ELIMINATION OF TIME DEPENDENCE OF INFORMATION VALIDITY BY APPLICATION OF RFID TECHNOLOGY

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Abstract: Following article deals with certain aspects of data acquisition for MRP, ERP and MES type of information systems from a shop floor level. Problems of time dependence of data validity are discussed and method of their elimination by application of radio frequency identification technology (RFID) is suggested.

1 INTRODUCTION

Since introduction of information systems for general management of processes at manufacturing companies, major obstacle on the way to their optimal performance was a lack of reliable and on time information. Shop floor level information was inaccessible directly for information systems and until nowadays inserted into the system by intermediary subject (e.g. human operator). Development of radio frequency identification technology or RFID for short, for the first time makes processes at shop floor visible for these systems. Following article will explain the major hindrances information system face during management of company processes. It will point out the drawbacks of current information acquisition for MRP, ERP and MES types of information systems. Then it will propose a way in which time dependence of information validity and amount could be eliminated by use of RFID technology. Subsequently implementation problems, benefits and goals of RFID technology use are discussed. Finally future development and application of RFID are indicated.

2 BACKGROUND OF RESEARCH

Product innovation is the greatest driver of company growth. Product proliferation and customization leads to greater fulfillment of customer demands and therefore the growth of market share. On the other hand customization of products adds greater complexity to product identification and company logistics by increasing assortment (Viswanadham, 2002).

Competitive market environment force companies to cut their costs and thus reduce their prices. For last decade main philosophy for cost reduction for OEMs was a lean manufacturing (Taylor & Brunt, 2000). The key to lean manufacturing is to compress time by eliminating waste and thus continually improve processes inside the company (Czarnecki & Lloyd, 2000) . Waste can be defined as any element of production that only increase cost without adding value the customer is willing to purchase (Ohno, 1988).

There are seven basic wastes in manufacturing process:

- overproduction
- excess inventory
- idle machine or operator time
- manipulation
- non-value added material flow
- defects
- extra processing

To eliminate excess inventory, manipulation and non-value added processes just-in-time (JIT) deliveries were applied in conjunction with lean manufacturing philosophy. In reality JIT deliveries were conducted in small batches several times a day. Basically JIT system moved a stock from OEMs to their suppliers. Consequently, to resolve the problem, just-in-sequence (JIS) system was introduced (ALTA/AS Whitepaper, 2003). Philosophy behind just-in-sequence supply means deliveries of the products directly to the assembly line of OEM not only at exact amount

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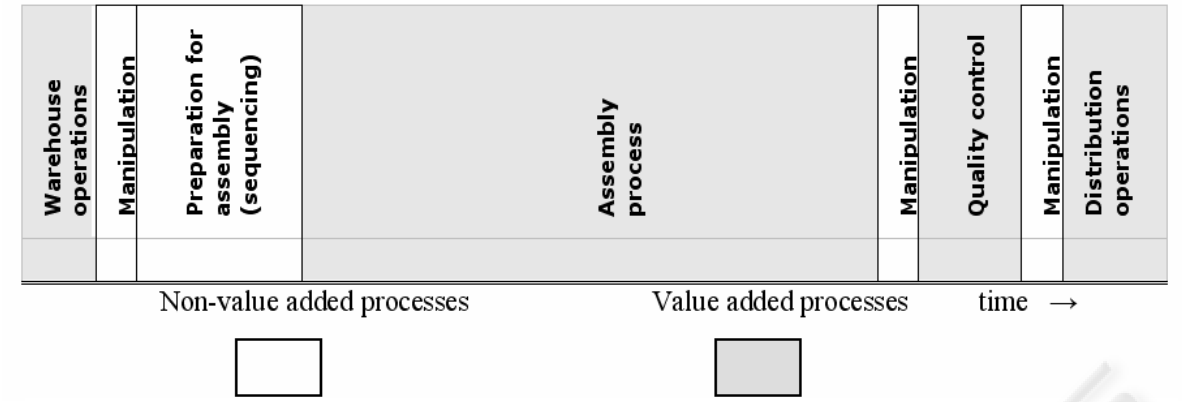

Figure 1: Scheme of processes at OEM.

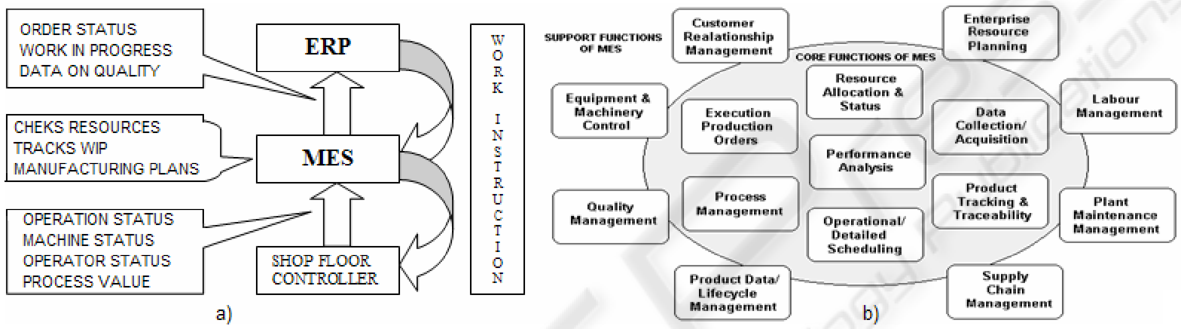

Figure 2: a) Scheme of information flow between ERP,MES and shop floor controllers, b)MES functional model.

and time (like in JIT) but also at right configuration and right order - sequence. If part or module is not delivered in right sequence and time, it cannot be assembled on the individually configured product, coming to the assembly line in certain sequence and therefore it will cause an assembly line to stop. Interruption of the assembly process will induce a considerable financial loss not only for OEM but also for all elements in supply chain [6]. This means that 100% on time, right sequenced deliveries for elimination of excess inventory; manipulation and non-value processes should have a highest priority for the management of OEM (ALTA/AS Whitepaper, 2003). Figure 1 shows the basic processes of OEM.

As it is evident the most time consuming non-value added process is preparation of delivered products for assembly process that rarely means more then placing them in right order – sequencing.

Management of OEM has two possibilities to eliminate non-value added processes. First is to apply philosophy of reengineering and change the structure of processes (Silva, Ramos &Vilarinho,2003). Effective and global, process restructuring is very time consuming and is usually associated with the considerable investment into the infrastructure (Kumar, 1996). Second one is to improve the performance of company's information system trough which processes are managed (Lawless, 2000). OEMs usually use Material Requirement Planning/ Manufacturing Resource Planning (MRP/MRP II), Enterprise Resource Planning (ERP) and Manufacturing Execution System (MES) type of systems for general management of the company processes (Bernroider&Koch, 2000). MES type systems represents a mid-layer between MRP/ERP and shop floor controllers (Choi&Kim, 2002) (see fig.2a).

There are several general models of typical MES functions that are principally divided into core and support functions. The core functions deal primarily with actual management of the work orders and the manufacturing resources. Other functional capabilities of MES may be required to cover support aspects of the manufacturing operations. A MES system by Kisiel (Kisiel, 2001) conducts following functions according to fig. 3b. MESA International (MESA Whitepaper 2, 1997) presents another attitude to MES functionalities that is more or less based on the assumption of profitability to begin to deal with wider model of basic elements to ensure incorporating all-important functions into MES.

Product Tracking and Traceability as a core function of MES (figure 2b) is aimed to provide "first hand" information about real material flow inside the company for MES and ERP systems. ERP/MES systems at OEM usually require following information on products and material flow:

- type of item
- individual identification number
- manufacturer/ supplier
- date of manufacturing
- location (current)
- item path
- batch details
- package details

The sum of all mentioned information ERP/MES system depends on, can be characterized as 100% requirement of those system in certain discrete period of time. Based on the mentioned information on material flows all other functions, such as planning and analysis of performance, are conducted. An important function of MES is to provide a feed back to ERP with aim to adjust their scheduling data and algorithms in more realistic manner (Modrak, 2005). Major drawback of MES/ERP systems is that they do not have an access to detailed information (Vokorokos, Adam & Petrik, 2004). Therefore they have no idea of what is really happening to material flow on the shop floor (e.g. subcomponents not being where they were expected etc.) (Chappell & Ginsburg, 2003). Also they do not have an ability to collect information independently. Basically it means that all data that information systems operate with are "fed" to them by intermediary subject, usually human operator (Rockwell Automation Whitepaper, 2004). Mentioned drawback leads to insufficient coordination between material and accompanying information flows and so-called bull-whip-effect (Donovan, 2005). Apart of bad coordination, information on material flow is time dependent so it is already outdated when inserted into the information system by human operator. In time 0, we will call it a synchronization of flows, when information is put into the system, validity error $\Delta = 0$. Until the next synchronization information become more and more outdated. Application of the standard mathematical procedure of data validity and reliability calculation and proposed by Werner,

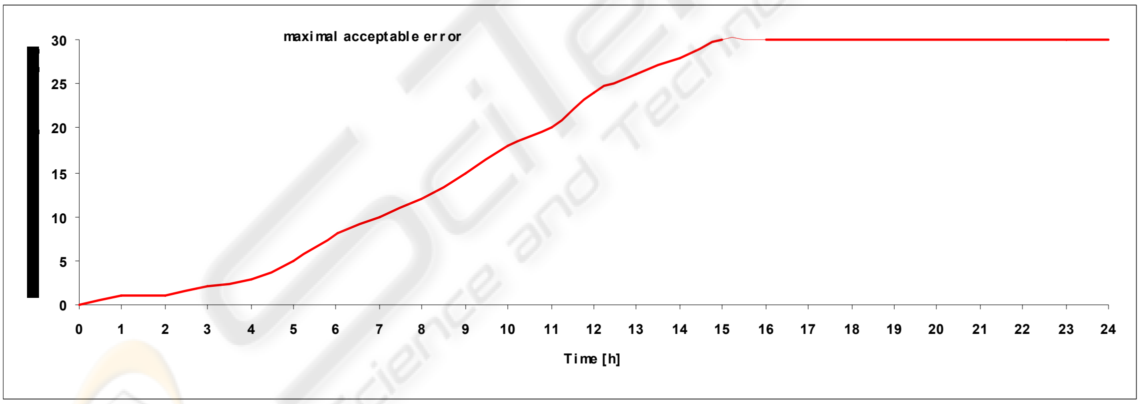

Figure 3a: Time dependence of data content validity.

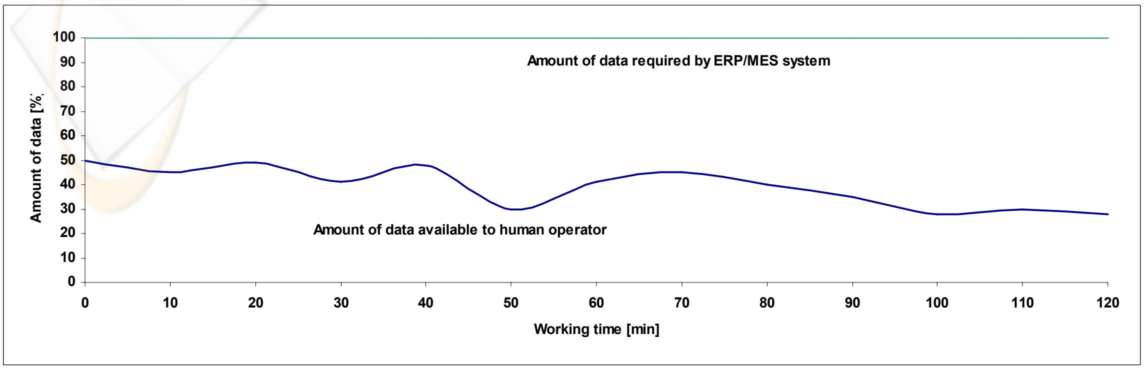

Figure 3b: Time dependence of data availability.

Wigert & Hampel 24-hour cycles of synchronization used for simulation of manufacturing processes allows us to compile the estimated data content validity error curve, shown in fig.3a. Another problem of information on material flow is its availability and amount. Human operator can input into the system only certain amount of information in discrete period of time if they are available. The information on material flow available to human operator at every point of manufacturing process without tracking & tracing of items is type of item, supplier, batch details and package details. Assuming those information as a part of 100% data required by ERP/MES systems and estimated periodicity of error occurrence during the 120 min. discrete period of operator's working time (Ohuchi & Okuda, 2001) following curve of time dependence of data availability can be compiled (see figure 3b). It is obvious that there's a considerable, time dependent gap between amount of information on material flow required by ERP/MES system and amour available to operator.

3 SMART LABELLING AS A SOLUTION

Tracking & tracing of products trough whole manufacturing process at OEM is one of the solutions for delivery of missing information on material flow (e.g. individual identification number of item, current location, date of manufacturing etc.) to ERP/MES system to bridge the information gap. Tracking & tracing of items was associated with "heavy metal" factory automation or labor-intensive bar code labeling systems for last decade (Chappell & Ginsburg, 2003). "Heavy metal" automation always means "heavy" infrastructure investments (Kumar, 1996). Bar codes have several drawbacks such as being a line-of-sight technology, environment sensitive and carry only a small amount of information.

Another step in tracking & tracing of products at every point of manufacturing process is an application of radio frequency technology or RFID (AutoID, 2002). RFID technology eliminates nearly all drawbacks of the bar codes and if correctly applied, is able to provide ERP/MES systems with correct, reliable, on-time information. Usual scheme of RFID industrial system is shown in fig.4.

RFID tags could provide 100% of above-mentioned information to ERP/MES systems because they could store much more data then a bar code and they could pass them to the information system at every point of manufacturing process (even directly from the manufacturing equipment or assembly line) since they do not require to be in sight of an optical sensor. Information between RFID tag placed on the item and ERP/MES system is shared by so-called Electronic Product Code (EPC). There are several types of codes known by their bit memory (64 bit, 96 bit etc.) but 96bit code is considered as most perspective one (AutoID, 2002) 96bit code provides a possibility to uniquely identify 68 billions of products types manufactured by 268 millions of companies (AutoID, 2002). Exchange of information is conducted automatically, without any intervention by a human operator. This can reduce sequencing, paper form fulfillment and checking time by up to 62%. Higher level of information on material flow, received by information system will lead to reduction of manipulation and internal transport operations by 6-

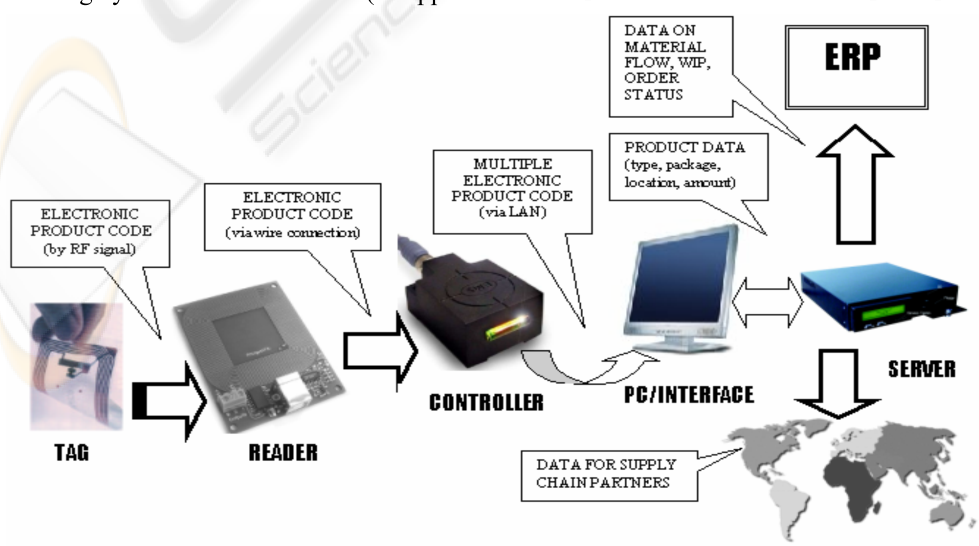

Figure 4: Basic scheme of RFID system configuration.

13%. This also depends on the degree of current OEM factory automation. Case studies proved that RFID technology reduced usual error rate (e.g. delayed supplies and even incorrect deliveries) of 1% to 0,1%.

Application of RFID technology for tracking and tracing of material flow will impact the whole performance of information systems in terms of information validity, availability and amount. Use of RFID system will eliminate time dependence of amount and quality of information available for ERP/MES systems.

4 DISCUSSION

Implementation of RFID technology into the OEM factory and whole supply chain can face certain problems associated with introduction of cutting edge technology as phenomenon. Although far less expensive then "hard" automation RFID technology requires considerably greater investments then simple bar coding. Advantages of RFID technology over bar coding are not always explicit and calculable. Major companies such Proctor & Gamble, Wall Mart or U.S. ministry of Defense already appreciated benefits of such a system. Proctor &Gamble, for example, expects to reduce its $3 billion inventory cost to $2 billion by application of RFID technology (Rockwell automation Whitepaper, 2004). Although market leaders expressed their trust to RFID technology it is speculative whether smaller OEMs can achieve the same level of effectiveness and cost saving. Without clear vision of profit they will not cover adoption costs of RFID technology by their own will. More likely they will be forced to introduce RFID by their market leader customers like in a case with U.S. DoD's RFID mandate released in January 2004. Department of Defense required its top 100 suppliers to introduce RFID tags into their supplies (DOD Information guide, 2005). Then it will be up to OEM to create new business models and find new a scope of RFID application to maximize a level of profit. For OEMs there are many areas of RFID use in-house. Not only tracking & tracing but also product genealogy, plant asset management, inventory visibility and labor usage could be greatly improved by introduction of RFID technology. Last but not least problem is a lack of widely accessible information on profits of this technology. Only 35% of consumers are aware of RFID in some way (Stageman, 2004).

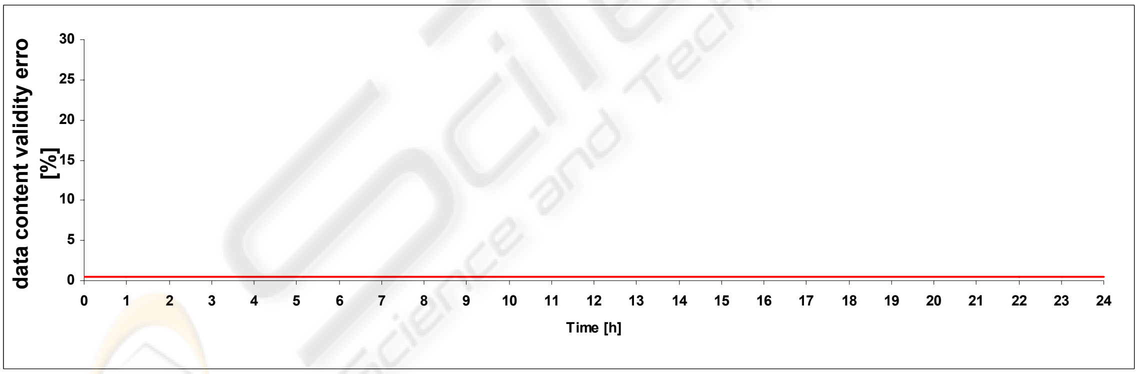

Figure 6a: Time dependence of information validity after application of RFID technology.

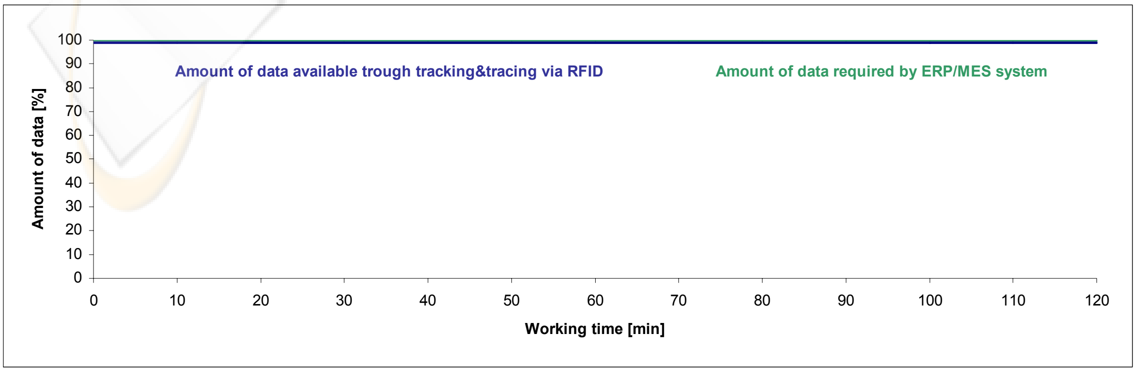

Figure 6b: Time dependence of available data amount after application of RFID technology.

5 FUTURE TRENDS

If RFID technology is to succeed in today's competition, it must be economically viable. Although RFID already found its place in supply chain and warehouse operations it is arguable if its short-term return of investment justifies initial cost of implementation. A major problem of today's RFID is a lack of unified electronic product code, making RFID tags an "internal inventory" of individual companies or supply chains. Although EPC global standards were adopted, for really wide spread use of RFID it will be necessary to introduce certain standardized format of codes as it was in case with bar codes. To make tags economically sensible for item-level tagging of low cost products it is essential to cut their costs from current ¢ 50 - $2 to maximum ¢ 5 (Sarma, 2003).Mentioned future development of RFID technology will allow better management of in-house and supply chain processes with greater accuracy and provide unprecedented visibility to the material flows.

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