

# **Analysis of WIP Inventory Control and Simulation of KANBAN System within Wiring Harness Company**

**Ilham Kissani and Wafa Bouya  
School of Science and Engineering  
Al Akhawayn University  
Ifrane, 53000, Morocco**

## **Abstract**

This project suggests an approximate implementation and simulation of KANBAN system within wiring harness company. The latter adopts Just-in-Time philosophy but without respecting it fully by resorting to push system in controlling its Work In Process (WIP) inventory. That is why, an analysis of the existing system has been conducted in order to shed light on the flaws and deficiencies existing at the level of managing the WIP stock. After detecting the alarming situation of inventory control especially in the pre-assembly area, an initial implementation and simulation of KANBAN system has been suggested using ProModel even if many constraints have been encountered at the level of data and software used.

## **Keywords**

KANBAN system, Just-in-Time philosophy, Work In Process inventory, ProModel.

## **Introduction**

Engineers and researchers rely on simulation tools to test the configurations and ideas for a new system design or also for system improvement, before making the decision of committing the time and the resources required for the implementation.

In this paper we intend to show how ProModel, a simulation tool well-known in process analysis, could be used to support a comparative study that reveals the effect of transforming a push system to a pull system which is Kanban.

The proposed model is used to explore the implementation of a lean practice, Kanban, in an effort to minimize the WIP storage excess from the process thereby reducing inventory level while ensuring the on-time delivery of products to the customer. The model will be used to simulate one-week's production based on the actual order file that the customer will send to its manufacturer.

The advantage of a simulation environment is that the decision maker can determine, whether reducing the WIP inventory at a particular workstation will have the desired positive effect on the end result before the team actually puts forth the time and effort in the real process.

The paper provided a list of constraints and costs associated with an array of possible lean improvements that can be tested using the simulation model.

After the simulation run we anticipate to compare the displayed outcomes showing the performance metrics in terms of time utilization and productivity for both systems.

## **1. Literature Review**

### **1.1. Pull/Push Systems & Just-in-Time**

Managing inventory efficiently in the supply chain has become a necessity especially with the spread of global sourcing. That is why, inventory managers are supposed to be able to develop an effective control system managing

the customer demand. Inventory control systems are classified as push or pull methods. In a push system, inventory forecasting is heavily used in order to meet the customer demand. Waters (2003) assures that in this traditional process each operation has a timetable of work that must be completed in a given time. Finished items are then pushed through to form a stock of work in progress in front of the next operation. In a line with this definition, Podolsky and Cheng (1996) highlighted the advantages of push systems. The latter provide visibility within the firm permitting the comparison of actual to planned production in addition to allowing for the development of cohesive, well-integrated production plans. However, inventory is expensive to maintain in push processes and this kind of systems lack the level of responsiveness required to maintain a smooth production run.

In pull systems, plants manufacture only enough products to meet customers' orders. Once one operation finishes work on a unit, it passes a message back to the preceding operation to say that it needs another unit to work on as pointed out by Waters (2003). This kind of process does not have earlier operations pushing work through, but has later operation pulling it through. Podolsky and Cheng (1996) investigated the pull systems advantages which are mainly about linking different production operations, keeping a low and stable level of inventory as well as adding value to units which are entailed to fulfill demand. Nevertheless, pull systems do not allow for full use of people and equipment at all times and inventory cost may not spread among all operations.

The approach of pull system to pull work through the process is used by Just-in-Time (JIT) which enables plants to identify the source of variability and minimize it in order to reduce inventory levels as assured by Myerson (2012). For this reason, several organizations switched to JIT system which allows them to create a sustainable competitive advantage. JIT concept has first appeared in Toyota manufacturing plants as a way of satisfying customer demands with higher quality and fewer delays. Indeed, JIT can be seen as an ideal manner of producing the right parts, at the right time, at a competitive price. Moreover, this method involves a set of elements such as using a pull method of coordinating the production process, decreasing the setup time and lot size in addition to many other elements.

JIT is also referred to as "zero inventory" and "stockless production" since this management philosophy aims to continuous improvement eliminating waste and uncertainty. Tersine (1994) points out that JIT endeavors to get rid of all costs (waste) with no added value to the product. Waste could take the form of any resource which exceeds the absolute minimum. Inventory is viewed by JIT as a major waste and an approach of concealing inefficiencies and even a symptom of inadequate management as argued by Fogarty, Blackstone and Hoffmann (1991). In addition to inventory waste, Myerson (2012) states seven other wastes which are considered as non-value-added activities which are basically transportation or movement, motion, waiting, overproduction, overprocessing, defect or error and behavioral wastes.

According to Podolsky and Cheng (1996), this philosophy of waste reduction which is associated with lean supply chain has three universal goals. The first objective is to provide the firm with a long term competitive edge by elaborating an optimal process for products manufacturing. Secondly, JIT aims to raise the efficiency degree within the process of production. In fact, efficiency is associated with increasing productivity while reducing the involved costs of production. As for the last goal, it is linked to the minimization of wasted materials, effort and time in the production stages. However, Graves, Kan and Zipkin (1993) claim that the major objective of JIT is substantial reductions in inventory and any other goal is just a result or implication of this reduction. In other words, all aspects of production systems are affected and need to change in order to enable such a minimization of inventory and end up with a successful management of JIT program. This stock minimization has several benefits such as the reduction of inventory carrying charges as well as warehouse and floor space. Also, material handling and inventory control costs are minimized without relinquishing the effect of inventory reduction on the decrease in lead times and quicker reactions to changes in demand as asserted by Graves, Kan and Zipkin (1993). Furthermore, by minimizing the levels of inventory, bottlenecks become more visible and thus queues are meant to be more traceable.

All these benefits and objectives elucidate that JIT implementation is perceived as a turning point in the production process without denying the shortcomings involved with it even if most published reports on JIT implementation are favorable. Podolsky and Cheng (1996) assure that a main limitation resides in the fact that the traditional approach to manufacturing entails the use of abundant inventory with safety stock. This latter could cause problems to the company especially that this stock becomes the only refuge for the firm to absorb any possible increase in the demand. Another shortcoming of JIT can be seen in the fact of resistance to change since JIT brings a new spirit to the organization and affects every member of it.

## 1.2. Mechanisms of JIT Implementation

The implementation of JIT is performed using a set of techniques. The technique which has been largely used by several manufacturing companies worldwide is KANBAN. The latter is a pull type reorder system where Kanban cards are used to authorize production or transportation of a given material as pointed out by Graves, Kan and Zipkin (1993). In a Kanban system, the final assembly schedule is the one which determines what to produce or supply. Waters (2003) shed light on the chief principles to use Kanban. At first, a message is passed backwards, asking preceding operations to send materials which are moved only in standard containers holding specific amounts. Only one container-full is produced or moved at a time and the size of this container should not be less than 10 percent of daily needs. Additionally, containers can only be moved if the container has a Kanban card attached. The Kanban cards fall under the category of P-Kanbans (Production) or T-Kanbans (Transportation or Withdrawal). Graves, Kan and Zipkin (1993) assure that P-Kanban gives permission to produce a fixed amount of a product while T-Kanban authorizes the product transportation. According to Waters (2003), a T-Kanban is put on an empty container once an operation needs more materials. Then, a full container is found which has a P-Kanban attached. This P-Kanban is removed and put on a post which provides the preceding operation with a signal to make enough to replace the container of materials. Afterwards, a T-Kanban is put on the full container, authorizing to take it back to the operation.

This methodology led Gross and Mcinnis (2003) to extract the benefits resulted in adopting Kanban system in the production process. Kanban basically enables the inventory reduction and flow improvement in addition to overproduction prevention. Besides, the control becomes placed at the operational level since operators are involved at every stage of production. Also, the responsiveness to changes in demand is enhanced and the risk of inventory obsolescence is reduced.

Gaury, Kleijnen and Pierreval (2001) claimed that Kanban policy basically relies on the principle of limiting the inventory level at every process stage. This is enabled via identifying control loops between each pair of consecutive stages. A classification of Kanban models was suggested using the criteria of operational design like the withdrawal strategy and blocking mechanism.

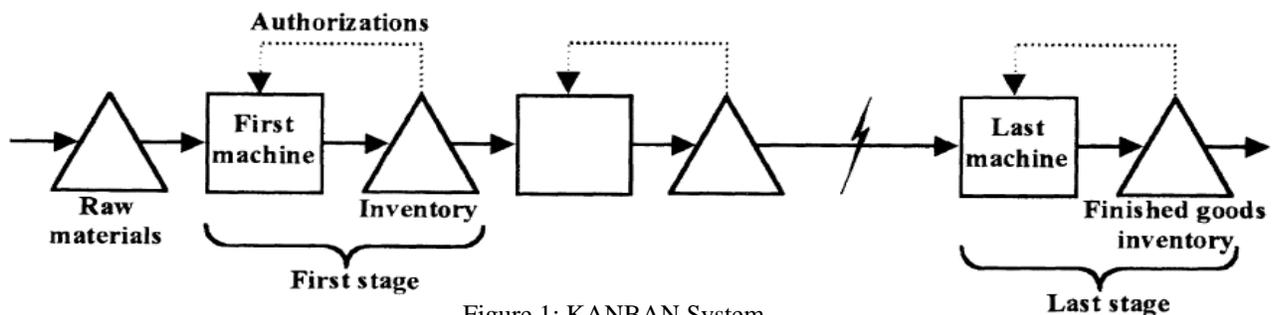


Figure 1: KANBAN System

## 2. Problem Setting

### 2.1. Order Reception

Every week, a firm order of the customer is received by via email as an Excel sheet containing the references to be produced in addition to their quantity and priority. The customer order is also received via the Production and Logistics System (PLS) and the Enterprise Resource Planning XPPS. As a first step, this order is sent to the logistics and information technology departments which take charge of disseminating it to the other departments and services concerned.

The logistics agents are the first ones receiving the customer order and then they collaborate with the information technology agents in order to generate programs of dynamic welding, test clip, electrical test and optical test. This is performed after comparing the order received via Excel to the one sent via XPPS. Additionally, the logistics agents supervise and coordinate with the logistics services: FST and JIT to manage the work in process inventory as well as to monitor the customer order with respect to the references priorities.

## 2.2. Production Stages

After the order dissemination, the FST agents send orders for fabrication to the pre-assembling area. The latter asks for the raw material needed from the warehousing which takes charge of delivering this material (e.g. wire coils & connectors). Then, this material goes through many production steps which can be classified as preassembly and assembly in addition to inspection.

- **Preassembly:** This stage is considered as the starting point of production which enables the manufacturing of semi-finished products and comprises four main steps which are: cutting, crimping, welding and twisting.

- *Cutting:* It is the first step in the process of manufacturing a wiring harness. It consists of cutting the raw material (i.e. wire coils) according to the instructions provided by the FST agents. The machines used in the cutting process by the firm are KOMAX which allow mainly for stripping and automatic crimping.

- *Stripping:* This is the process of removing the insulating material at the end of the wire in order to clear the conductive filaments.
- *Automatic Crimping:* This process allows the junction of a contact to one or more conductive wires.

The setup time for the cutting machines is 30 minutes. Processing time is variable and normally distributed with a mean of 15 minutes and a standard deviation of 5 minutes. Currently the factory has 60 cutting machines which can process around 6000 units per day. When the cutting process is completed, the cut wire is put in a pallet placed in front of the cutting machines. Once the pallet reaches its capacity which is 300 units, it is moved to the storage of WIP inventory.

- *Crimping:* In some cases, it is impossible to crimp the end of a conductive wire automatically. Hence, it becomes necessary to perform this operation manually. The plant currently possesses 40 crimping machines. Processing time varies with a standard deviation of 3 minutes and has tended to be normally distributed around the mean time of 10 minutes. As units complete the crimping process, they are moved into the storage of semi-finished products.

- *Welding:* This process permits to supply the electric current to the wire. Two types of machines are used in order to weld wires which are basically:

- *Ultra Sonic:* Used to join several wires by vibration.
- *Bonder:* Used to weld the extremities of many wires to a contact.

The company currently owns 55 welding machines. Process time for these machines averages 12 minutes with a standard deviation of 3 minutes and tends to be approximately normally distributed. Units exit the welding process and proceed to the storage of WIP inventory.

- *Twisting:* It consists of bonding two wires in order to protect them from the magnetic field. The firm possesses 35 twisting machines. Process time varies with a standard deviation of 4 minutes and tends to be normally distributed around the mean time of 15 minutes.

- **Assembly:** This is the final step of assembling the components all together to obtain the final wiring harness. The assembly lines are generally characterized by the use of a chain of tables mechanized at the same time depending on the number of circuits contained in the cable in addition to its complexity. The plant possesses 30 machines. Process time for these chains is specified by the engineering staff which averages 20 minutes with a standard deviation of 5 minutes and tends to be normally distributed. At this stage, wiring harnesses go through four main steps: plug-in module, mounting, piping and test clip.

- *Plug-in Module:* This step permits to insert the car options enabled by the wiring harness as requested by the customer.

- *Mounting:* It consists of inserting the wires contacts to the corresponding connectors manually.

- *Piping:* It is the process which allows which allows wrapping the wires once inserted with ribbons and tubes.

- *Test Clip*: This process is performed using a clip checker which is device permitting to check that each clip is in the dedicated slot. The clip checker is generally used for the wiring harnesses with a big number of wires and large dimensions.

### 2.3. Inspection and Quality Control

This stage enables the company to ensure the relevance of the wiring harness characteristics to the customer requirements. It encompasses three main steps: visual control, electrical test and optical test. Inspection time has been approximately normally distributed around a 10 minutes per mean with a standard deviation equal to 2 minutes.

- **Visual Control**: This inspection allows verifying the branches length and the presence of the wrapping material and accessories in addition to the respect of the final architecture required.
- **Electrical Test**: This test consists of checking the electrical connectivity of the wiring harness. It also permits to test the presence of connectors through integrated sensors.
- **Optical Test**: This test aims to check that the fuse box is properly assembled. This process is performed using a simulation software system.
- **Packaging**: The finished products are put in packages at the package workstations. The latter are placed next to the optical test workstations to create a sort of synchronization between these operations. Processing times tend to average 8 minutes with a standard deviation of 2 minutes. Packaging times are normally distributed. From packaging, unites are grouped into their original batch size and moved to finished goods inventory.

### 2.4. Finished Goods Inventory

Once the batches reach finished goods inventory, they are bar coded, processed and placed on pallets to be stored or moved directly to shipping. This process has averaged about 30 minutes per unit with a standard deviation equal to 10 minutes. The exportation of finished goods takes place twice a week.

### 2.5. Work Schedule

The company operates 24 hours a day, five days a week for the administrative staff and six days a week for the operators and storekeepers. High quality maintenance is synchronized with all the production stages in order to avoid any machine downtime. That is why, the production process runs smoothly in most cases even on the days of exportation. The latter takes place twice a week.

### 2.6. Storage of Semi-finished Products (P0)

#### 2.6.1. Definition

The storage P0 in the firm is responsible for the reception, handling and storing of semi-finished products as well as satisfying the needs of the different preassembly and assembly workstations for this kind of products.

The “in” gate of the storage of WIP inventory P0 receives the semi-finished products manufactured in a specific area (cutting, crimping, welding & twisting); whereas the ”out” gate permits the exit of the material needed by one of the preassembly or assembly (i.e. plug-in module) areas.

#### 2.6.2. Storage P0 Purposes

The construction of a storage dedicated to the semi-finished products was due to the following reasons:

- Most semi-finished products are basic ones which make them needed in all production areas and hence produced with huge quantities. However, the space constraints do not make it possible to keep them next to the upstream workstations before being requested by the downstream ones.
- The customer has the right to change the order whenever desired by cancelling some references and ordering new ones. For this reason, the preassembly area produces large quantities of the basic references in order to handle such cases but this safety stock needs to be stored somewhere before being needed.

#### 2.6.3. Management of WIP Inventory

Work In Process (WIP) inventory is the amount of semi-finished products waiting to be used which adjusts the delivery flow to consumption flow. The stock records are often kept using the enterprise resource planning (XPPS) in addition to other software systems, yet the company draws up a physical inventory.

The company manages its inventory using Just In Time (JIT) method. The latter aims to eliminate unnecessary stock, the item must arrive where and when needed. Indeed, JIT ensures to avoid the costs of owning inventory and risk of stockout.

The exhaustion of the batches stored in the storage P0 is performed using First In First Out (FIFO) method. According to this method, the oldest batches are exhausted first to retrieve the items stocked by the storekeepers. The latter proceed as follows to respond to the needs of preassembly and assembly areas:

- They consult at all times the orders registered in XPPS coming from all areas and sections of production.
- The orders requesting semi-finished products are processed from oldest to newest (decreasing rank by date and time is provided by the XPPS system).
- Before moving any kind of material from the storage P0, the storekeeper enters the item to be moved into XPPS.
- The time between the request and delivery of materials is one hour.
- The storekeeper assembles the semi-finished products on pallets and separates them by destination.
- The storekeeper transports the semi-finished products to the appropriate areas of production and drops them off using a hand pallet truck.

Despite of all the measures taken to facilitate the management of WIP inventory within the firm, it still suffers from many flaws at this level. At first, the information entered by the storekeepers is not accurate in several cases and does not reflect the actual level of the stock. Also, the storage P0 comprises an excess of semi-finished products which makes the company violates one of the JIT rules: producing only the quantity needed in the suitable moment.

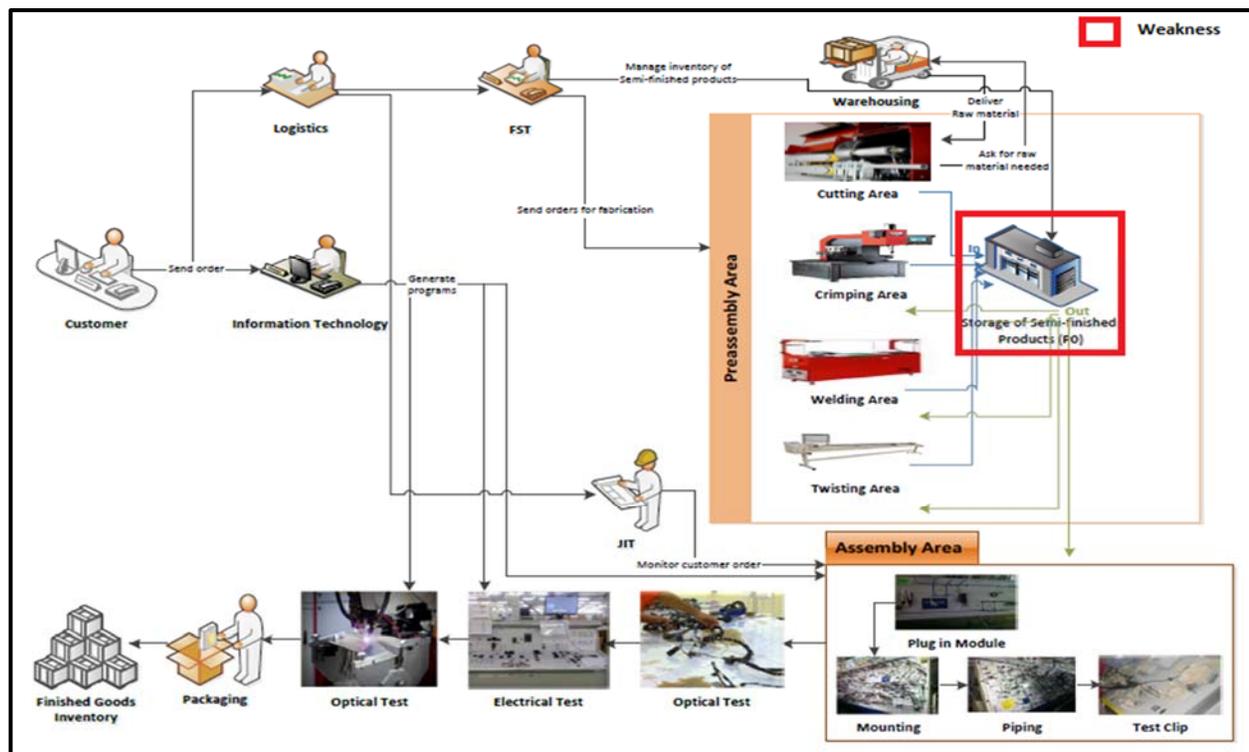


Figure 2: Materials Flow within Wiring Harness Company

#### 2.6.4. Economic Order Quantity

For the case of the storage P0 in which semi-finished products are stored, we consider the supplier to be the warehousing in addition to the cutting area and calculate the economic order quantity for the week 12. The data used has been got from the company except the cost which has been estimated during benchmarking due to data confidentiality reasons.

Demand = 2,026,561 units a week

Unit Cost = UC = MAD 100

Reorder Cost = RC = MAD 210 an order

Holding Cost = HC = MAD 10

Thus:

$$Q_0 = \sqrt{\frac{2 \times RC \times D}{HC}}$$
$$= \sqrt{\frac{2 \times 125 \times 2026561}{10}}$$
$$= 450 \text{ units}$$

In the data provided by the service FST, we found that more than 4000 units have been stored in P0 for the order of week 12. This excess of units represents leads to additional costs that could be avoided. That is why a new mechanism of inventory control has to be applied to be adopted for the semi-finished products.

### 3. KANBAN System

#### 3.1. Objectives of KANBAN Method

The main objectives of Kanban methods are as follows:

- Internal regulations of demand fluctuations and production volume in each section, so as to avoid the transmission and the increase in these fluctuations.
- Minimization of fluctuations in the stock of finished product, with the aim to reduce storage costs.
- Decentralizing the management of the factory, creating conditions for direct executives in which they can play an effective role in managing production and inventory.
- Producing the quantities required at the time of solicitation.

#### 3.2. Characteristics of a KANBAN Label

Kanban is none other than the label attached to a container. This is usually presented in the form of a small cardboard rectangle which can be whether plastic or not. A certain number of information is identified on this card.

This set of information varies widely among companies, but we find the minimum necessary information on all Kanban:

- The reference of the piece manufactured.
- The capacity of the container, and therefore the quantity to be produced.
- The address or workstation reference of the upstream supplier.
- The address or workstation reference of the downstream client.

### 3.3. Functioning of KANBAN Loop

Let's suppose a production workshop where workstations are positioned one after the other, and where the material flow runs from left to right through a post and then the other. The material flow represents the movement of parts. Kanban method places on top of the material flow the information flow. This can be represented as follows.

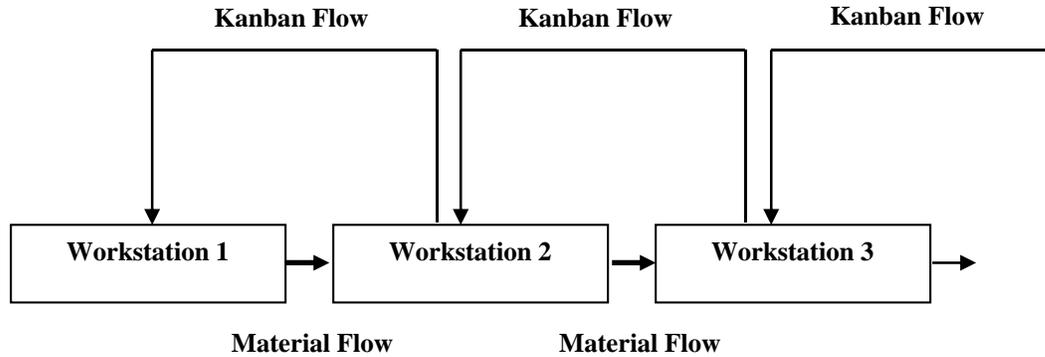


Figure 3: Types of Flows in KANBAN System

### 3.4. Dimensioning of KANBAN System

To determine the size of a container, it is first necessary to consider the product characteristics (weight, volume, etc.). Moreover, the size must ensure the smooth flow of production. We take into account the production time and the time of consumption of products. It is customary to say that a container must find a number of pieces representing less than a tenth of daily consumption to ensure a minimum flow. But this rule is not mandatory and does not fit all situations. It is therefore necessary to hook some time to observe the system functioning in different situations before making a decision.

**Empirical Method:** It is about putting empirically many Kanbans at the beginning and then gradually reducing the number until the flow breaks.

**Calculation Method:** Whose objective is to find the minimum number of Kanbans to be created without causing out of stock. This optimum (N) is obtained by applying the following formula.

$$N = Dd(1+K)/C$$

Where:

**D:** Daily demand of workstation 1

**d:** The duration of a cycle corresponding to the return to the starting point of Kanban (d is the sum of several types of time: Manufacturing time on workstation 2, latency in the storage area, transportation time to workstation 1).

**K:** Security coefficient

**C:** Container capacity

## 4. Simulation of the Existing System & KANBAN System

### 4.1. Description

ProModel is a powerful, Windows-based simulation tool for simulating and analyzing production systems of all types and sizes. It has been opted for in order to simulate the production process in the plant. The first simulation is about the existing system focusing on the preassembly area and storage P0 while the second simulation revolves around the implementation of KANBAN between the preassembly area and plug-in module. Due to the constraints imposed by the software since it is a student version, we were obliged to provide just an approximate modeling of the two systems.

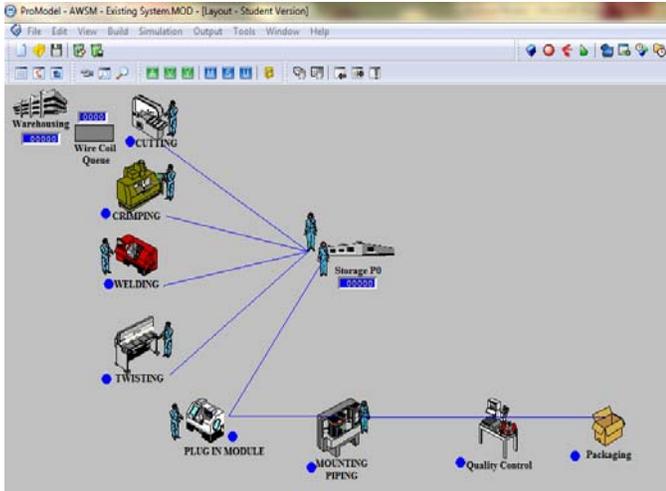


Figure 4: Simulation of the Current System

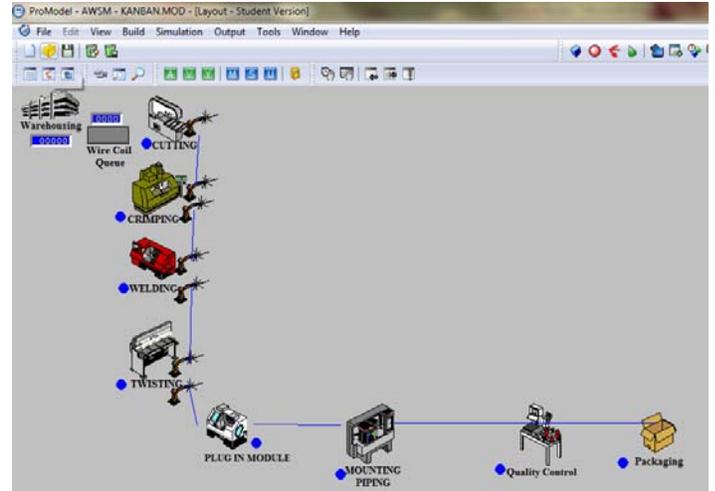


Figure 5: Simulation of the KANBAN System

#### 4.2. Simulation Results for the Current System

This section opted for to be focused on in the simulation results report comprises different information about each location which could be defined as follows:

- Scheduled Time: The total amount of time the location was scheduled to be available.
- Capacity: The number of entities the location can hold or process at any one time.
- Total Entries: The total number of entries that entered the location.
- Average Time Per Entry: The average time each entry spent at the location.
- Average Contents: The average number of the entities entries at the location.
- Maximum Contents: The maximum number of entries which occupied the location over the course of the simulation.
- Current Contents: The number of entities remaining at the location when the simulation ended.
- % Utilization: The percentage of capacity occupied on average during the simulation.

It can be noticed that one of the most utilized units is the storage P0 with about 83 which asserts what has been discussed in the previous sections about the urgent need for replacing this storage with another alternative. The existence of WIP inventory in P0 is perceived as a transgression of JIT philosophy especially that this involves overproduction. Consequently, additional costs are incurred which could have been avoided in case JIT was fully respected.

General Report (Normal Run - Rep. 1)											
General	Locations	Location States Multi	Resources	Resource States	Failed Arrivals	Entity Activity	Entity States	Variables	Location Costing	Resource Costing	Entit
<b>AWSM - Existing System.MOD (Normal Run - Rep. 1)</b>											
Name	Scheduled Time (HR)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization			
CUTTING	1,85	1000,00	1046,00	105,98	999,63	1000,00	1000,00	99,96			
CRIMPING	1,85	1000,00	144,00	83,97	109,03	114,00	112,00	10,90			
WELDING	1,85	1000,00	30,00	34,06	9,21	14,00	12,00	0,92			
Warehousing	1,85	1000,00	600,00	30,31	163,97	600,00	47,00	16,40			
Packaging	1,85	1000,00	1,00	7,04	0,06	1,00	1,00	0,01			
Storage P0	1,85	10,00	105,00	8,72	8,26	10,00	8,00	82,59			
TWISTING	1,85	1000,00	16,00	30,84	4,45	9,00	7,00	0,44			
MOUNTING PIPING	1,85	1000,00	3,00	9,12	0,25	2,00	1,00	0,02			
PLUG IN MODULE	1,85	1000,00	6,00	21,74	1,18	4,00	3,00	0,12			
Quality Control	1,85	1000,00	2,00	5,89	0,11	1,00	1,00	0,01			
Wire Coil Queue	1,85	7,00	53,00	14,62	6,99	7,00	7,00	99,84			

Figure 6: Simulation Results for the Current System

#### 4.3. Simulation Results for the KANBAN System

In the report below, we can notice that the total entries in the preassembly area (cutting, crimping, welding and twisting) have been remarkably reduced. However, the percentage of utilization has increased which is a normal result of KANBAN adoption.

General Report (Normal Run - Rep. 1)									
General	Locations	Location States Multi	Resources	Resource States	Entity Activity	Entity States	Variables		
AWSM - KANBAN.MOD (Normal Run - Rep. 1)									
Name	Scheduled Time (HR)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization	
CUTTING	0,74	1000,00	39,00	26,65	23,35	37,00	37,00	2,33	
CRIMPING	0,74	1000,00	25,00	11,79	6,62	9,00	8,00	0,66	
WELDING	0,74	1000,00	16,00	8,12	2,92	8,00	7,00	0,29	
Warehousing	0,74	1000,00	600,00	39,85	537,14	600,00	470,00	53,71	
Packaging	0,74	1000,00	0,00	0,00	0,00	0,00	0,00	0,00	
TWISTING	0,74	1000,00	8,00	5,10	0,92	3,00	2,00	0,09	
MOUNTING PIPING	0,74	1000,00	4,00	5,23	0,47	4,00	2,00	0,05	
PLUG IN MODULE	0,74	1000,00	6,00	4,93	0,66	3,00	2,00	0,07	
Quality Control	0,74	1000,00	2,00	1,31	0,06	2,00	2,00	0,01	
Wire Coil Queue	0,74	7,00	42,00	5,14	4,85	7,00	3,00	69,26	

Figure 7: Simulation Results for the KANBAN System

## Conclusion

This project investigates the possibility of implementing the KANBAN system within a wiring harness company. The data used in this study was provided by the firm staff. The first step in this project was to analyze the existing system especially in the preassembly area which suffers from several deficiencies such overstock and space wasting. After analyzing the current system, it has been concluded that it has become urgent to place a new system. The latter is what is called KANBAN system which would enable an effective and efficient control of WIP inventory. This fact has been affirmed by the simulation performed using ProModel software.

## References

- Apreutesei, M. (2010). Applications of Kanban System for Managing Inventory. *Bulletin of the Transilvania University of Brasov*, 3, 161-165. Retrieved March 4, 2013, from <http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=c97b57cf-af9a-479b-80d3-8b8402a3c695%40sessionmgr13&vid=1&hid=24>
- Cheng, T. C. E., Podolsky, S. (1996) Just-in-Time Manufacturing: An Introduction. London: Chapman & Hall.
- Fogarty, D. W., Blackstone, J. H., Hoffmann, T. R. (1991). Production and Inventory Management. Ohio: South-Western Publishing Co.
- Gaury, E. G. A., Kleijnen, J. P. C., Pierreval, H. (2001). A Methodology to Customize Pull Control Systems. *Journal of the Operational Research Society*, 52, 790-791. Retrieved February 26, 2013, from <http://www.jstor.org/stable/254125>
- Graves, S. C., Kan, A.H. G. R., Zipkin, P. H. (1993). Logistics of Production and Inventory. Oxford: ELSEVIER Inc.
- Gross, J. M., Mcinnis, K. R. (2003). Kanban Made Simple: Demystifying and Applying Toyota's Legendary Manufacturing Process. New York: American Management Association.
- Myerson, P. (2012). Lean Supply Chain and Logistics Management. New York: McGraw-Hill.
- Topan, E., Avsar, Z. M. (2011). An Approximation for Kanban Controlled Assembly Systems. *Annals of Operations Research*, 182, 133-150. Retrieved March 3, 2013, from <http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=4d07e556-5820-4986-8953-c307c716f96c%40sessionmgr113&vid=6&hid=126>
- Tersine, R. J. (1994). Principles of Inventory and Materials Management. London: Prentice-Hall International (UK).
- Wang, S., Sarker, B. R. (2004). A Single-Stage Supply Chain System Controlled by Kanban under Just-in-Time Philosophy. *Journal of the Operational Research Society*, 55, 486-488. Retrieved February 24, 2013, from <http://www.jstor.org/stable/4101908>
- Waters, D. (2003). Inventory Control and Management. Chichester: Library of Congress Cataloging in Publication Data.