

## INVENTORY MANAGEMENT OF PHARMACEUTICAL INDUSTRIES IN BANGLADESH

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### ABSTRACT

This paper presents inventory management processes in the pharmaceutical industry of Bangladesh. It introduces arena, a simulation software, that calculates process and production time in industry and radio frequency identification (RFID) technology, and their implementation in inventory management. In this work, a case study is conducted and a simulation is done using the arena to calculate the process and product times of a product. In Bangladesh, inventory control of the raw materials and finished products and tracing of the products are done by barcode and labeling. Conventional identification process requires manual intervention and manual data collection, which is costly and time consuming. Moreover conventional process is unable to prevent any counterfeiting. By implementing Radio frequency identification technology inventory control, i.e. identification of raw materials, packaging of raw materials, quality assurance, finished products identification, control of material flow through the total supply chain can be done easily and more effectively than present conventional methods present in Bangladesh. RFID tags offer secure rewritable memory that can be used to improve visibility and security. A combined implementation of RFID technology and arena simulation can be used in the pharmaceutical industry of Bangladesh.

**Keywords:** Inventory Control, Arena, Rfid, Pharmaceutical Product Management, Production Process, Operations Management.

### 1. INTRODUCTION

Arena is a simulation software and a very powerful tool and allows creating animated models of any system, i.e., machines, operators, various devices, etc. Models can also be customized according to the environment and specific application. In pharmaceutical sector, arena can give an entirely graphical layout of overall production process and gives simulated results including process and production time of any products. Reorder point of raw materials can be determined very easily by using the arena. Whether decisions impact manufacturing, supply chain, or customer service operations, simulation help to avoid risky investments, reduce variability, slash costs, and identify bottlenecks. Through a combination of process simulation and optimization technologies, simulation helps demonstrate, predict and measure system performance under varying conditions and decision criteria before implementation on live operations [1].

Simulation is the next best thing to observe a real system. In simulation, computer models are used. As the simulation advances with time, pertinent statistics are gathered about the simulated system in very much the same way it is carried out in real life. Simulation is the process of designing a model of real life system and conducting experiments with this model for the purpose

of understanding the behavior of the system or of evaluating different strategies for the operation of the system [2], [3].

Pharmaceutical is one of the most sensitive and major industry that deals with human and animal life. Purity is highly deserved in this industry and there is no option of second chance. Quality, security, identity are the most important to maintain. So inventory management of the industry is a difficult job. A pharmaceutical company handled 500-600 types of products that includes huge amount of raw materials movement, packaging and secondary packaging of the finished products. Planning and scheduling in the pharmaceutical companies is a critical activity. Demand management under constraints of life-limited inventory buffers and non-discrete nature of products is challenging. Animated simulation model of overall production process is created to analyze the pharmaceutical production process and to determine production process time. It will help the pharmaceutical company to determine the reorder point of the raw materials and to reduce raw materials wastage. In order to obtain valid results from a simulation model, it is important to parameterize the simulation inputs as accurately as possible. A wide variety of probabilistic distributions such as the exponential distribution, gamma distribution, beta distribution, etc. can be used to mimic

real life occurrences [4].

In this work, a case study is conducted and a simulation is done using the Arena to calculate the process and product times of products. In Bangladesh, inventory control of the raw materials and finished products and tracing of the products are done by barcode and labeling. Conventional identification process requires manual intervention and manual data collection, which is costly and time consuming. Moreover conventional process is unable to prevent any counterfeiting. By implementing Radio frequency identification (RFID) technology inventory control, i.e., identification of raw materials, packaging of raw materials, quality assurance, finished products identification, control of material flow through the total supply chain can be done easily and more effectively than present conventional methods present in Bangladesh.

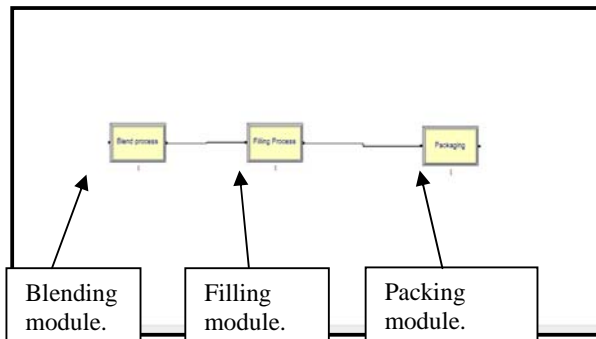


Fig 1. Pharmaceutical processes in arena

## 2. INDUSTRIAL DATA ANALYSIS

A simulation model representing a simple drug manufacturing process has been developed as shown in Fig. 1. The elements of this simulation model are generic, such that, almost all companies have the same or similar structural components in their manufacturing process. This model represents a manufacturing sequence of three suites or departments: Blending, Filling and Packing.

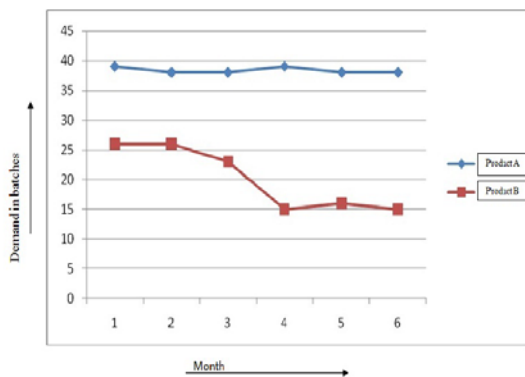


Fig 2. Demand data of two pharmaceutical products of six month

In this section, demands of two typical products in a pharmaceutical industry are analyzed. Demand of two

pharmaceutical products (product A & Product B) of six month is collected and a graphical representation of the demand is shown in Fig. 2.

Cycle length are calculated for the above products as

$$Q=dT \quad (1)$$

$$T= (S_1+S_2) / 1-(P_1d_1+P_2d_2) \quad (2)$$

Equations (1) & (2) are used to determine theoretical cycle length of the products and then compared with the simulated cycle length.

## 3. SIMUATED DATA AND RESULT

In arena, animated simulation model of overall production process is created to analyze the pharmaceutical production process and to determine production process time. Data collected from the industry are used as model inputs. Table 1 shows the production rate of the products, setup time for machines, demand and table 2 shows number of batches and the cycle time. Cycle time in table 2 is theoretical that is calculated from equation (2)

Table 1: Model input for six month.

	Setup times, $S_i$ (weeks)	Production rate, $p_i$ (batches /week)	Demand rate, $D_i$ (batches/ week)
<b>Product A</b>	0.429	0.04545	10
<b>Product B</b>	0.429	0.0526	5.26

Table 2: Cycle length calculation

Model Inputs.	$P_1$	0.0455	weeks
	$d_1$	10	Batches/week
	$P_2$	0.0526	weeks
	$d_2$	5.26	Batches/week
	$s_1$	0.429	weeks
	$s_2$	0.429	weeks
Model Outputs	<b>T</b>	<b>3.4188</b>	<b>weeks</b>
	$Q_1$	34.188	Batches
	$Q_2$	19.145	Batches

There is a different between the theoretical and simulated result. For the same amount of batches and same environment the cycle time is different that can make a difference while evaluating inventory and making decision. Comparison between theoretical and simulation cycle time is shown in table 3.

Table 3: Comparison between theoretical and simulation cycle time

Number of batches	Required time (theoretical)	Required time (simulation)
53	3.4188 weeks	3.7006 weeks

#### 4. RFID TECHNOLOGY

Radio identification technology (RFID) is a means of gathering data without touching or seeing the data carrier, only by the use of electromagnetic waves. The data is in the form of a unique number form. One possible approach to item identification is Electronic Product Code (EPC). It is actually a standard proposed by the Auto-ID center with two different types, a 64- and a 96 bit code and 96 bit chip would be the dominant data format for commercial RFID tags [5]. The 96-bit code gives a unique number to 268 million companies, with 16 million different object classes and 68 billion serial numbers in each class. The 64-bit version should be a compromise between the cost of a tag and the number of different codes. This version offers lower cost but fewer serial numbers. The EPC number is made up of a header and three sets of data. The header clarifies the EPC version used, as versions of different length and type might be used in the future. The second part represents the manufacturer's code. The third part identifies the type of product, usually the Stock Keeping Unit (SKU). RFID enables identification from a distance, and unlike barcode technology, it doesn't require a line of sight. An RFID system includes three primary components: a transponder (tag), a transceiver (reader) and a data collection device.

##### 4.1 Types of tags and reader

RFID tags are generally classified in three groups as shown in Fig. 3, such as, passive, semi passive and active. Passive tags obtain operating power from the battery; semi passive

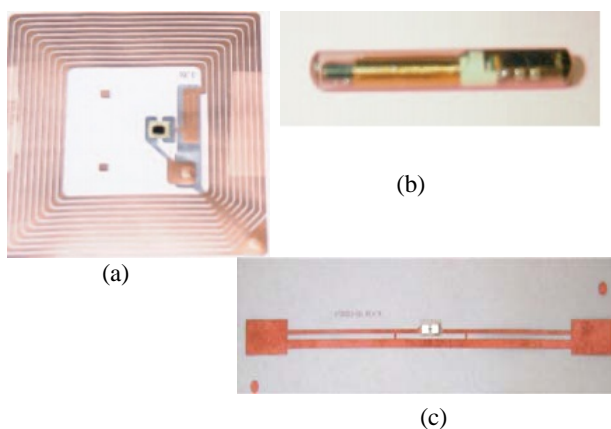


Fig 3. (a) 13.56 MHz Tiris tags; (b) 128 kHz trovan tag; (c) 900 MHz Alien tag [7].

tags use a battery to maintain memory in the tags and the tags are partially powered by the battery but active tags are totally powered by internal battery. Microchip, broadcast all are done by internal battery power.

According to tags memory there are two types, such as, read-only and read-write. In read-only type tags the memory is programmed in the factory and can not be edited. It a static data and very limited data can be stored but it is cheap compared to read-write type tags. In the read-write type tags, data dynamically can be alternated, can store large amount of data and expensive compared to read-only tags [6].

On the basis of wireless signal used between reader and tag there are two classifications, such as, induction and propagation. Induction type tag uses low and high frequency bands and induction type tag uses ultra high and microwaves bands.

On the basis of technology and design, the readers are of two types, such as, read and read-write. Based on mobility again are of two types, such as, stationary and mobile.

##### 4.2 Operating frequency

The frequency used for the communication between reader and tag is one of the leading factors, besides the choice between active and passive tags, affecting the read range for an RFID system. In addition to influencing the read range, the choice of frequency also has an effect on the data transfer rate that can be achieved between tag and reader. Frequency is furthermore influencing the sensitivity to metals and fluids as well as the possible selection of sizes and shapes for the tags. Each of the frequency ranges thus becomes more or less suitable to certain applications.

There are two types of modulation, amplitude modulation (AM) and frequency modulation (FM). Amplitude modulation works by using the data stream to vary the signal strength of the carrier wave. On the other hand frequency modulation keeps the signal strength constant and instead works by varying slightly the frequency of the carrier wave.

RFID system utilizes a variety of radio frequencies from 30 KHz to 5.8 GHz. Reading length and writing speed depend on frequency range. Lower the frequency, lower the read/write speed and lower the cost.

Low frequency (30 KHz-300 KHz) has small read range and slow data transfer rate. Read range varies from 1 to 90 cm. Low frequency tags can transmit through elements such as water, wood and aluminum. But in the environment with metal like iron, steel the transfer rate decreases.

High frequency (3MHz-30MHz) has high data transfer rate than low frequency tag. It can penetrate materials and has a read range from 1 to 75 cm. It works well in environments containing fluids. The high frequency tags are less sensitive to metals and sources of electronic noise than ultra high frequency tags.

Ultra high frequency (866MHz-960MHz) tag has high data transfer rate, it can store large amount of data and it can read up to 9m. Due to high frequency the transfer rate is also high. A disadvantage of ultra

frequency tag is that it is highly sensitive to the presence of water and may not work properly if it is attached to materials with high content of water. Ultra frequency tags are unable to penetrate through wood or water. Microwave (2.4GHz-2.5GHz, 5.8GHz) has a read range from 0.3m to 0.9m and these types of tags are small in size compare to other tags. The characteristics of micro wave frequency are same to ultra wave frequency but the micro wave frequency can read very fast [8]

Figure 4 shows the working process of frequency and data carrying by frequency.

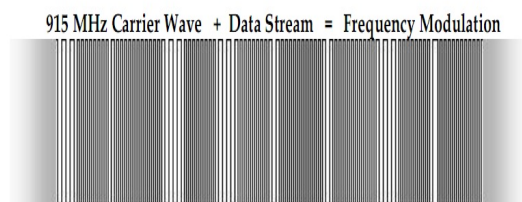


Fig 4. Working process of RFID frequency

### 4.3 Middleware

RFID middleware is an important part that creates link between reader and the ERP system. RFID middleware operates between RFID hardware and ERP system acting as a bridge between them. Due to the nature of RFID technology data must be captured in a intelligent manner, cleaned and distributed in the appropriate locations. RFID middleware [9], manages the readers and extracts data from the readers, followed by tag data filtering, aggregating, and counting, and finally sending the data to the database.

Figure 5 shows the RFID system and the working process. Data are collected wirelessly and through access point the collected data are stored in the server. Then it will be distributed automatically within the ERP system.

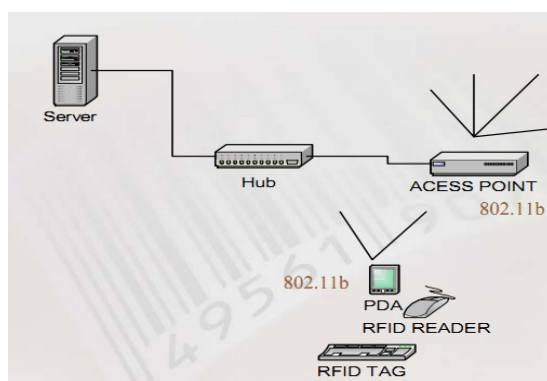


Fig 5. RFID system overview

## 5. APPLICATION OF RFID TECHNOLOGY IN BANGLADESHI PHARMACEUTICAL INDUSTRY

In Bangladesh tracking, tracing, data collection, material collections are done manually. Supply chain visibility is not available and manual effort needs lots of

time. So there is a huge scope for the implementation of this technology that can make the total system more effective and less time consuming. In Bangladesh RFID is not used in industry. RFID tags offer secure rewritable memory that can be used to improve visibility and security. It helps to identify various materials i.e. raw materials, packaging materials as well as the finished products in a very effective way that is a prime requirement for any pharmaceutical industry. RFID has the potential to offer the following significant benefits, such as better tracking and tracing, reducing counterfeiting, increase the process efficiency, better temperature monitoring, better inventory management of both raw materials and finished products, reduction of inventory cycle time, reduction of administration error, etc. The other major problem faced by the pharmaceutical industry is counterfeit drugs and drug diversion because of different pricing and taxation structures prevailing in the country.

Companies are trying to protect themselves from possible disruptions to the supply chain, the lack of visibility for in-transit material are causing high buffers of inventory. Manufacturers have pursued practices such as lean production and Just in Time (JIT) to obtain the benefits of reduced inventory in production operations. With RFID companies can obtain a higher visibility through the supply chain and they can thereby reduce the buffers of inventory. Major applications of RFID technology in the pharmaceutical industry are discussed below.

RFID can easily identify the entry and exit products in a warehouse. If each arriving container has a RFID tag manufacturers' identity, product serial number, expiry date everything can be checked very easily and at the same time it would help to certify that the material has arrived from the approved vendor. RFID tags can help to validate the manufacturing and maintain quality control and quality assurance by documenting that only approved materials as being used.

Entry and exit of the products can be controlled. Not only products movement but also movement of employee can also be controlled and an automatic system would allow only the authorized person to enter the highly secured and restricted area. There are various advantages of using RFID technology over barcode. They are no line of sight needed, scanning from a distance, greater capacity for information, possibility to write and therefore update information, ability of enabling triggered activities, identification of discrete items, improved data collection accuracy. RFID tags can be placed inside the packaging or even in the product itself, the readability of barcodes can be impaired by dirt, moisture, abrasion, or packaging contours. RFID tags are not affected by those conditions.

Process validation is establishing documented evidence which provide a high degree of assurance that a specific process (such as the manufacture of pharmaceutical dosage forms) will consistently produce a product meeting its predetermined specifications and quality characteristics. All pharmaceutical processes are required to be validated before they are used to manufacture a specific product. Documentation contains

product development data, product stability data, technical audit report, market complains etc. Documents like these and several others are required to be handled with utmost secrecy and confidentiality. RFID can be used for access control of these data.

By RFID technology product can easily be checked and it does not require human intervention or line of sight to read .RFID tagged items can be read even they are behind other items.

By attaching RFID tags to reusable assets, such as vehicles, containers, racks and other load carriers, these will be allowed to be uniquely identified. No extra time slowing down the movement of the asset will be needed since the reading operation will be automatic as the reusable asset passes check points or detection areas.

RFID technology can offer smart shelving and searching solutions. To do this all shelves in a warehouse should be first uniquely identified; this can be done using RFID tags. Each unique shelf location could then be used to associate it with a palette. Hence, whenever a new consignment arrives at the warehouse, the RFID system can direct the consignment to the most appropriate location within the warehouse. Since the RFID system is capable to keep track of all the empty shelf space in the warehouse, the whole process can be automated. The whole warehouse can thus be operated from a remote location.

As RFID offer better tracking, tracing and product visibility it ensures smart security and protection against thief.

Counterfeiting is a major problem in pharmaceutical industry. Every year pharmaceutical industries losses more than 750 crores because of counterfeiting. The World Health organization defines counterfeiting as “A medicine that is deliberately and fraudulently mislabeled with respect to identity and/or source. Counterfeiting can apply to both branded and generic products and counterfeit products may include products with the correct ingredients or with wrong ingredients without active ingredients, with insufficient or with fake packaging” [10].

## 6. CONCLUSION

Arena has been used to calculate cycle time for products in pharmaceutical industry. Simulated and theoretical results show the difference in the cycle length though warm up length is not included in the simulation. Expired batches are available with simulation result that is not included in the theoretical data. This expiration will affect the whole process, demand rate and the raw material in the inventory and the lead time.

Inventory control in pharmaceutical industry is very complicated as it includes receiving batches, quality control, product delivery, product record and overall inventory that require high effort. Implementation on RFID technology can make it easy and effective and reduces material handling time and counterfeiting of the pharmaceutical products up to a high rate. There are three major benefits of this technology such as, automation, visibility and flexibility. These three things are again interrelated. Flexibility is achieved by high visibility,

accurate data providing by the tags provide visibility to supply chain. So automation, flexibility and visibility can provide huge benefits for the industry but it requires time to implement. There is a huge scope for the implementation of this technology for the development and modernization of pharmaceuticals industry in Bangladesh. At present the initial costing may seems big. Case, pallet or item tagging or combination of all can be done and it may prove beneficial if proper planning and time is given for the implementation. If it becomes popular in pharmaceuticals industry, then combined implementation of RFID technology and Arena simulation may prove highly beneficial in the long run.

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## 8. NOMENCLATURE

Symbol	Meaning
P	Pharmaceutical products
d	Demand of products
S	Set up time
Q	Quantity produced of a product in a cycle
T	Cycle time