TPC COMPONENTS AB
INCREASING EFFICIENCY BY USING SIMULATION

KPP319 INDUSTRIAL EXCELLENCE

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Abstract

This paper guides the reader through the subject of simulation. Simulation models are useful to visualize a wanted or future state of a process and they can also visualize what would happen if you changed some parameters in a current process. This is an effective way to see what would be beneficial for the company to implement or not. In this paper; a cutting department at TPC Components AB is simulated and the simulations are evaluated.
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INTRODUCTION

In the course Industrial Excellence, a cutting process at the company TPC Components AB is simulated. It is done on collaboration between Mälardalen University and Robotdalen.

BACKGROUND AND DESCRIPTION OF SIMULATION CASE

As a foundation for this project a pre-study from a previous course was used. The pre-study was performed at TPC Components, which is a medium size company that produces steel components in the energy, automotive and process field. TPC Components is a leading company within casting foundry in Europe. They offer installation-ready components globally to many attractive sectors which are based on the components they make and their applications [Anderstig et. al., 2010].

In this project we will use simulation modelling to manipulate the interaction of the cutting process. Since TPC Components produce many different products and many of them are processed in the cutting department, a generalization had to be made. By choosing only one product it was possible to make dependable measurements for the time study. The current process and the future/desired process will both be simulated in this course. ExtendSim is used to simulate the current state and 3D Create is used to simulate both the current and the future state. The results are compared to evaluate how the suggestions can improve the productivity and the simulation models are analysed to investigate the reliability and to determine possible improvements of the models.

OBJECTIVES AND GOALS

Simulation results can provide a decision support for choosing the best alternative of improvement, in this project ExtendSim and 3D Create is used for modelling the cutting process. Our goal is to automate the cutting department at TPC Components. Today the cutting area has two cutting machines that are run by manual workforce. Benefits gained by automate the department are shorter cycle times and decreased manual labour. It would also increase safety and improve the working conditions for the employees.

The goal for the students in this project group is to gain more knowledge in both simulation programmes; ExtendSim and 3D Create.

PROJECT PLAN

In project planning, according to the course plan, the standard steps in simulating a model with the goal of solving the problem are following the standard. These steps contain [Dahlquist, 2006]:

5
1. Identify the problem
2. Interaction with outside world
3. Physical or statistical, data driven model
4. Continuous, discrete or combined
5. Simulation environment selection
6. Verification of models
7. Initialization
8. Use of the simulator

The project plan for this group is presented in the Gantt-chart below, figure 1. The Gantt-chart is based on the three different project reviews where the group is supposed to present parts of the result to the class, and of course to be able to present this; these parts needs to be finished in time. To easily follow the Gantt-chart and see how we are doing, the weeks are colored in green or blue, depending on whether the activity is finished or just planned to be executed. The expected result which is also an important part of the project plan is presented in the next section.

![Gantt-chart](image)

**Figure 1: Gantt-chart**

The expected outcome of the project is to present a feasible automated concept of the cutting area through simulation modelling. This desired state should also rationalize the process, decrease the lead time, increase productivity and improve safety and ergonomics. The students in the project group also want to increase their knowledge about ExtendSim and 3D Create.
THEORETICAL BACKGROUND

SIMULATION AS A TOOL WITHIN PRODUCTION AND LOGISTICS MANAGEMENT

Simulation is used to test or experiment with a developed model based on features from reality or estimations made based on the reality. The main objective of simulation is manipulating the interaction of product and production flow and acquiring the ability of choosing correctly.

DISCRETE EVENT SIMULATION

In modeling a dynamic manufacturing process, discrete event simulation is used based on operational or strategic applications. In discrete event simulation, the operation of the system is illustrated as the sequence of events in countable number of points in specific duration of time. The major purpose of discrete modeling is detailed analysis of linear processes. In discrete modeling, the focus is on detailed features related to discrete event dynamic.

3D MODELING

3D Modeling is simulating a defined object on mathematical logic, in a three dimensional world. In 3D modeling; objects in a 3D world are used by connecting triangles, curves, etc. to visualize the model. The 3D models are categorized in solid models and shell-boundary. Solid models defined the volume of the object and shell-boundary models defined the structure of a model.

PROCESS DESCRIPTION

Cutting operations are done by two machines; Grenkap and Stamkap. One is used to remove the big semi-conical part from the casting; the other is used to cut the useful component down. Operators are managing the cutting machines and the input and output of the material.

The product analyzed in this project is a steel part contained in a Scania truck motor. The incoming material to the cutting department is a component tree where 96 products are grouped on a frame, as shown in picture 1. In the cutting department the products will be separated to single components.

Picture 1: Product tree
**Problem and Reason for Simulation**

Observations in the cutting department have showed that there are some bottlenecks in the process;

- No continuous flow between the cutting machines
- Unplanned breaks, because of manual work
- Most of the time one machine is idle
- Low utilization

**Data Collection**

The data used in this project is taken from a previous conducted pre-study, which means that no further data has been collected. Where the data were not sufficient; estimations were made.

**Inputs, Outputs and Delimitations of the Model**

Every process has an outside environment that has to be considered, when creating a simulation delimitations have to be made to define the boundary of the model. In *figure 1* all the process steps in TPC Components can be seen.

*Figure 2: Process description, TPC Components AB.*
The chosen area to analyse is the cutting department, marked by orange in the process description above. *Figure 2* shows the current layout and process flow in the cutting department.

Production equipment used in the cutting area is; cutting machines, forklift and lift crane.

The incoming material; the product tree, is stored at pallets. In *picture 1* a product tree can be seen. Forklifts transport the pallets with products between the departments and also from the storage in the cutting department to the work station. A lift crane is used to move the products into the cutting machine. A small storage is created between the two cutting machines, which results in an average waiting time of 3.5 hours for the products, before further processing. The finished parts are collected in a box that is placed on a conveyor before a forklift transports it to the next department.
**Production information:**

There is a centrally connected computer in the middle of the station where the workers can check the demand and the schedule of their respective work. According to the demand, they come to know the relevant information about the number and type of products to be cut in the cutting machine. Operators use visual control on the products before they go into the cutting process, to know in which machine they should be entered.

**Production volume:**

TPC Components has a wide variation of the batch sizes for different products. Some customers order only a low volume of a component per year, while others are high volume customers that order continuously. In average 400 trees per week, of the specific product observed, are being processed in the cutting department.

**Cycle Time:**

<table>
<thead>
<tr>
<th>Process Name</th>
<th>Set up time (min)</th>
<th>Pieces/Hour (Actual average)</th>
<th>Capacity Pieces/Hour (Theoretical)</th>
<th>Utilization (min)</th>
<th>Cycle times/Tree (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting, Stamkap</td>
<td>5</td>
<td>1019</td>
<td>1277</td>
<td>79.8%</td>
<td>2.02</td>
</tr>
<tr>
<td>Conveyor</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>210.00</td>
</tr>
<tr>
<td>Cutting, Grenkap</td>
<td>10</td>
<td>1059</td>
<td>1545</td>
<td>68.5%</td>
<td>1.67</td>
</tr>
<tr>
<td>Total cycle time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>213.69</td>
</tr>
</tbody>
</table>

The parts that have been cut in the first machine, waiting to be cut in the second one, are placed on a conveyer between the machines. The average waiting time is 3.5 h.

**Simulation Model**

To clarify the process and the problem statement a couple of simulations in ExtendSim and 3D Create will be presented. These models will help to argument for or against an implementation of an automation system.

**Simulation Model Construction**

The pre-study presented two improved suggestions for the cutting department layout. For this simulation the layout most likely to be implemented was chosen. After choosing the layout the data required to simulate this process was extracted from the pre-study and anything that could not be found in the pre-study has been estimated. This way a simulation has been produced.
LOGICAL MODEL DESCRIPTION

The initial problems observed were the long waiting time between the two cutting machines and that the machines are operated manually and that the work plan is not efficient enough to get a high utilization. Therefore the current state of cutting area was simulated in ExtendSim with focus on the problem, in order to find the best solution to improve the cutting area.

In the logical model produced in ExtendSim (figure 4), the data previously collected was used as a foundation when building the simulation model.

The main areas in the logical model are two cutting machines and the unfinished product storage. The unfinished products are transported from the previous department (casting) to the cutting department, by a forklift. The products are placed in a temporary storage until the cutting machines are available. The products will be processed in two different cutting machines; Grenkap and Stamkap, and they are stored on a conveyor in between the machines while waiting for the next cutting. When the semi-finished products are processed in the cutting area, they will continue to the blasting department.

![Figure 4: Process description, ExtendSim](image)

In ExtendSim, related blocks from these libraries were used:

- Discrete event
- Item
- Mfg
- Plotter
- Utilities
At first, with considering the process description, the discrete event model was created using related blocks:

**Buffer Block from Mfg Library:** Simulates a first-in-first-out (FIFO) queue for buffering products needed by machines, conveyors, or batching operations. The maximum length, which determines how many products the buffer can hold, can be set in the dialog.

**Transport Block from Item Library:** Moves the product from one block to another.

**Stock Block from Mfg Library:** Provides and stores items such as raw materials, work in process, and so on. This block may be used in an open system such as when items are shipped, or in a closed system such as when exchanging parts in spares inventory.

**Activity Block from Item Library:** Defines process activities.

**Queue Block from Item Library:** Queues products and releases them based on a user selected queuing algorithm.

**Plotter Block from Plotter Library:** Defines the results on plot.

**Unbatch from Item Library:** Produces multiple products from a single input product, “unbatching” them. The number of products produced at each output is specified in the dialog. This block holds its inputs until its outputs are used.

**Queue Stats from Discrete Event Library:** Place this block anywhere in the model and it will report the following statistics for all queue-type blocks in the model:

- Block number (or block label, if a label is entered in the block)
- Block Name
- Average Queue Length
- Maximum Queue Length
- Average Wait Time
- Maximum Wait Time
- Time of Observation

When modeling the cutting department in ExtendSim the times and logic behind it was considered.

In the cutting department the machines actual operation time is 35 hours per week (126 000 sec) for each machine. In average 400 trees per week are being processed in the cutting department. The parts that have been cut in the first machine, waiting to be cut in the second one, are placed on a conveyor between the machines. The average waiting time is 3.5 h. This information along with other data from the table of cycle times and set times are entered in the model and the verification of the model is made.
As the model is run for 35 hours, the result is:

**3D Model Description**

**Current State**
A simulation model for the current state was created. The way it works on TPC Components today is that there are two cutting machines managed by manual work. To get a finished product the product trees must go through both cutting machines. In between the machines there is a conveyor that works as storage more than a transport tool. The product trees are heavy and the ergonomic situation in the current state could be improved.
**Future State**

Improvement Option: Robot (pick and hold) and a fixed cutting blade

This solution requires a robot for holding and moving the trees, a fixed cutting machine and a visual system. The visual system is used to locate where and how the trees are placed on a pallet, so that the robot knows where to grip the tree. An operator is only needed when it is time to change the pallet, approximately once an hour. The figure below, *figure 6*, shows how the new plant layout could look like for this solution. The red figures are the changes that have been made.

![Figure 6: Plant Layout](image)

When the cutting is performed the robot moves the tree to a fixed cutting blade. The rows are cut one by one; two rows deep on one side, and then the rest from the opposite side. A conveyor will send the products to a box. The scrap will be dropped in a scrap box.

The robot that has been considered for this solution is an ABB robot: IRB 6620, *picture 3*, which can reach 2.2 m and handle up to 150 kg. The unique feature of this robot is its agility.

Since the best improvement alternative is using Robot (pick and hold) and a fixed cutting blade, this was the improved suggestion that was simulated in order to show the improvement results more vivid and visualized.

![Picture 3: The chosen robot, IRB 6620](image)
The simulation is focused around the robot and the robot's working area. The input is a pallet filled with the product trees; the unfinished products. The robot is moving the product tree to the cutting machine and releases the scrap in a scrap box. Conveyors are transporting the finished products to a buffer. *Picture 4* shows the future state layout.

### Validity and Relevance of the Model

The current simulation model is based on input and output data that are valid today. That makes it easy to compare the simulation with the reality, that way it is possible to confirm whether the model is valid.

The simulation results in ExtendSim were compared with the data in the pre-study, and it proved valid.

The future state model is loosely based on the input and output of today, which makes it hard to estimate exactly if the model is valid since there are so many changes from the current state.
SIMULATION

Pictures of the results of the simulation in 3D Create are presented in picture 4 and 5. The robot is picking the product trees from a pallet and moves them to the cutting machine, where the products are being cut of the frame. The finished products are being transported on a conveyor, to the finished product box. The robot drops the empty frame; the scrap, into the scrap box.

3D MODEL DESCRIPTION

To be able to create the simulation models in 3D Create, a number of components were needed. Most of them could be found in the program; robot, operators, conveyors, pallets, machines, boxes and feeders. The product tree and the finished part were created and imported from CAD.
ROBOT
The robot suggested in the pre-study was imported from ABB’s folder in 3D Creates library. The robot was placed on a machine tending robot manager, which simulates the computer program telling the robot what to do.

OPERATORS
Two operators were added into the current state simulation. To be able to communicate with the operators, machine tending managers were needed. Through the machine tending managers it is possible to communicate how the operators work; which machines to attend, pathways etc.

CONVEYORS
The conveyors used in both simulations are basic belt conveyors. Some of them are equipped with sensors to let the machine tending robot manager and the machine tending manager know when there are products to pick up.

PALLETS
The pallets used in these simulations are standard Euro-pallets. These can be imported from the component library in 3D Create.

MACHINES
Process machine work tables were imported in the current state simulation. The process point conveyors were used in both the current and future state simulations, but it is not an actual machine that can be manipulated. It represents the cutting machines.

BOXES
There are already existing boxes in 3D Creates’ library, which were imported in the simulations. The sizes for the boxes were changed to fit the Euro-pallets.

FEEDERS
Feeders were used to create input to the process and products created in CAD were imported and connected to these feeders, to be able to simulate the unique product.

Picture 6: Future layout, created in 3D Create.
RESULTS AND CONCLUSIONS

RESULTS FROM SIMULATION

The current situation simulation of the cutting department in ExtendSim and 3D Create has proved the bottlenecks in the process;

- No continuous flow between the cutting machines
- Unplanned breaks, because of manual work
- Most of the time one machine is idle
- Low utilization

The simulation of the current state confirms that there is a lot of idle time for the cutting machines in the cutting department. The simulation of the future state proves that the suggested improvement would create a continuous flow. One reason for the continuous flow is that the time for mounting the product tree will be reduced. Another reason is that the product trees only need to be processed in one cutting machine, this way the product only has the be mounted one time and the storage that used to be between the machines will be removed completely. Continuous flow also provides a higher capacity. The ergonomic situation would be improved because the operators would not have to lift the product trees.

If TPC Components AB would chose to implement the suggested future solution, there would be a high cost to implement the solution, but in the long run it would be profitable. Further calculations can be found in the pre-study, which this project is based upon [Anderstig et. al., 2010].

THE USE OF SIMULATION TOOLS

Simulation in this project has helped us clarify the problem within the cutting department. The lack of continuous flow, storage between the two cutting machines and the idle time of the machines is obvious in the simulation.

Also, using simulation tools have helped us to increase our knowledge about simulation and the specific programs we have used; ExtendSim and 3D Create. Our understanding of the importance for simulation as a tool for improving the efficiency in production systems has increased. We find simulation useful when it comes to evaluation and visualization of production systems.
REFERENCES
