A SIMULATION STUDY OF LOGISTICS AND MANUFACTURING ACTIVITIES IN AN AUTOMOBILE SUPPLY CHAIN

Maziar Gholamian Moghadam\textsuperscript{a}  
Behrooz Karimi\textsuperscript{b}  
Mohamad Darayi\textsuperscript{c}

\textsuperscript{a}Amirkabir University of Technology, Tehran, Iran, +989121712485, maziar.moghadam@yahoo.com  
\textsuperscript{b}Amirkabir University of Technology, Tehran, Iran, +982166413034, B.Karimi@aut.ac.ir  
\textsuperscript{c}Tarbiat Modares University, Tehran, Iran, +989131047152, mohamad.darayi84@gmail.com

Abstract
This article studies an application of discrete-event simulation (DES) combined with multi-criteria decision analysis (MCDA) to study manufacturing procedure integrated with logistics activities in an automotive supply chain. Automotive Industries Development Pressed Components Company (AIDCO PRESS) as an important supplier is linked to IRANKHODRO CO, a distinguished automobile company at Iran, by a web based inventory management system implementing Kanban philosophy. AIDCO PRESS’s inefficiencies in responsiveness to the received Kanbans from IRANKHODRO CO endanger the automotive supply chain’s agility, and also threaten its future role as a reliable supplier. DES modeling approach is used to analyze such a complex system in order to determine the causes of lateness in receiving the requested parts by IRANKHODRO CO. Consulting with the executive and plant managers, improvement scenarios are defined in order to obviate the inefficiencies’ origins, and then MCDA methodology considering responsiveness, cost and utility criterions is pursued to find the best scenario. Collectivity of the studied problem together with the reality nature of the case distinguishes this paper from the decision analysis studies in the automotive supply chain literature.

Keywords
Automobile supply chain, Discrete-event simulation, Multi-criteria decision analysis, IRANKHODRO CO, AIDCO PRESS

1. INTRODUCTION

In the automobile industry, the competitiveness of manufacturers depends on the responsiveness of their supply chains. Inefficiencies such as long cycle times, shortages and logistical deficiencies across chains threatened the competitiveness of the whole automobile supply chain. Implementing lean philosophy is pursued by the managers of some automobile supply chains in order to improve and sustain the stability of their systems in the changing business world (Ambe and Badenhorst-Weiss, 2010). Kanban cards are popular inventory management tools in lean supply chains which help manufacturers to control their suppliers. Studying and analyzing suppliers’ inefficiencies in response to the manufacturers is a complex problem, since production related activities and logistical procurements must be considered concurrently. Simulation modeling as a what-if analysis tool can handle the complexities and randomness in such a problem (Gunal, 1998; Terzi and Cavalieri, 2004).

IRANKHODRO CO as a manufacturer in an automobile supply chain controls suppliers by a web based inventory management system using Kanban cards. AIDCO PRESS as a supplier of press products has unacceptable tardiness in response to the manufacturer’s released Kanbans. In this study, modeling
operational procedure in AIDCO PRESS together with the logistical activities relating to the sending and receiving of the demanded parts, using DES techniques, sources of tardiness are investigated and then considering found origins, improving alternatives are proposed. Finally, MCDA methodology is used to rank the alternatives considering responsiveness, cost and utility criterions.

2. LITERATURE REVIEW

Logistics, production planning and inventory management problems in the automobile industry has been studied by several researchers but supply chain context opens a new window which makes it possible to have a thorough view toward automobile industry investigations. This new holistic view helps automobile manufacturers to pursue management strategies in relation to their suppliers in order to be flexible and responsive to market demand (Ambe and Badenhorst-Weiss, 2010). The complexity, enormity and broadness of scope in such manufacturing logistics problems weaken the analytical modeling approach usefulness and satisfy the exploit of simulation modeling methodology (Terzi and Cavalieri, 2004).

Simulation as a what-if analysis tool has been widely used to investigate the supply chain management problem consisting of operational, tactical and/or strategic decision level studies (Terzi and Cavalieri, 2004). Particularly, in the automotive industry, Ali Gunal (1998) has classified the simulation studies based on the stage of the development of the design of the system or the nature of the problem to be investigated. Based on the nature of the problem to be investigated, the relating works is studied to shed a light on the background of the proposed study.

In the operational/tactical decision level problems, Lee and Farahmand, 2010 used simulation modeling to study implementation of (r, R) inventory replenishment management system integrated with transportation strategies in the context of logistic network management. Brito et al., 2010 developed a decision support system using discrete event simulation integrated with multi-criteria decision analysis tool to study the strategic decisions about the planning and sizing of the logistics and production elements of a steel plant. Sharda and Bury, 2010 studied the bottleneck analysis of a chemical plant using discrete event simulation modeling approach. Gunal, 1988 presented a new approach in simulating complex manufacturing systems which is based on developing several general purpose simulation generators for an assembly station, a manufacturing cell and an inventory transfer function that can be linked together to create a complex manufacturing system. The problem which we are faced with in this study is to model AIDCO PRESS’s operational procedures considering in the context of a whole automotive supply chains called IRANKHODRO. Modeling both the operational/tactical decisions together with the improving strategic options in the form of proposed scenarios and the applying nature of the research distinguished this study from the previous works.

3. PROPOSED METHODOLOGY

In this study, investigating the current situation of the AIDCO PRESS, alternatives for improving its agility in response to the received Kanbans from IRANKHODRO is pursued. The proposed methodology plans in three main steps (Figure 2):

I. System studying and problem definition
II. Developing a simulation model
III. System improvement

In the first step, local production procedures in AIDCO PRESS, its relationships with other companies and what are important for this study is investigated in interviews with the executive managers and experts. In the second part, a simulation study of the current situation of AIDCO PRESS Company is pursued in order to investigate the possible causes of delayed Kanbans. Finally, proposed alternatives are discussed considering system performance measures using MCDA techniques. It is worth mentioning that the Analytic Hierarchy Process (AHP) technique is a popular approach used in determining the relative importance of a
set of attributes or criteria (Saaty, 1990). TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is a linear weighting technique which was developed by Hwang and Yoon (1981).

4. SYSTEM DESCRIPTION

As the improvement of AIDCO RESS agility in response to the received Kanbans from IRANKHODRO is the aim of this research so the first step is to become familiar with the system and its relations in the supply chains context. The company produces categorize into four groups consisting of cradle 206 (RAM 206), cradle 405 (RAM 405), fuel tank (FT), and general press products (GP). Also, it provides a company (ISACO, a famous automobile parts producer in Iran) with painting services. The raw metal materials in the form of coil and sheet arrive the company and after being uncoiled and/or cut are feed into the press shop and the following procedures according to the type of the products are done. The types of press processing depends on the production scheduling and the on hands plans. Final products are stocked in warehouse waiting the receiving Kanbans from IRANKHODRO. As for the FT products, they need to be out sourced for painting. The company’s vehicles consist of four lift trucks, seven trailers and two cranes. The studied automobile supply chain is shown in Figure 2.
5. SIMULATION MODELING

Simulation can be used to study processes that are too complex to permit analytical model formulation and/or evaluation. Complexity and stochastic nature of the problem satisfy the use of simulation modeling as a what-if analysis tool in this problem. The simulation modeling and analysis study of the AIDCO PRESS Company is pursued as following steps (Law, 2007):

a) Conceptualization: defining the system and its objectives, conceptual modeling, and data gathering;

b) Model development: developing computer model, Verification and Validation (V&V);

c) Analysis: setting simulation run’s parameters, sensitivity and results analysis.

After developing a conceptual model based on the described system visualized in Fig. 2, a simulation model has been built using famous Arena software.

5.1. VERIFICATION AND VALIDATION

The aim of verification is to assure that the conceptual model is reflected accurately in the simulation model. Validating is the overall process of comparing the model and its behavior to the real system. Comparing the computer model with the conceptual model, detailed operational view of Figure 1, and tracing the developed animation model with the consult of the experts, the developed simulation model is verified. We use one third of historical data of the company to answer the question about the validity of the simulation model (Law, 2007). The most important performance measures, which are the lead time of the received Kanbans for all the four types of products, are used to study the validation of the developed model (Table 1).
5.2. ANALYSIS

The model has been run for 270 working days with 10 days as a warm up period for 20 replications because of the consistency which model showed in these settings. Consulting with the executive managers at the company, production lines’ and vehicles’ utilization and four types of products’ lead time are considered as the performance measures to study the system. Current system is studied using simulated model (Table 2). Using the simulation model, the sources of the tardiness in response to received Kanbans are investigated in order to cover the inefficiencies with proposed improving scenarios.

Table 2: Simulation modeling results of the current system

<table>
<thead>
<tr>
<th>Product type</th>
<th>Avg. lead time (hours)</th>
<th>Avg. production lines’ utilization</th>
<th>Avg. vehicles’ utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>GP</td>
<td>26.26</td>
<td>0.63</td>
<td>0.71</td>
</tr>
<tr>
<td>Cradle 405</td>
<td>14.18</td>
<td>0.59</td>
<td>0.61</td>
</tr>
<tr>
<td>Cradle 206</td>
<td>29.87</td>
<td>0.63</td>
<td>0.49</td>
</tr>
<tr>
<td>FT</td>
<td>27.09</td>
<td>0.59</td>
<td>0.61</td>
</tr>
<tr>
<td>RAM 206</td>
<td>0.63</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>RAM 405</td>
<td>0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FT</td>
<td>0.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General trucks</td>
<td>0.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Press shop lift trucks</td>
<td>0.49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Sources of long lead times

<table>
<thead>
<tr>
<th>Product type</th>
<th>Long lead time source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg. inventory shortages (hour)</td>
</tr>
<tr>
<td>FT</td>
<td>19.98</td>
</tr>
<tr>
<td>Cradle 206</td>
<td>24.45</td>
</tr>
<tr>
<td>Cradle 405</td>
<td>9.22</td>
</tr>
<tr>
<td>GP</td>
<td>19.89</td>
</tr>
</tbody>
</table>

6. SYSTEM IMPROVEMENT

6.1. SCENARIO DEFINITION

Considering the sources of delay, nine scenarios are proposed with the mixed up these options: different allocation of the lift trucks in plant, buying up to two new lift trucks, buying guard pallets to prevent quality related rejections, implementing maintenance strategies and constructing a painting shop not to outsource the fuel tank painting.
6.2 RANKING SCENARIOS

Consulting with the experts the chosen criteria consisting of cost, lead time, production machine utilization and vehicle utilization and its sub-criterions are weighted through group AHP methodology using Expert choice software. Due to the number of criteria and choices, TOPSIS method is choose to rank the proposed scenarios. The best choice is the one which suggests the managers to implement maintenance strategies together with the allocation of two lift trucks of general purposes to press shop at the time between 6pm to 8am.

Table 4: Simulation modeling results of best proposed scenario

<table>
<thead>
<tr>
<th></th>
<th>Avg. lead time (hours)</th>
<th>Avg. production lines’ utilization</th>
<th>Avg. vehicles’ utilization</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GP</td>
<td>Cradle 405</td>
<td>Cradle 206</td>
<td>Fuel tank</td>
</tr>
<tr>
<td>Results</td>
<td>6.35</td>
<td>5.83</td>
<td>8.37</td>
<td>6.59</td>
</tr>
</tbody>
</table>

7. CONCLUSIONS

The aim of this study is to improve the AIDCO PRESS inefficiencies in response to the received Kanbans from IRANKHODRO which may threatened his role as an important supplier and the whole automobile supply chain competitiveness and responsiveness. The simulation modeling and the proposed analyzing methodology help us to study the case close to real world situation and experiment the proposed improving alternatives without any disruptions for the company. Adding the inventory control policies together with the production planning improving strategies could be a new avenue toward the studied problem.

REFERENCES


