting the real system (Y.Chang). F. Hosseinpour (2009) wrote in his journal on how simulation models might perform and explore, or how a new system might behave before the prototype is even completed, thus saving on costs and lead times. This is also supported by Arne, 2003 stated that DES is powerful tool to analyse disturbances, their effects and propagation in a manufacturing system due to the easiness of alterations in a model, and improvement in the system can easily be shown.

The DES model has a potential tool to indicate production disturbance such as disturbance in manufacturing system. If potential bottleneck can be eliminated the cost for the DES model is paid many times compared to the investment in equipment and design costs (Arne Ingemansson,2005).

2.1 ADVANTAGE OF SIMULATION

Simulation can provide estimates of measures of performance such as time in the system, worker/machine utilization, number in queue and time in queue. Simulation can also being used to evaluate the effect of changes to system operational parameter for example changes to system input or resources such as rate of arrival and rate of service. (Martha,2001)

- Once a model is built, it can be used repeatedly for various analyses.
- Simulation data is usually cheaper than data coming from real system.
- Simulation methods are usually easier to apply than analytic methods.
- Simulation models do not require the many simplifying assumptions of analytic methods.

3. INDUSTRIAL CASE STUDY

DRB-HICOM Group's Automotive Division is its principal core business, and encompasses the manufacture, assembly and distribution of passenger & commercial vehicles. The Group's main automotive facilities in Pekan, Pahang, developed since 1984 and occupying 240 acres of land, has been an important operating hub for the Group and is the catalyst for its manufacturing and assembly operations.

The internal logistic flow for Suzuki Swift model is started when material received from internal or external supplier. After the process of receiving, unpacking, checking, sorting and storage, production line can start its operation according to the schedule as planned. The overview of the flow of logistic in Hicom shown as in figure 1.

The plant is design to complete targeted throughput (cars) on time. While completing orders on time has always been a challenge, the problem seems to have grown worse in one of the shops that create disturbance to the smoothly operations. Disturbances can occur in many and different parts of a manufacturing system. Normally disturbance is a unplanned or undesirable state or function of the system (Kuivanen, 1996). Capacity and capabilities of the slowest operation limit the output of the whole process (Yu-lee,2002) .

In this study all the disturbances are related to the actual production in the Paint Shop. The production process started in Body Shop then to the Paint Shop and finally at Trim & Final Shop (see figure 2). The major disturbance arises in painting shop where the cars congested to be painted. It occurs when two models of cars which are assembled in different plants were then being transferred to the same location to have the painting process.

The disturbances occurred in painting shop that caused the slowest operation and low output process. Utilization and cycle time can be used to analyse the slowest operation. According to Yu-Lee, 2002, the cause of the problem of this situation might originated from low efficiency, poor planning at upstream operation and longer cycle time.

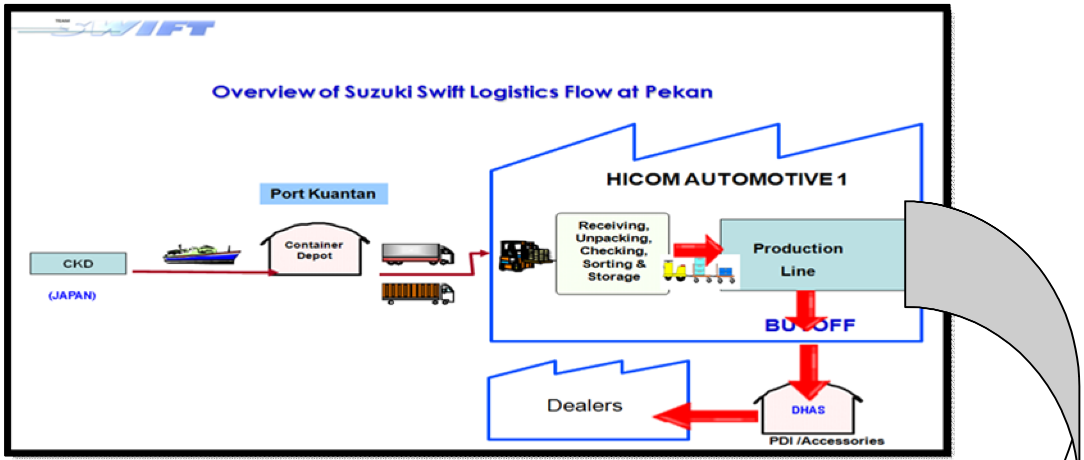

Figure 1: Suzuki Swift logistic flow
Source : Hicom

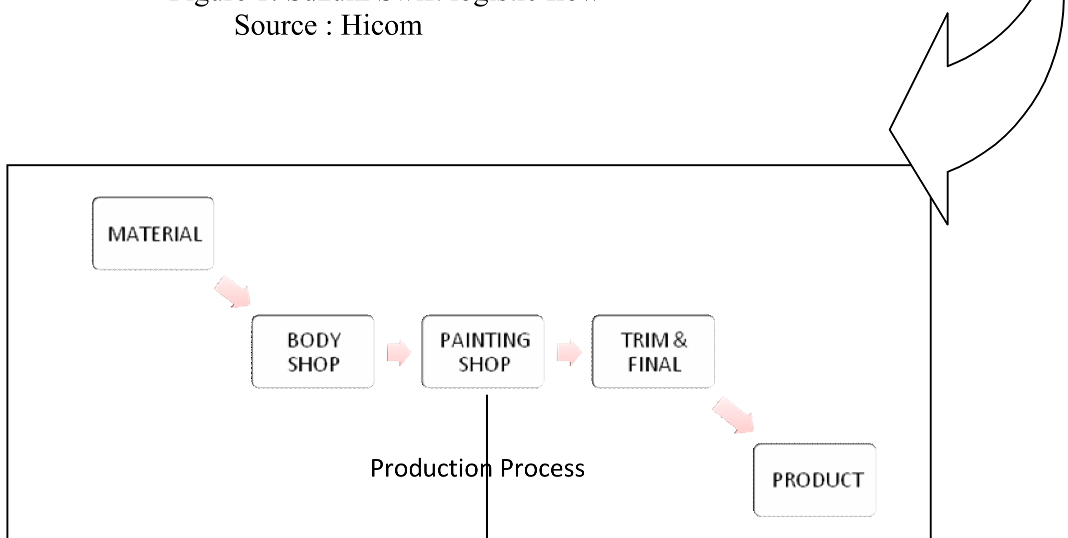

Figure 2 : Production line process in Hicom

Slowest operation
(black box)

3.1 CASE STUDY METHODOLOGY

Input data of the model were extracted from the daily production status for the month of January 2011 in the paint shop. The daily output were extracted to calculate the average time taken (seconds) per unit car. The daily effective capacity is calculated using daily output divided by effective capacity multiply by 100 to get the percentage. The physical of paint shop flow chart was used as a basis for the layout of the DES model to enable a realistic simulation model (see figure 4).

Interviews with personnel at the company were also carried out mainly among the head of section and executive. The main reason of the interview carried out was to understand the flow process and the possible problems that can occur to achieve the information about the production disturbance.

3.2 MODEL BUILDING

When DES model was built, the utmost question can be asked – is the simulation model can adequate representation of the real world system (Kleijnen,1998). A model must accurate represent the reality. Otherwise it may end up being a nice toy but good for nothing. Therefore, two aspects should be certified – verification and validation. Verification is the process of checking out that the model built as one as intended it to build, whereas, validation is the process of insuring that the model truly represent the real world (Martha and Manuel, 2001).

The basic steps and decisions for a simulation study are incorporated into a flowchart as shown below:

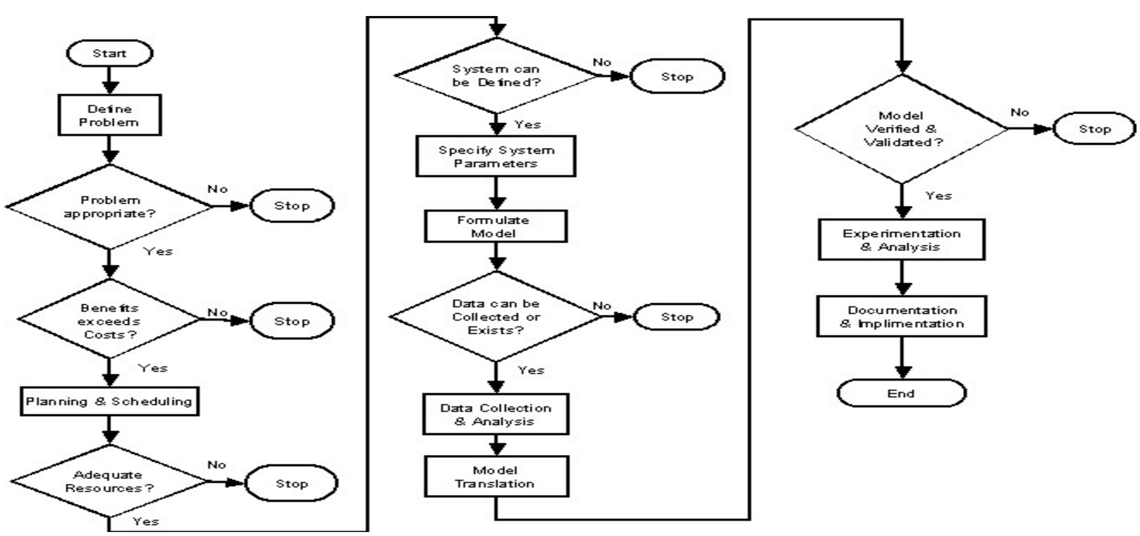

Figure 3 : Steps and Decisions for Conducting a Simulation Study
Source : Martha A. Centeno and Manuel Carrilo, 2001

Once simulation has been recognized as the ideal approach to solving a particular problem, the decision to implement the course of action suggested by the simulation study's results does not necessarily be a sign of the end of the study, as indicated in the flowchart above. It is a continuous process where the model may be maintained and reviewed from time to time to check the system's response to variability experienced by the real system. However, the extent to which the model may be maintained largely depends on the model's flexibility and what questions the model was originally designed to address. In this case, the flow chart in PS is been identified as a approach to solving a disturbance problem. The flow is taken as a base model to be implemented in the study (figure 4).

Figure 4 : The flow of Painting Shop Process in Hicom

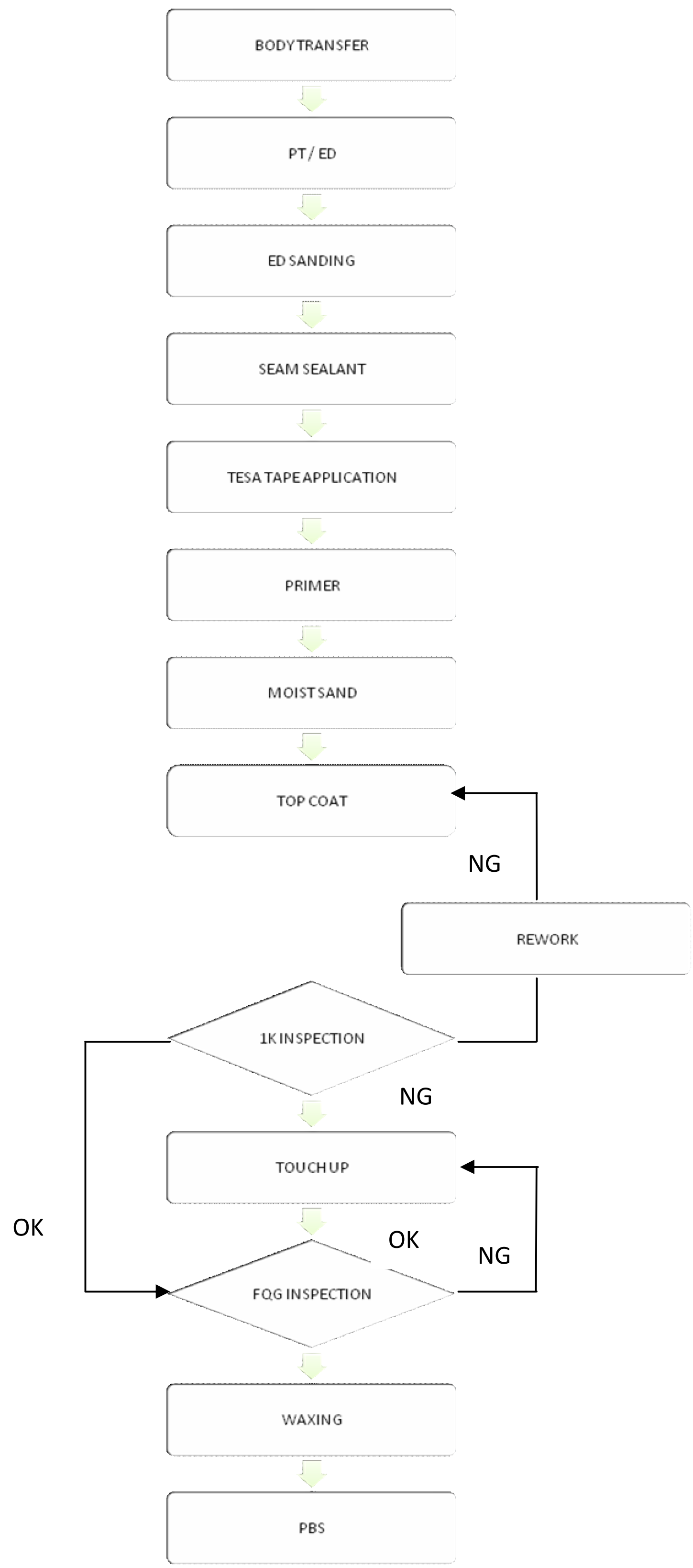

Figure 4 : The flow of Painting Shop Process in Hicom

4. DATA COLLECTION

Quality of this study was defined in terms of production of the process. From the moment the car entered the paint shop to when it leaves the paint shop. In order to gather further insight into where delay/disturbance are occurring, we identified high level activities or “black-box” that occur within the PS. Black box is defines as the slowest process which the disturbance occurred.

A typical car’s journey in PS begins when the Body Shop (BS) transferred their output to Pre-Treatment or Electro Deposition (PT/ED) section in PS until reached the first and second inspections before it is delivered to the PBS section. The whole process in PS is shown in figure 3. The data recorded in terms of actual daily output produced by PS within the month of January 2011. Target output is 23 unist per day. The PS running in one shift and 8 hours per day. Figure 5 summarize the data collection of the throughput at PS within 20 days working days in January 2011.

Data collections are not without limitations. First, we were only taken a sample of 20 days working hours within January 2011. Therefore we only cater the circumstances that only happened on that particular period of time. In other period of time, the problem occurred might be different. Second, we were not taking into consideration the output that produced during overtime because it is not included in original schedule. The data only provide the target output, the actual output and the statement of disturbance why the target cannot be achieved. The actual downtime or disturbance time were not provided.

Daily targeted unit is 23 cars. Paint Shop output is varies from the minimum 10 unit per/day and 26 unit per/day. According to the output status in January 2011, there were 8 days out of operation days the PS operated below 80% of the capacity. It is being pointed out that PS could not achieve 40% of their target planned. Figure 5 illustrated the gap between the planned and actual production output.

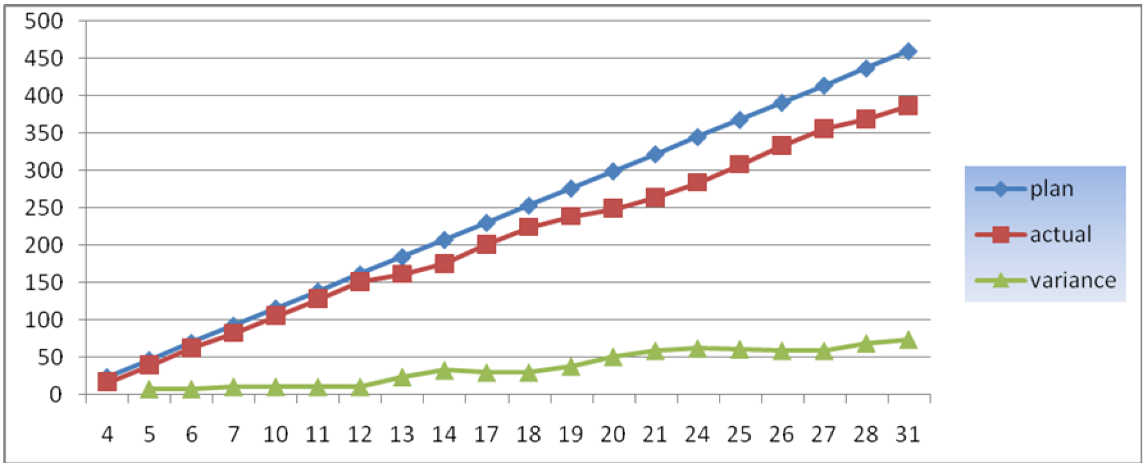

Figure 5 : The plan and actual output in PS during 20 days

To explain the gap between the planned and actual of production line, the disturbances can be classified into downtime, quality issues and technical problems. During the interview session, quality issue is seen as the most important factor in order to increase overall of a system. The disturbance can cause blocking, which means that when certain model of the car face high rate of rejection, the rework process will take longer time in production line.

DATE (20 days)	TARGET	P/S OUTPUT	VARIANCE	EFF CAP (Output/Eff Cap x 100%)
4/1/2011	23	16	-7	69%
5/1/2011	23	23	0	100%
6/1/2011	23	23	0	100%
7/1/2011	23	20	-3	87%
10/1/2011	23	23	0	100%
11/1/2011	23	23	0	100%
12/1/2011	23	23	0	100%
13/1/2011	23	10	-13	43%
14/1/2011	23	14	-9	61%
17/1/2011	23	26	3	113%
18/1/2011	23	23	0	100%
19/1/2011	23	15	-8	65%
20/1/2011	23	10	-13	43%
21/1/2011	23	15	-8	65%
24/1/2011	23	20	-3	87%
25/1/2011	23	24	1	104%
26/1/2011	23	25	2	109%
27/1/2011	23	23	0	100%
28/1/2011	23	13	-10	56%
31/1/2011	23	18	-5	78%
TOTAL	460	387	-73	Average 84%

Figure 6 : The target, actual output and the daily effective capacity of production in Paint Shop, January 2011

5. A METHOD FOR IMPROVEMENT OF MANUFACTURING SYSTEM

There is a need for new ideas in the area of disturbance reduction to increase efficiency and one of radiant idea is the combination of DES in the system. The normal method for improvement in manufacturing system is presented in figure 7. The first step is a identifying the constraints or disturbance in the system. From the data observed, the disturbance or constraint may be further studied. A positive aspect, with the involvement from personnel the improvement action could be taken. This method requisite the improvement or the corrective action implied in the real system.

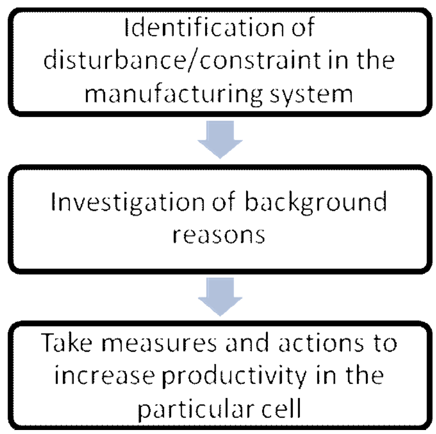

Figure 7 : The method to identify disturbance in manufacturing system

The next step in the method improvement is the DES model work. A model which design similar to the real process and the input data can be combined to visualise the real background of the problems. The DES model enables many alternatives test to be carried out to find one of the best solutions. The measurement and actions are then implemented to increase productivity and efficiency when the disturbance constraints discovered.

With the help of DES model, the problem in manufacturing system can be identified clearly. Time can be compressed and the visualisation feature is beneficial to decide where the actual Disturbances are in the system. The main advantage with this methodology is the possibility to test the changes in the DES model before it is applied in the real world (Arne, 2005). One strengths is that all tests can be made beforehand in the DES model before the actual implementation. When a specific type of disturbance is identified, it can be removed from the DES model and the new results from output can be observed. This is how improvement process can be repeated as showed in figure 8.

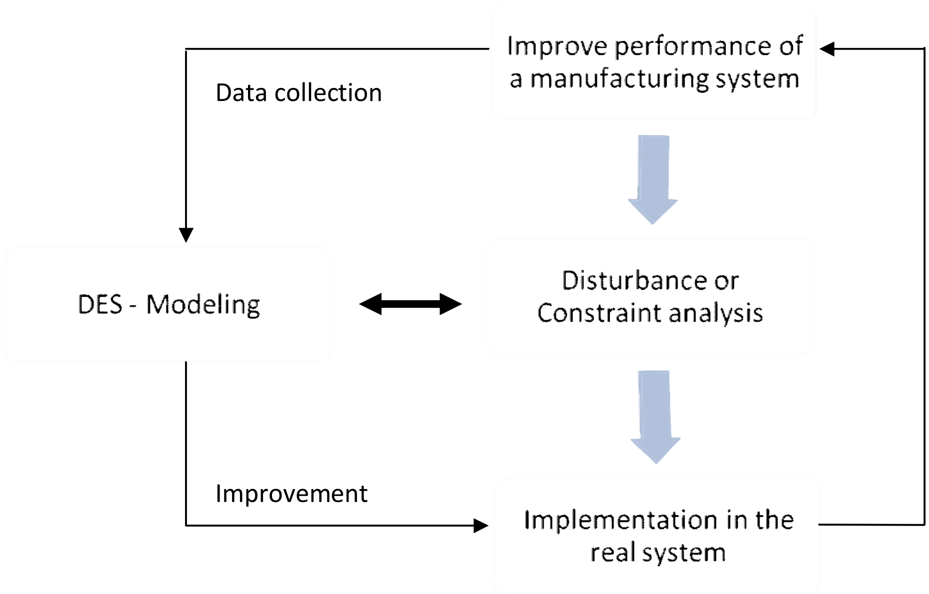

Figure 8 : The DES model can be applied in identifying disturbance in manufacturing system

6. CONCLUSION

Reducing processes associated with critical operations are the most effective way to manage an organisation to support its goals. By improving weakness processes, a business can improve its internal effectiveness and efficiencies. Documenting process can lead to insights the potential problems. But Simulation has proven to be a useful and powerful tool for modelling operations in manufacturing.

The purpose of this paper is to insights that process improvement can be effectively accomplished with an integrated approach of using proposed computer-based tool. Understanding the process in the system, data analysis, modelling and simulation in computer can be successfully reduce the risk of ineffectiveness of the process.

REFERENCES

Aldowaisan, T.A and Gaafar, L.K (1999), "Business process reengineering: an approach for process mapping", *Omega*, Vol. 27 No. 5, pp. 515-24.

Arne Ingemansson, Torbjorn Ylipaa and Gunnar S. Bolmsjo (2005), "Reducing bottle-necks in manufacturing system with automatic data collection and discrete-event simulation", *Journal of Manufacturing Technology Management*, Vol. 16 No.6, pp.615-28.

Arne Ingemansson and Gumar S.Bolmsjo (2003), "Improved efficiency with production disturbance in manufacturing system based on DES", *Journal of Manufacturing Technology Management* Vol. 15 Number 3 – 2004, pp.267-279.

C.Carl Pegels and Craig Watrous (2004), "Application of the theory of constraints to a bottleneck in a manufacturing plant", *Journal of Manufacturing Technology Management*, Vol.16 No.3, pp.302-311.

F. Hosseinpour and H. Hajihosseini, "Importance of simulation in manufacturing", *World Academy of Science and Technology 51*, 2009.

Martha A. Centeno and Manuel Carrillo (2001), "Challenges of introducing simulation as a decision making tool", *Proceedings of the 2001 Winter Simulation Conference*.

Kleijnen, J.P.C (1998), "Experimental design for sensitivity analysis, optimization and validation of simulation models",in Banks, J(Ed), Handbook of simulation; Principle, Methodology, Advances, Application and Practice, *Engineering & Management Press*, Norcross, GA, pp.173-233.

Kuivanen, R. (1996), " Disturbance control in flexible manufacturing", *The International Journal of Human Factors in Manufacturing.* Vol. 6 No. 1, pp. 41-56.

Reginald Thomas Yu-Lee (20020, *Essentials of Capacity Management*, John Wiley & Sons, Inc., New York, NY.