

**JUST IN TIME MATERIAL FLOW WITH ABB Oy
DRIVES AND CONTROLS**



Bachelor's thesis

Degree Programme in Industrial Management

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ABSTRACT

This thesis was made for ABB Oy Drives in Helsinki specifically the Galactica production line of low power AC drives.

The main objective of this research was to reduce the lead time from five days to 24 hours by optimizing the material flow from the warehouse to the factory, reducing inventory within the factory and by ensuring that materials are delivered just in time for production. The focus here was on the mechanical and electrical parts of the ACS 550 & 800 drives with a view to running a pilot.

The aim was waste reduction in the complete production process through planning the most effective layout and work station that would enhance smooth flow of materials while not compromising employee safety.

The theoretical part of this study focuses on materials handling from the warehouse to the factory and within the factory. The work also introduces inventory management principles, the Just in time philosophy, as well as lean manufacturing.

Meetings were held with representatives of the commissioning company. The Materials and Logistics Management team played a key role here. An analysis of the current state of operations was carried out and a few problems were uncovered. At the end of this thesis new models were proposed and these will be tested at a convenient time for the commissioning organization.

Keywords Just in time manufacturing, inventory management push and pull production systems, warehouse.

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ABBREVIATIONS

ABB- ASEA Brown Boveri

AC- Alternating current

DC- Direct current

EPA- Electrostatic protection area

ESD- Electrostatic discharge

FIDRI- Finland Drives

GW- Geodis Wilson

HMI- Human Machine Interface

ITR- Inventory turnover ratio

JIT- Just- in- time

PLC- Programmable Logic Controller

R & D- Research and development

R6- Frequency converter frame size

RFID- Radio- Frequency Identification

WIP- Work in process

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1 INTRODUCTION

1.1 Background

This work was aimed at carrying out a feasibility study for ABB drives and controls to identify the pros and cons of embarking on a new process of material flow.

The choice of topic was created through the need for change and innovation in order to better satisfy the customer and also to create an enabling environment for work. I collaborated with the material and logistics department of ABB drives and controls (Galactica production line).

1.2 Research problem and objective of thesis

The commissioning organization plans to reduce its lead time to 24 hours in the near future and in order to do this, certain measures need to be taken.

ABB drives and controls, specifically the Galactica production line, currently has a problem of an excess inventory within the production facility. The excess inventory comes with a lot of negative issues including inventory handling costs, space issues and work in process etc.

At the start of this work, the materials moved from an external warehouse to the factory and were stored on shelves on the shop floor. These shelves took up space. Employee safety was also an issue because of the traffic within the factory.

The objective of this work was to de-clutter the shop floor, to propose a productive and more cost efficient and a safer system for the material flow from the external warehouse to the factory and also to highlight the pros and cons of this proposed system.

1.3 Research method

The research method applied in this thesis was empirical research methodology. Empirical research is a way of gaining knowledge by means of direct and indirect observation or experience.

According to A.D De Groot (Wikipedia 2013), the researcher must use a five step empirical cycle to achieve a good result. These steps are:

- Observation: The researcher must collect and organize empirical facts.
- Induction: The researcher should then formulate hypothesis.
- Deduction: Deduct consequences of hypothesis as testable predictions.
- Testing: The researcher should then test the hypothesis with new empirical material.

– Evaluation: Evaluate the outcome of testing. .(Wikipedia 2013)

1.4 Research process

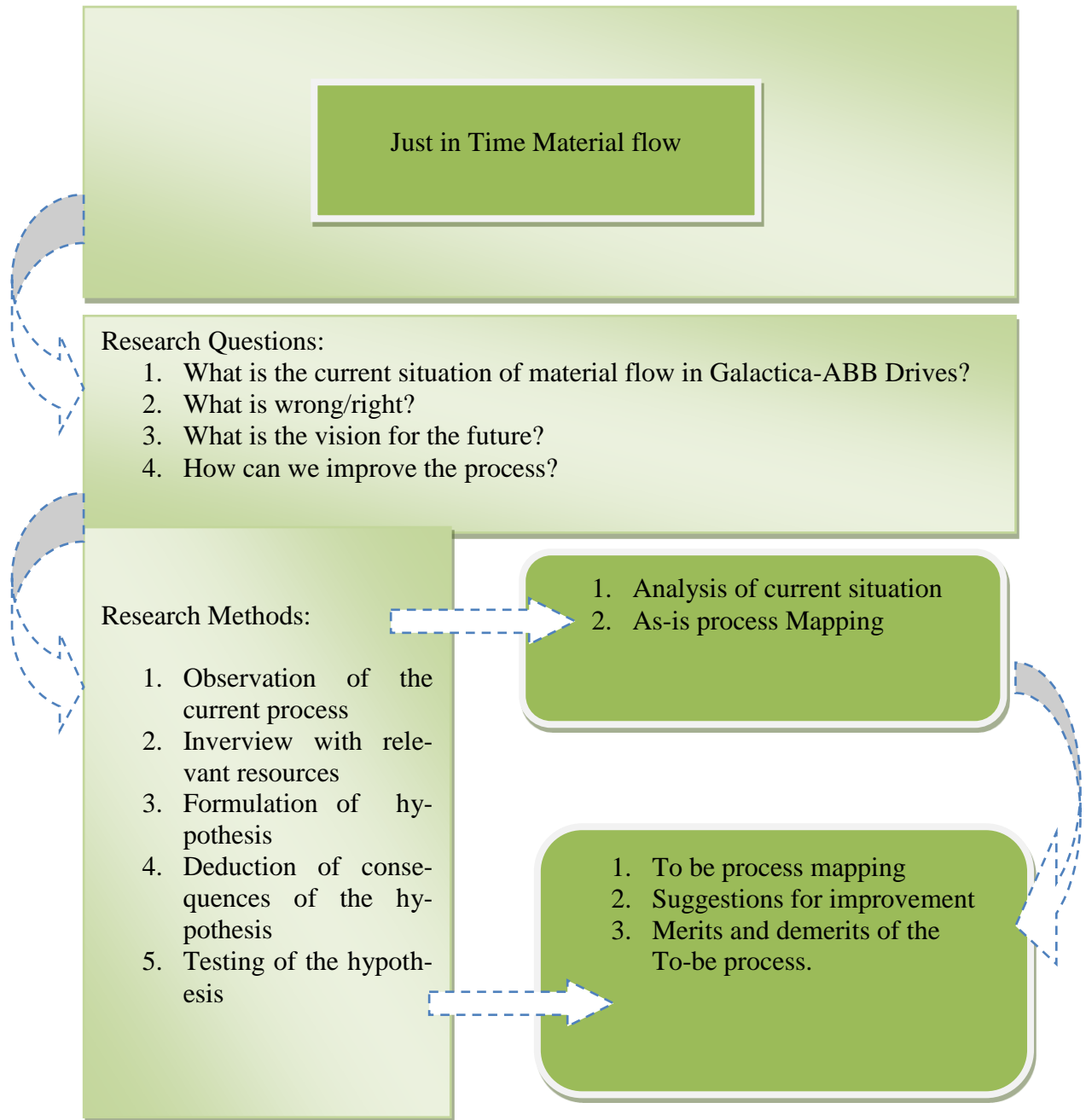


FIGURE 1 *Research process*

Figure 1 illustrates the research process applied in this work. The figure shows the research questions that served as a guide to achieving the required results. The research questions were:

- What is the current situation of material flow in Galactica-ABB Drives?
- What is right/wrong?
- What is the vision for the future?
- How can we improve the process?

In order to answer these questions I used the empirical research method which involved observing and interviewing key people who helped me formulate my hypothesis. I analysed the current state of material flow and I mapped the complete process step by step, I called this the As-is process. Next I deduced from my hypothesis the resultant consequences, and this led me to find some flaws in the As-is process, which further led me to suggest some improvement solutions. I then mapped the new improved process known as the To-be process. I also enumerated the advantages of the To-be, and the challenges that it may face. Finally I presented my findings to the organization and the organization would look into it and test run the new process that I suggested.

2 OVERVIEW TO COMMISSIONING COMPANY

2.1 ABB Group

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, the company employs 145,000 people and operates in approximately 100 countries. The firm's shares are traded on the stock exchanges of Zurich, Stockholm and New York. (ABB 2013)

ABB group is comprised of five divisions that are in turn organized in relation to the customers and industries it serves. The five divisions are:

Power products-The product offering across voltage levels includes circuit breakers, switchgear, capacitors, instrument transformers, power distribution and traction transformers, as well as a complete range of medium voltage products.

Power systems-Turnkey solutions for traditional and renewable energy based power generation plants, transmission grids and distribution networks. These solutions play a key role in the optimization of electricity generation and the evolution of more flexible, reliable and smarter grids.

Discrete automation and motion-Motors, generators, drives, mechanical power transmission, robotics, PLCs, wind converters, solar inverters, voltage regulators, rectifiers, UPS systems, excitation systems, traction converters, fast DC chargers.

Low voltage products-Products and solutions suitable for multiple electrical applications from residential home automation to industrial buildings, including low-voltage circuit breakers, switches, control products, wiring accessories, enclosures and cable systems designed to ensure safety and reliability.

Process automation-Products, systems and services designed to optimize the productivity of industrial processes. Solutions include turnkey engineering, control systems, measurement products, life cycle services, outsourced maintenance and industry specific products (eg, electric propulsion for ships, mine hoists, turbochargers and pulp testing equipment).

Today, ABB stands as the largest supplier of industrial motors and drives, the largest provider of generators to the wind industry, and the largest supplier of power grids worldwide. (ABB 2013)

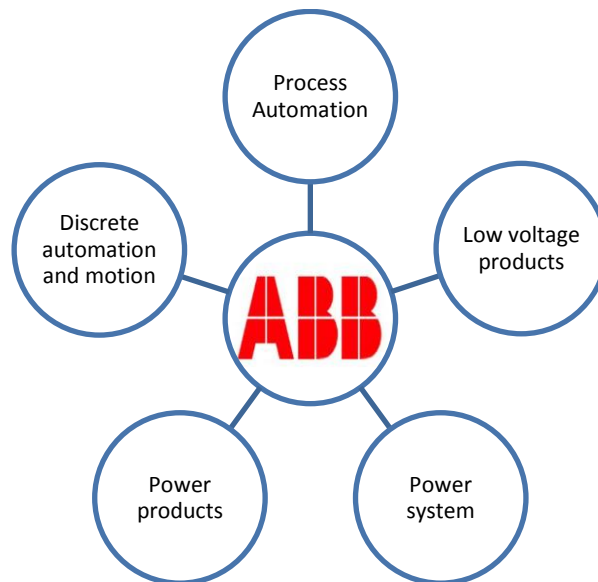


FIGURE 2 *ABB Divisions*

Figure 2 depicts the five divisions of ABB. It illustrates that all divisions are independent but connected.

2.2 ABB Drives and controls

ABB drives and controls is a Business Unit under the Discrete Automation and motion division of the ABB Group.

It is the world's largest drives and PLC manufacturer. It employs 6,300 employees in over 80 countries. ABB Drives are compatible with all industry requirements. ABB drives are easy to select, purchase, install and commission and use.

ABB drives portfolio includes:

- Low Voltage AC Drives from 0.12 to 5600 kW
- DC Drives from 4kW to 15000kW
- Medium Voltage Drives from 200kW to 100MW
- PLCs, HMIs and wireless sensors and actuators
- Software tools
- Energy saving tools
- Service

The drives form part of ABB's Industrial IT philosophy, which allows all automation products to be easily integrated within a plant, thereby bringing significant production efficiencies and reduced costs to customer. (ABB 2013)

Figure 3 shows an aerial view of ABB drives and controls facility in Helsinki Finland.



FIGURE 3 *ABB Drives & Controls, Helsinki. (ABB,2013)*

2.3 Low power AC drives

ABB low voltage AC drives improve process efficiency, reduce energy consumption, and improve productivity. (ABB 2013)

The low power AC drives are tailored to suit the customer; these drives are designed to be compatible with different industries and their unique requirements. The drives offered ranges from micro drives used in machine building to industrial drives used to control processing lines. ABB drives are available directly from stock or can be built to order to meet more complex customer requirements. (ABB 2013)

ABB drives are designed with the safety and satisfaction of the customer in consideration. The drive also helps in energy savings and reduces the impact of carbon dioxide emissions on the environment.

2.4 Galactica production platform

Nicknamed 'Galactica' because of its futuristic manufacturing techniques, the production line has yearly production capacity of 25,000 units in the power range 100 kW to 610 kW. (ABB 2013)

The Galactica line is a flexible production platform that makes to stock and makes to order and also allows for mass-customization of ABB drives. This means that drives can be customized to any application, no matter how demanding, by tailoring the product as it passes through production. (ABB 2013)

The highly automated production line uses ABB's own precision robots and has fully automated material flow and testing routines. Each drive takes 4.5 hours to produce, which is some 30% faster than previous drive types. (ABB 2013)

2.5 ABB ACS 550 & 800 (R6 Frame size)

ABB general purpose drives can be used in a wide range of industries. Typical applications include pump, fan and constant torque use, such as conveyors. ABB general purpose drives are ideal in those situations where there is a need for simplicity to install, commission and use and where customizing or special product engineering is not required. Industrial drives are very flexible and can be tailored to suit precise industry requirements.

2.5.1 ACS 550-General purpose Drive

This drive is designed to control a wide range of applications such as pumps, fans, conveyors and mixers. The power range is from 0.75 to 355kW.



FIGURE 4 *Diagram of ACS 550*

The figure 4 above illustrates the ACS550 drive assembled at ABB drives and controls Helsinki.

2.5.2 ACS 800-Industrial Drive

This drive covers a wide voltage and power range of up to 690V and 5600 kW respectively. This drive can be used in various industries such as: Oil and gas, food and beverage, water and wastewater etc.



FIGURE 5 ACS 800(Clearwater Tech,2012)

Figure 5 illustrates a fully assembled ACS 800 made at ABB Drives and controls Galactica production line in Helsinki Finland.

3 THEORETICAL BACKGROUND

3.1 Push vs. Pull production systems

There are two main production systems that are implemented either singularly or in synergy. They both have their merits and demerits and organizations strive to take advantages of the advantages of these strategies according to the requirement of its business operations requirement. These systems are called the push and pull production systems. (BDC 2013)

3.1.1 Push production system

This is a system of production that is considered ‘producer-centric’. This so because what to produce is determined by the producer. In other words the producer judges the customer’s needs and based on that, determines what is produced and in what quantities.(BDC 2013)

However, the push system has its pros and cons. A significant advantage of the push system is that it deals better with fluctuating demand but does so at the risk of having too much inventory and hence inventory cost. It may also lead to over stocking. In this system, customer satisfaction is sometimes in jeopardy. (BDC 2013)

3.1.2 Pull production system

A pull system exists when a work center is authorized to produce only when it has been signalled that there’s a need for more parts in a downstream (user) department. It means no work center is allowed to ‘push’ materials to a downstream work center. (Jacobs, Berry, Whybark & Vollmann, 2011, 335.)

Pull production system is ‘customer-centric’. What that means is that customers determine what is produced and when it is produced. The customers need triggers production. Production in the pull system is typically made-to-order.

Like the push system, the pull system has its pros and cons. In a pull system, inventory is low and hence low inventory handling costs, R&D is very vital due to constantly changing customer demand, customers are more satisfied since they basically get what they want when they want it. Conversely, the heavy investment on R&D to meet customer ever changing demand increases production cost.

Furthermore, recent studies have suggested that a synergy of both production systems may be better off than any individual one on its own but (BDC 2013), decisions on which system to employ should be dependent of the type of production the organization is into. ABB Drives & controls employ both the push and pull systems of production.

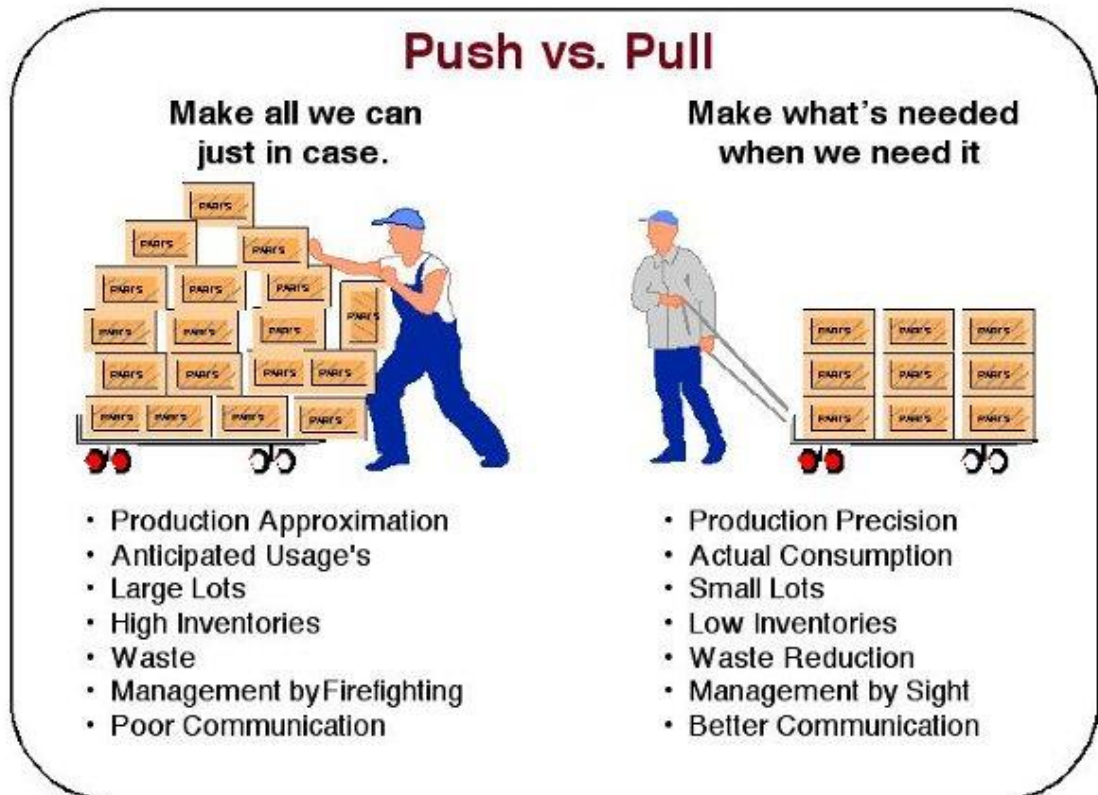


FIGURE 6 *Push vs. Pull production systems*(Elsmar, 2012)

Figure 6 compares the push production system to the pull production system. It shows that unlike the Push system which produces and hopes to sell, the Pull system produces based on demand. In other words, the Push production system is Just in case while the pull production system is Just in time.

3.2 Just-in-time Manufacturing

Globalization has resulted in making the world ‘smaller’. This means that organizations now have a wider reach and this has led to fiercer competition between rival companies. In order to survive and remain profitable, organizations must come up with cost efficient and effective ways to out-compete competitors and get a larger market share. JIT when applied correctly has been proven to be quite effective in helping organizations achieve this goal.

JIT can be defined as the production of the minimum amount of different units, in the smallest possible quantities, at the latest possible time, thereby eliminating the need for inventory leading to a resultant reduction in waste and improvement in quality (AIDT 2006, 1.) The foundation of modern day JIT was laid by a Toyotas Taiichi Ohno, a Japanese businessman shortly after World War II.

Legend has it that Taiichi Ohno drew from his Japanese culture and the American culture to invent JIT. World War II left Japan in shreds and this led Japanese companies at the time to frown seriously at any form of waste. On the other hand, he visited some companies in the US and while he was there, he made an important discovery that went on to be the heartbeat of JIT. He devised a system whereby the rate of production determined the use of parts/components. (AIDT 2006, 2)

Over the years, JIT has evolved to a relatively low cost, flexible and simple process of manufacturing whereby the production rates are determined by the end user and not the manufacturer. But despite the evolution, one thing has remained in the JIT philosophy and that is the quest to eliminate waste from all stages of manufacturing.

Application of JIT Manufacturing should be founded on the following systems:

- Improved inventory control system
- Quality improvement system
- Maintenance improvement system
- Productivity improvement system
- Set-up time improvement system

For this research, the focus will be on improving inventory control, Set-up time improvement and productivity improvement.

When JIT is implemented properly the following would be the indicators:

- Production would be dependent on demand of the end user.
- High quality.
- Zero lead time.
- Zero waste of labour, material or equipment.
- No idle inventory.
- Rate of production determined by end user.

JIT has a lot of advantages. When applied well, organizations stand gain the following:

- Reductions in downtime
- Reductions in inventory
- Reductions in workspace
- Reductions in scrap and re-work
- Increased inventory turns
- Increased labour utilization

3.3 Inventory management

Inventory in simple terms can be defined as a stock or store of goods. Inventory ranges from small items like screws and nuts to large one like forklifts and cranes. (Stevenson 2012, 556.)

Inventory serves a number of functions. Some important functions are:

- To meet anticipated customer demand
- To protect against stock outs
- To hedge against price increase
- To take advantage of quantity discounts
- To take advantage of order cycle times

Organizations need inventory to carry out their day to day business. Although inventory is needed, too much or too little inventory poses a big threat to the profitability of businesses. Under stocking results in missed deliveries lost sales, dissatisfied customers and production bottle necks and on the other hand, overstocking can lead to high inventory costs. (Stevenson 2012, 559.)

The objective of inventory management is to replace a very expensive asset called 'inventory' with a relatively less-expensive asset called timely, accurate, reliable and consistent 'information.' Inventory management answers the question of how much inventory is needed to buffer against the fluctuations in forecast, customer demand and supplier deliveries. (Viale 1996,3.)

Therefore, control and management of inventory is key to exploiting the benefits of inventory. Inventory management is aimed at ensuring that the right good are in the right places at the time and in sufficient quantities. Inventory management also considers the cost of ordering and carrying inventories. All this is done to keep the level of customer satisfaction high and also to maximize profit, minimize inventory investment and maximize efficiency in purchasing and production. (Viale 1996, 3.)

In order to manage inventory, there has to be a system to keep track of items in inventory and also the right decision has to be made about when and how much to order.

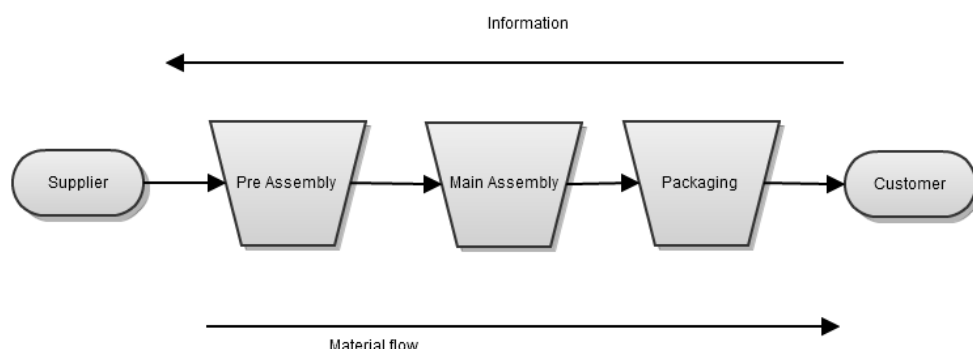


FIGURE 7 *Information and Material flow*

Figure 7 illustrates the flow of inventory and information to and from the supplier(s) to the customer-via ABB Drives production line.

The supplier-Geodis Wilson- transports materials to the factory. These materials are stored and when needed are picking and used in the various stages of the production line. The WIP goes from the pre assembly through to the Packaging and finally the customer.

3.3.1 Inventory costs

Inventory costs refers to all the costs that are directly or indirectly associated with inventories. Organizations must have a informed knowledge of the costs related to its inventory in other to manage inventory well.

There are four basic inventory costs, they are:

- Purchase cost: The amount paid to a vendor or supplier to buy the inventory. This is typically the highest of all inventory costs.
- Setup cost:
- Shortage costs: This occurs when demand exceeds the supply of inventory on hand. If shortage occurs in an item to be used in the production line, the cost of lost production or downtime is also considered a shortage cost.
- Ordering costs: This refers to the costs associated with ordering and receiving inventory. Ordering costs are shipping costs, determining how much is needed, preparing invoices, inspection of good upon arrival for quality and quantity and movement of the goods to temporary storage. Ordering costs are expressed as a fixed dollar amount per order.
- Holding costs: This refers to the cost of physically holding inventory in storage. The costs include interest, insurance, taxes, depreciation, deterioration, spoilage, breakage, tracking, picking and costs related to warehousing (heat, light, rent, security). They also include opportunity costs associated with having funds that could be used elsewhere tied up in inventory. Holding cost can be stated as a percentage of unit price or as a dollar amount per unit.

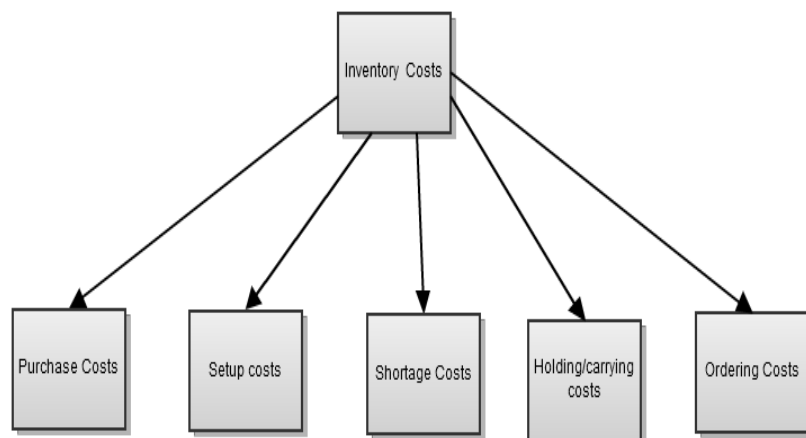


FIGURE 8 *Inventory costs*

Figure 8 shows the most significant costs related to inventory. It is important to know the importance of all these costs and also how to manage them.

3.3.2 Inventory turnover ratio

Inventory turnover ratio, ITR is the ratio of average cost of goods sold to average inventory investment. This is a significant performance measure used by managers to judge how effectively they have managed their inventory. The turnover ratio indicates how many times a year the inventory is sold. (Stevenson 2012, 559)

The aim of smart inventory managers is to keep the ITR at an optimum. This optimum though dependent on the industry, is usually high meaning more efficient use of inventories. Managers must also strive to maintain a healthy balance between investment in inventory and customer satisfaction. This is important because, no matter the amount invested in inventory, if it doesn't translate to customer satisfaction then it would be safe to assume that the resources used to purchase the inventory were wasted. And on the other hand, there is no use spending more than is necessary to keep customers satisfied. (Stevenson 2012, 559.)

3.4 Warehouse

Saving for the future is innate in man and foundation of modern day warehousing was laid long ago. The first commercial warehouse was built in Venice by a brotherhood of merchants called a guild and the system they employed helped improve foreign trade (Tomkins & Smith 1998, 3.)

Today, warehouses have become very useful in business operations. Warehouses are now a valuable weapon used by organizations to get the competitive edge.

The mission of the warehouse is to effectively ship products in any configuration to the next step in the supply chain without damaging or altering the product's basic form (Tompkins, White, Bozer, & Tanchoco 2010, 387.)

The major functions of warehouses today are:

- Receive the goods from the source
- Storing the goods until they are required
- Picking the good when they are required
- Shipping the goods to the right place where they are needed.

A warehouse may be a gift or a curse to the user depending on the user's understanding of what a warehouse really means and why it is relevant to its business operation. For a warehouse to be considered beneficial, it has to have space for storage, it has to have an efficient method of storing the products that would also ensure easy storage and retrieval of products, and it has to have in it the right products at the time when they are needed.

Managing a warehouse requires a lot of understanding of the processes and this may be a problem for large organizations whose sector may not be related to warehousing and logistics. Some of these organizations realized that it would be more profitable to add a logistics company to their

supply chain. This logistics company would then run and manage the warehouse which may or may not belong to the organization.

ABB drives and controls use an external warehouse and it is managed by Geodis Wilson. Geodis Wilson is one of the world's largest freight Management companies. They focus on making the supply chain more transparent and easy to manage by providing value added services, e-services to help stream line goods.(Geodis Wilson 2013)

The warehouse is a 6,750sqm located in Juvanmalmi in Espoo about 20minutes from the factory in Helsinki. Inside the facility, there are 12,000 pallet places and it supplies to ABB in Helsinki, Estonia and ABB services (warranty).

Geodis Wilson manages the facility and they receive the goods, place them in the pallets, and pick the goods that are required by ABB Drives and ship them off to the factory at Helsinki and goods receiving in ABB facility. They also provide value added services like kitting etc. All this is done within a pre agreed time frame.

ABB has some risk policies that are used to hedge against unforeseen circumstances. For electrical parts, at every point there is expected to be a 2-month safety stock while for mechanical parts 2-4 weeks safety stock is the norm.

4 CURRENT STATE ANALYSIS: AS IS

4.1 Description of present situation

The ACS 550 and 800-R6 frame size are manufactured in ABB Oy-Drives and Controls Helsinki at the Galactica production line. Currently, the materials are stored in a warehouse managed by Geodis Wilson; this warehouse is located in Juvanmalmi, Espoo –about 20minutes by road to the ABB facility in Helsinki.

Materials are transported from the external warehouse to the factory. This movement of materials occurs every 2 hours. When the materials arrive at the ABB facility the goods are moved through goods receiving. At goods receiving the palettes and/or boxes have a code on them that helps ABBs fully automated RFID system identify and check that inbound materials are the right ones and in the right quantity. This process though very significant, takes just a few seconds. If the RFID gives a red light it indicates that there might be an error in the materials or the amount. This signals the supplier to make the necessary corrections before the materials come in to ABB. On the other hand, a green light means everything is correct and the materials are then moved to their respective in factory storage locations.

When production starts, the required materials are picked using a picking list. The picking list is a list of all the components needed to successfully assembly any specific frequency converter. The component on this picking list is unique to the type of frequency converter being made. Because ABB makes frequency converters that are tailored to suit the customer, there are lots of variations and hence different picking lists. Picking takes an average of 18 minutes. The materials are picked using a trolley.

Next is the assembly of the heat sinks this takes an average of 18 minutes per person and the work station provides for a maximum of 2 persons. The pre assembly follows-This stage deals with the assembling of some of the materials that have been picked it is usually handled by 1 or 2 workers and the processing time is about 18 minutes per person and the work station provides for 2 persons to work at a given time.

The soft loading is also done for depending if it is an ASC 550 or ACS800. The ACS 550 no soft loading needed while the ACS 800 soft loading is needed. This takes about 20-30 seconds.

After the pre assembly, the remaining materials are then moved to a space where other workers in the main assembly can collect them. The WIP is then lifted using a crane to the robot that then sends it to another work station. This work station is the main assembly. In the main assembly, the remaining components are assembled. There are about 10 work stations in the main assembly and its takes an average processing time of 1 hour to complete this stage.

When assembly is complete, the worker sends the machine to the robot which then sends it for the testing. Testing is in two phases; phase 1 is the

hipot testing and phase 2 is the burning test. The testing takes a total of 1 hour to complete.

Finally, when the frequency converter has passed the testing, it is sent for outfitting and packaging both of which have an average processing time of 6 and 18 minutes respectively. This gives an average time of 3 hours 18 minutes from start of production to end of packaging of the ACS 550 & 800 frequency converter-R6 frame size.

It is also noteworthy that ABB makes-to-stock and makes-to-order. The ACS 550 is made to stock, while the ACS 800 is made-to-order and hence goes straight to the customer after production.

A fully automated RFID system is also installed so that the completed and packaged frequency converters can be identified as they exit the facility.

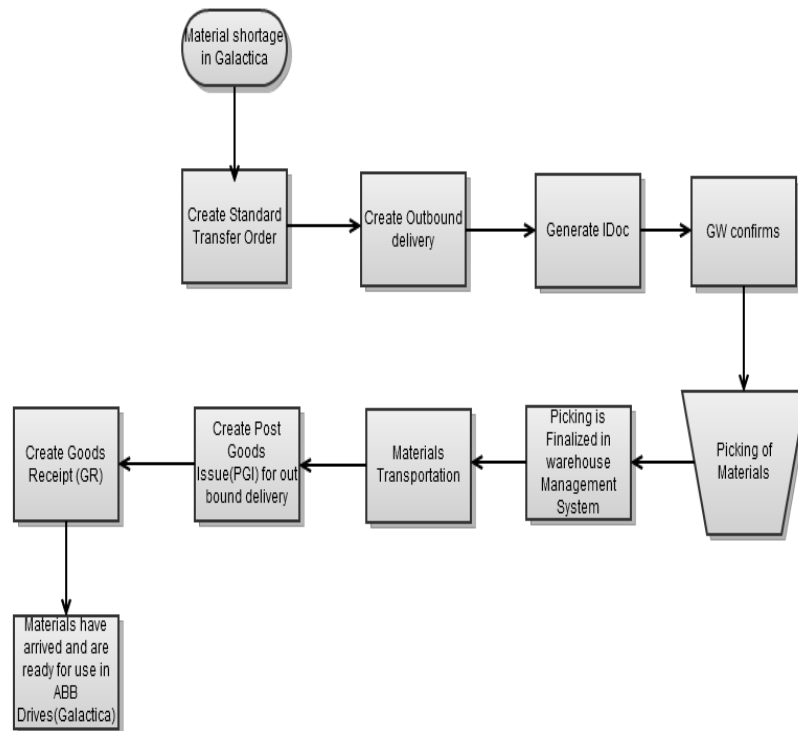


FIGURE 9 As is Material flow from External Warehouse to ABB Drives (Galactica)

Figure 9 shows flow of the materials needed for production from the external warehouse to ABB Drives and controls (Galactica) triggered by pre agreed intervals made by ABB with GW.

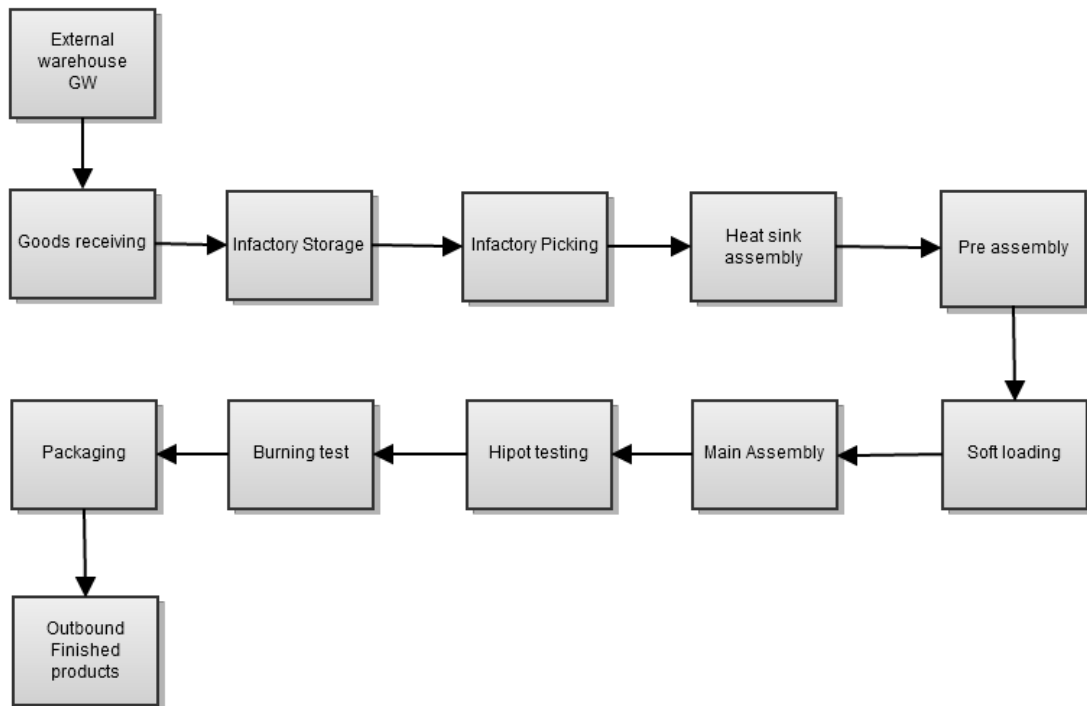


FIGURE 10 AS IS Process flow.

Figure 10 illustrates the production process of the ACS 550 and 800. It shows the current flow of materials in the Galactica production line from the external warehouse managed by GW through ABB production line to the finished product. This current process is not without flaws, flaws that ultimately affect productivity.

TABLE 1 Operation Overview

Operation Overview			
Op.	Operation short text	Processing Time	Unit
*0010	Production Start	0.0	H
*0011	Heat sink assembly	0.3	H
*0015	Material picking	0.3	H
*0020	Preassembly ready	0.3	H
*0030	Main assembly	1.0	H
*0040	Testing	1.0	H
*0045	Outfitting	0.1	H
*0050	Packing	0.3	H
		3.3	

Table 1 shows the various stages of production of the ACS 550 and 800 and their processing times- that is, time taken to complete each stage. The total processing time per unit of either the ACS 550 or 800 is 3.3 hours (3 hours 18 minutes).

5 PROBABLE SOLUTION: TO BE

5.1 Description of the new system and its working process

The To-be process would be similar to the As- is process with only a few but significant changes. Figure 10 illustrates the proposed To-be. Here, the supplier does the heat sink assembly-which takes about 18 minutes- then materials needed for production are first picked and kitted in the external warehouse by the supplier. These kits will be specifically packed for the pre assembly and main assembly respectively. The pallets are then transported by road to ABB facility in Helsinki.

Upon getting to ABB facility, the pallets go through goods receiving and after getting the OK signal from the automated RFID system, it moves straight to the work stations. The pre assembly kit goes to the pre assembly and the main assembly kit goes to the main assembly and production starts.

The processing time at the pre assembly would take 18 minutes and that of the main assembly, 1hour. After the main assembly, it WIP is tested. Testing takes up another 1 hour. When it passes the hipot and burning tests the machine is then sent for outfitting and packaging which take 6 and 18 minutes respectively.

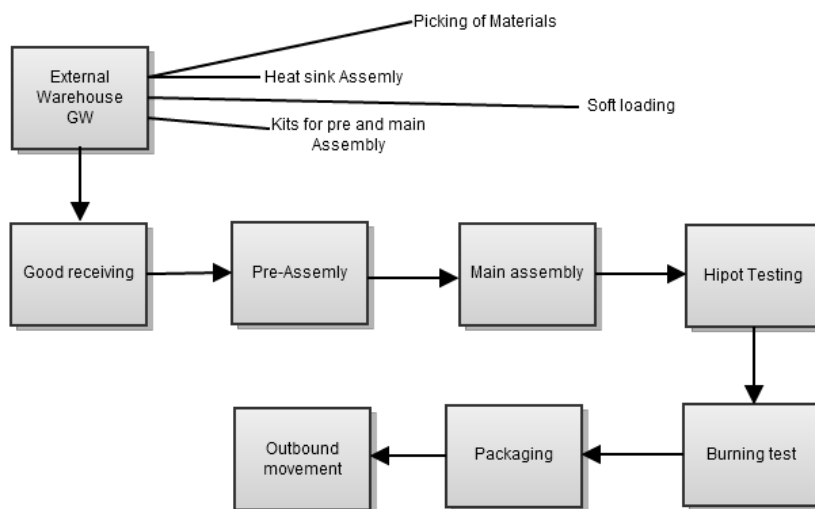


FIGURE 11 Proposed TO-BE process

It is clear to see the differences in the AS-IS process from the TO-BE process and this differences also have significant effect on the lead time. All things being equal, the proposed system would have faster total processing time from 3 hours 18 minutes in the AS-IS to 2 hours 42 minutes per frequency converter. That is reducing the lead time by 36 minutes per unit.

It would also mean more free workers (those that would have otherwise done the picking and made the heat sinks) that could be given other tasks in the production line.

Thirdly, the proposed system would lead to space creation within this factory because material flow would be more or less Just in time and hence not much need for in factory storage. This would go a long way in reducing inventory handling costs and also the risk of having goods damaged during storage.

Finally, the proposed change may not necessarily increase cost of labour because the hourly wages of the regular ABB production line worker is quite similar to that of the hourly wages of GW worker. Even more accurately, the hourly wages of the ABB worker is slightly higher than that of the GW worker.

TABLE 2 TO BE operation overview

Operation Overview			
Op.	Operation short text	Processing Time	Unit
*0010	Production Start	0.0	H
*0020	Preassembly ready	0.3	H
*0030	Main assembly	1.0	H
*0040	Testing	1.0	H
*0045	Outfitting	0.1	H
*0050	Packing	0.3	H
		2.7	

$$\text{Percentage savings} = \frac{P_A - P_B}{P_A} \times 100\%$$

Where:

P_A = Total As-is processing time

P_B = Total To-be processing time

FORMULA 1 Percentage reduction in processing time

From tables 1 and 2 we can calculate the percentage reduction in processing time. By using formula 1 above we have:

$$\begin{aligned} \% \text{ savings} &= \frac{3.3 - 2.7}{3.3} \times 100\% \\ &= 18.18\% \text{ reduction in processing time Per frequency converter} \end{aligned}$$

5.2 Advantages of To-be

- Decreases lead time of production
- Improves customer satisfaction
- Since in factory storage is eliminated, inventory within the factory is reduced and as a result inventory handling cost is also reduced
- Because the heat sink, picking and soft loading are eliminated from the factory, there are more free workers that can be used in other stages of the production line

- More space
- Less in factory traffic
- ‘Just in Time’ production
- Decrease in idle time
- The size of the work stations can be increased and the excess workers can be absorbed there
- Minimal changes to the already existing layout of the production line

5.3 Challenges of To-be

The To-be process promises cost savings, improved flow of materials, safer and more efficient production processes and potentially more profitability for the company. In order to maximize the benefits of the To-be, it is important to consider the effects of the following determinant factors and how to manage them:

- The cost implications of the whole To-be process and the cost of SAP development work (modifying SAP production modules to be used at GW), factory layout space savings, number of workers needed. What are the cost implications of all these in relation to the As-is?
- What does the Taxi cost and how many are needed?
- What is the new lead Time? Compare it to the As-is lead time.
- How will the To-be deal with order back log?
- Is the To-be flexible enough to deal with express orders. Industrial cabinet drives orders and R&D orders?
- FIDRI production runs in three shifts and because in the To-be production starts in GW would GW run in three shifts too?
- How would information flow between FIDRI production planners and GW supervisors?
- Quality checks and feedback between FIDRI and GW
- Can the To-be work simultaneously with the As-is? What are the likely problems?
- Who would own the production tools and who would be responsible for calibration and maintenance, FIDRI or GW?
- What would be the TPT of the To-be?

6 RECOMMENDATIONS

For the To-be system to be effective, it is important to suggest possible ways to deal with the aforementioned challenges. The following should be done to reduce the probability of these challenges affecting the proper functioning of the proposed system:

- ESD requirement- As a result of the proposed relocation of the heat sink assembly to the external warehouse, it is important to carry out a test on the work station to ensure that it is an Electrostatic Protection Area (EPA). The area must meet all the necessary requirements to avoid the negative effects of ESD on any of the sensitive components.
- Picking errors- Picking the right materials in the right quantity at the right time has been a challenge at ABB for various reasons and it is foreseen that these challenges will still be a problem when the picking is conducted at the external warehouse. Picking errors in the proposed system can pose an even graver problem than when those same errors were made within the ABB facility because of the distance between the external warehouse and the ABB factory. As a result of this potential challenge, it is important to recommend steps that must be taken to reduce the probability of picking errors in the external warehouse. The use of voice picking technology would provide an easy, paperless, natural, faster and more accurate picking solution that has been known to cut warehousing costs by as much as 5%, improved picking rates by as much as 15%, and accuracy rate of 99.97%-99.99% it also reduces training time by as much as 50%.(GLM Group Video,2012)

This method is pre-emptive and therefore aimed at averting or deterring the unproductive situation of stopping production as a result of lack of or incorrect materials.

Figure 12 shows the devices used in voice picking; a head set, microphone and a small computer that is worn on the belt and has the voice recognition software that interacts with the worker prompting him/her to pick specific components in specific amounts.



FIGURE 12 *Voice enabled picking devices (Telectronica,2010)*

- Movement of materials: After picking the materials, it is important to use a safe and efficient medium to transport the materials to the desired locations. In my study, I discovered several ways to transport the materials but one in particular stood out. It stood out because it was efficient, fast, safe, and flexible and had the capacity to move more materials at once. The materials can be conveyed using a ‘taxi’. The taxi is a smart solution whereby several different trolleys can be transported in a train at the same time hence minimizing the number of transports and increasing the frequency of good delivery for production. Other advantages of this medium are:
 - Less internal transports
 - Reducing the risk of accidents hence it is a safer solution.
 - Heavy fork- lift trucks can be replaced with smaller and flexible towing trucks
 - It is an ergonomic solution.



FIGURE 13 *Helge Nyberg Taxi*(*Helge-Nyberg,2013*)

Figure 13 illustrates a Taxi. The taxi can take up to four trolleys and each trolley can carry a maximum of 600kg. The taxi trolley also makes provision for a pallet. This solution provides a very flexible, efficient and safe medium to transport a lot of materials in the shortest time possible. I recommend this solution for ABB because of the advantages it provides and also because it suits ABB drive production layout and also because it will have a good synergy with JIT manufacturing.

I also recommend that further study be done on the management of the warehouse at Juvanmalmi. I noticed a lot of 'scrap' products that are kept in the warehouse and these scrap accumulate much inventory handling cost in the long term. This problem should be looked into because finding a better way to handle non-production materials could potentially save the company from huge unnecessary expenses.

7 CONCLUSION

Management of materials in any manufacturing industry is very important because it relates directly to profit or loss and as a result should be taken seriously. ABB Drives and controls is not an exception. ABB strives to keep its customers constantly satisfied by optimising the flow of materials, reducing production lead time and ensuring that the production process is fast, efficient and safe.

This work was commissioned to examine the flow of materials in the production of the ACS 550 and 800 and to recommend feasible solutions for improving the process of material flow using JIT principles.

During the course of this work, I gained invaluable knowledge of the production process and the tasks involved in the manufacturing of the ACS 550 and 800 from start to finish. I studied the flow of materials and with the support of the Materials and Logistics team at ABB Drives and controls I came up with feasible solutions to the research questions.

In conclusion, to ensure a successful implementation of the solutions, I have put forward some recommendations which should be adhered to and if needed improved upon.

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