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A Study of RFID Smart Parts

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Abstract:

After exploring industrial and consumer applications of Radio Frequency Identification (RFID) and reviewing the state-of-the-art and development in RFID technology, the paper put forward RFID smart parts. A currently operative smart part based manufacturing system is described which uses RFID as the key technology. The role of them in the emerging Wireless Internet Manufacturing field is highlighted.

Keywords: RFID; Application; Smart Parts; Manufacturing

Introduction

Personalized products and tailor-made solutions are taking over large shares of the marketplace from mass produced goods and standardized solutions respectively. The so-called smart parts based manufacturing system addresses these concerns well. The smart part will introduce the operating workers or automatic NC machines what and when to do. Uniquely identified individual parts can be processed according to their specific requirements based on individual customer preferences. Therefore, there is the need to correctly identify every part to ensure reliable process control in such a flexible and customer oriented manufacturing system.

1. RFID Technology

1.1 Operating Principle

The structure of RFID system is showed on the Fig.1. The system consists of three main portions: Reader/Programmer, Antenna and Tag or Transponder. Today the vast majority of 13.56 MHz system operate "passive", without the need of an integrated battery. They have positive implications on cost, lifetime and the environmental situation. The basic operating principle of passive 13.56 MHz and <135 KHz RFID systems is energy and data transmission using inductive coupling (see Fig.2). This is exactly the same principle as used in transformers. Data transmission from the reader to the tag is done by changing one parameter of the transmitting field (amplitude, frequency or phase). The return transmission of the tag is done by changing the load (amplitude and/or phase).

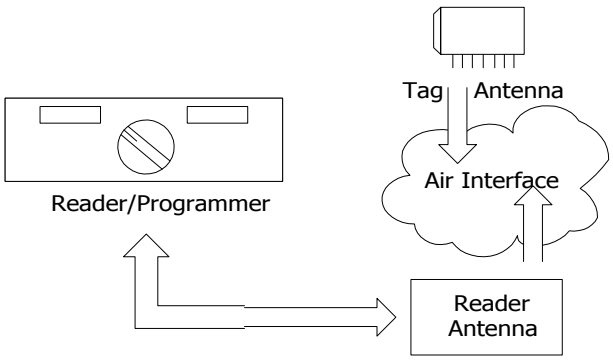

Fig.1 Structure of RFID System

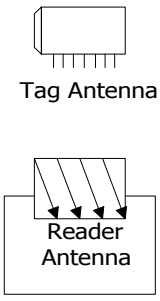

Fig. 2 Inductive Coupling

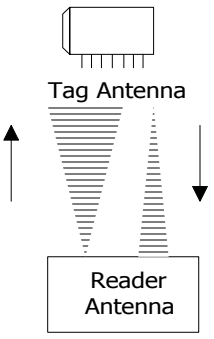

Fig. 3 Propagation Coupling

UHF- and MW- systems (e.g. 400-1000 MHz and 2450 MHz, especial 5.8-GHz) RFID systems make use of conventional electromagnetic wave propagation (see Fig.3) to communicate their data and commands, and in the case of batteryless tags also to power the RFID transponders. The basic operating principle of this RFID system is energy and data transmission using propagating radio signals ("E" field transmission).

1.2 Operating Distance

The operating zone of passive inductive RFID systems (13.56 MHz and <135 KHz) is in the "near field" of the read transmission antenna, which results in achievable operating distances of approximately the diameter of the transmission antenna. Differences are mainly given by the output power of this RF-module and by the sensitivity and the selectivity of its receiver. The "proximity" <100mm; "medium range"<400mm; "vicinity" (long range): 1.5m; "far field"(2450 MHz) 0.5 to 12 meters (passive power) and >30 meters (active power tags depending on microwave frequency).

1.3 Some characters of Tags'

Memory: Like common computer memories there are three types: read-only (ROM), write once read many (WORM) or read/write (EPROM or EEPROM). The memory sizes are very differences from 1 bit, 48bit and 64 bits (8 byte) to several Mbytes.

Physical Forms: RFID tags come in a wide variety of physical forms, shapes sizes and protective housings. A 0.3 mm^2 tag (2450 MHz, 128 bits, 300mm) has researched and developed. Animal tracking tags, inserted beneath the skin, can be as small as 0.16mm^2. Tags can be screw-shaped to identify trees or wooden items, or credit-card shaped for use in access applications.

Cost: Usually ultra low cost from 1 to 10 cents each, the active ones are expensive and the long range tags are expensive too. With increasing use, the production costs and hence prices will drop.

1.4 Miniaturization

Japanese have been developed an ultra-small (0.4 x 0.4=0.16mm^2) RFID chip named mu-chip [1]-[2]. The chip, which has a 128-bits memory, is designed to be 0.06 mm thick so that it can be applied to paper and to thin paper-like media. At 2450MHz the maximum communication distance between the mu-chip and a reader is 300 mm.

1.5 Noticeable Problems

Absorbing: Differing from UHF- and MW- systems, the RF field at 13.56 MHz is not absorbed by water or human tissue, which allows operation through water or human beings. The influence of water or moisture on the performance is negligible. 2450 MHz UHF and microwave signals are attenuated and reflected by materials containing water or human tissue, work flat on metallic objects and easily penetrate wood, paper, cardboard, clothing paint, dirt, and similar materials. This allows higher data rates than the inductive systems and allows many systems to operate independently without interference within a small operating area.

Spectrum: Choice of field or carrier wave frequency is of primary importance in determining data transfer rates. In practical terms the rate of data transfer is influenced primarily by the frequency of the carrier wave or varying field used to carry the data between the tag and its reader. Generally speaking the higher the frequency the higher the data transfer or throughput rates that can be achieved. This is intimately linked to bandwidth or range available within the frequency spectrum for the communication process. The channel bandwidth needs to be at least twice the bit rate required for the application in mind.

2. The Applications of RFID

Almost 100 million contactless 13.56 MHz cards sold in the world so far. It is used in library field, carton marking, airline baggage sector, express parcels and high value/big ticket item management, advanced shipping label and item level identification where the primary identifier, barcode, suffers from a line of sight problem. The normal application areas are: Transportation and logistics; Security; Waste management; Postal tracking; Airline baggage reconciliation; Electronic article surveillance - clothing retail outlets being typical; Protection of valuable equipment against theft, unauthorized removal or asset management; Controlled access to vehicles, parking areas and fuel facilities - depot facilities being typical; Automated toll collection for roads and bridges - since the 1980s, electronic Road-Pricing (ERP) systems have been used in Hong Kong; Controlled access of personnel to secure or hazardous locations; Time and attendance - to replace conventional "slot card" time keeping systems; Animal husbandry - for identification in support of individualized feeding programs; Miniature tags can be placed within tool heads of various types such as block or Cat V-flange, or even within items such as drill bits where individual bits can be read and selected by reader guided robot arms. Automatic identification of tools in numerically controlled machines - to facilitate condition monitoring of tools, for use in managing tool usage and minimizing waste due to excessive machine tool wear; Identification of product variants and process control in flexible manufacture systems; Sport time recording; Electronic monitoring of offenders at home; Vehicle anti-theft systems and car immobiliser; etc.

3 Applications in Manufacturing

Radio frequency tagging is no longer just a science project—it's a full-fledged, mainstream supply chain technology. First, these companies adopted RFID because a compelling business need could not be filled by any other technology. These firms are technology leaders, but they implemented RFID for purely business reasons. Second, they paid careful attention to the systems integration aspects of the adoption. The competitive advantage to be gained comes not from RFID technology itself but from the improvements to software systems and business processes that would be impossible without the RFID devices. Finally, each company sees its RFID project as but one phase in a continuous improvement process. The lessons they've learned are already being put to use in revised procedures and new system designs.

The Ford Motor Company successfully used RFID to improve products quality on the automated assembly production line [3]. The Ford Motor Co.'s facility in Cuautitlan, Mexico, produces 300,000 to 400,000 cars and trucks each year. Ford builds vehicles in Cuautitlan using a method of just-in-time suppliers with vendors supplying parts on an as-needed basis. Because of this method, it's crucial that inventory and tracking in the plant be precise and closely monitored. However, keeping track of inventory and production automation in a large facility can be a daunting task. Before Escort Memory Systems (EMS, Scotts Valley, CA) was called in, Ford used a manual coding system to track auto and truck frames as they went through the final assembly, paint and body shop areas of the production line. Unfortunately, this manual system was very ineffective due to frequent error and costs associated with production oversights. Paper identification sheets, used to track the vehicles, were being lost, switched or ruined, making quality control difficult. The 48-byte memory and 1,200bytes/sec transfer rate could easily handle Ford's 23-digit reference serial numbers and production rates.

Ford Motor Co. is using RFID tags to streamline its Essex engine plant in Windsor, ON. This facility assembles about 700,000 engines a year in almost a dozen different varieties. Some engines hang from overhead hoists during assembly; others proceed down the production line on transport pallets. To properly meet the Just-in-Time (JIT) requirements of the final assembly plants Essex feeds, Ford managers must tailor their lines' output. That means you may find a 3.8-liter engine for a 1998 automatic transmission vehicle following directly behind a 4.0-liter model for a 1999 stick shift. Quality considerations dictate that an avalanche of information—from test data to torque levels—must be recorded for each engine built.

Like many heavy machine producers, Ford uses RFID tagging to enable the only manufacturing process that will keep it profitable. It has become such a routine manufacturing tool that RF parameters such as tag frequencies and air interface protocols take a back seat to more pragmatic concerns. It had to interface to [the plant's] Allen-Bradley PLC 5 installing the Escort Memory Systems (EMS) RFID system at Essex. Trade Electric and EMS engineers had to "teach" the Allen-Bradley (AB) controller how to talk to the EMS RFID controller.

4. RFID Smart Parts in the Process of Manufacturing

4.1 Concurrent production process (see Fig. 4)

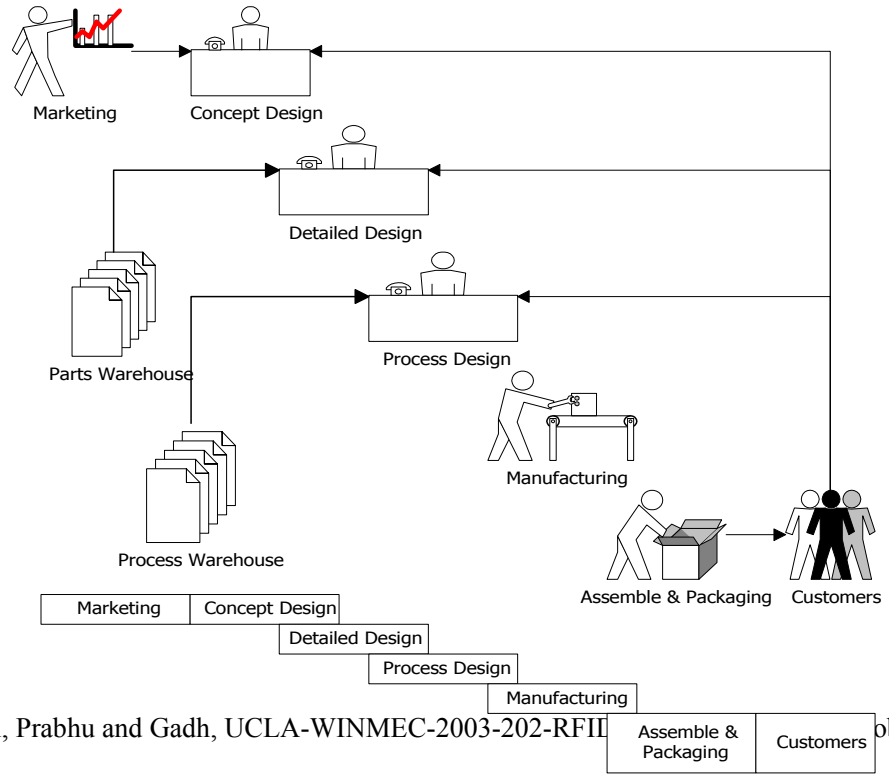

Fig4. Concurrent Manufactruring

In the structure of concurrent manufacturing some designs can be done in the same time. It will save time and enhance the ability of competition of industries. It is a kind of new advanced manufacturing technology. If the RFID technology is introduced into the manufacturing process, a complete new mode of manufacturing will be produced as showing in the Fig.5 that is a mode of manufacturing including wireless Internet and RFID technology. Here the RFID plays an important role in the manufacturing process. It can connect the message of whole manufacturing processes and customers' together. And it is easy for controlling and administrating the products production. The information or manufacturing instructions can be transferred by

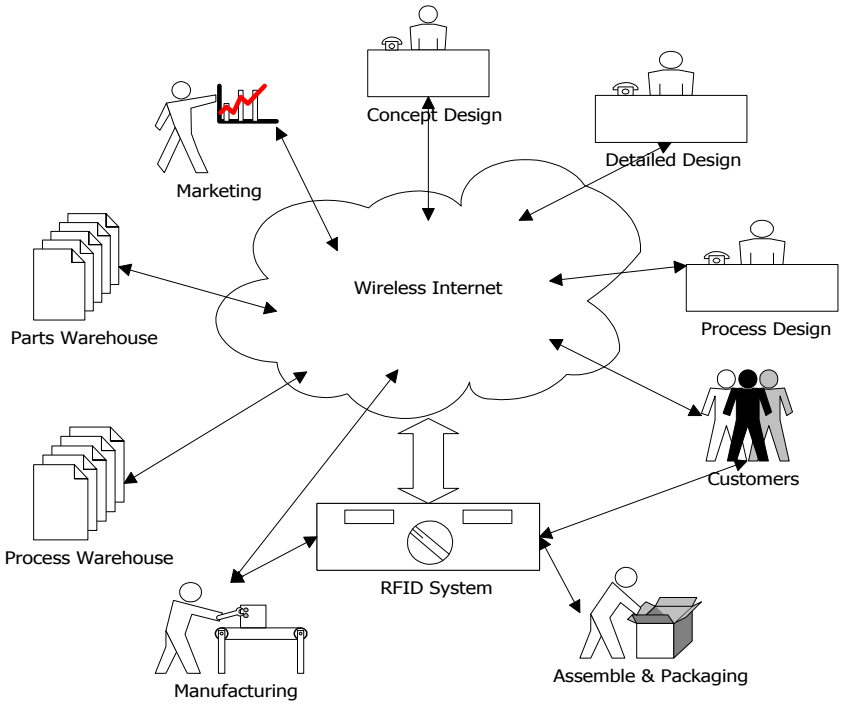

Fig. 5 RFID & Wireless Internet

Wireless Internet and RFID at any time.

4.2 RFID Smart Parts in the Process of Manufacturing

As an example of smart parts is AT FORD'S ESSEX PLANT in Windsor, Ontario, Escort Memory Systems tags carry all instructions needed to assemble each engine, as well as all test data accumulated during manufacturing. Designers design product according to customers' orders and the design information is stored in the RFID tag's memory after design that will instruct the manufacturing process. By the wireless Internet technology, people can know the whole process of manufacturing including assembling and quality information. In the process of manufacturing the designer could change the design and manufacturing process immediately by wireless Internet if the customer present some new requirement before the manufacturing process finished. The operating worker will receive new manufacturing instructions at a quiet state. The smart parts will tell the operating worker how to machine them. The whole manufacturing process will be under the control automatically. The material will be tagged as it goes out from warehouse and it will be smart until all processes have finished. The tag could be tore off and useable again. For some important part, the tag will be tagged at the whole life cycle. It will record the repairing, inspecting or history information of the part. This information will help manufacturers and merchants improve their designs and services. It will set up a system for tracking important part in its life cycle. On the other hand, the RFID tag will be a security brand (product ID) of the product to prevent counterfeit and protect the benefit of the producers.

If the smart part is the key part of a product, people could simply control the manufacturing of the key part to get the aim of controlling the whole production. Under this condition the key part will have the longest machining time or very important or being the main part of the product and so on. This kind of control method is optimization control. The RFID could make the optimization control be timely, reality and correct. The useful information could be transmitted at any time and instruction could be sent out at once. The manager especially the customer could know the condition of the product or the status of commercial article. It shows the important role of smart parts in the process of manufacturing and market.

5. The Support of Technology

The followings are famous international organization and companies that can supply RFID technology in the world.

AIM (Automatic Identification Manufacturers) serves over 1000 member worldwide and has some 14 licensed national and regional affiliates around world. They are in the Argentina, Belgium, Brazil, Denmark, Finland, Germany, Italy, Japan, Mexico, Netherlands, Norway, Russia, Sweden, the United Kingdom, and the United States.

Texas Instruments Radio Frequency Identification (TI-RFid™) Systems is an industry leader in radio frequency identification (RFID) technology and the world's largest integrated manufacturer of RFID tags, smart labels and reader systems. With more than 200 million tags manufactured, **TI-RFid** technology is used in a broad range of applications worldwide including access control, automotive, document tracking, livestock, product authentication, retail, sports timing, supply chain, ticketing and wireless payment. For more information visit the company's Web site at www.ti-rfid.com.

Philips Semiconductors, headquartered in Eindhoven, The Netherlands, employs over 32,000 employees in more than 50 countries. With sales of around $4.3 billion in 2002, Philips Semiconductors is one of the world's top semiconductor suppliers and has 18 manufacturing and assembly sites, 30 design centers, four system labs and more than 100 offices. Manufacturing facilities are in the USA, the Far East and Europe serving customers worldwide. It offers contactless smart cards and is a global leader in RF technology.

Escort Memory Systems (EMS) provides RFID solutions for every link of the Supply Chain. Since 1985 EMS has been developing, manufacturing and supporting RFID installations in companies around the globe. It makes Supply Chain customers with applications such as WIP, Quality Control, Warehousing, and Logistics have EMS RFID for inventory management, tracking, and data collection systems. EMS uses technology that has the added advantage of being able to read through water, oil, concrete, and a variety of other elements without line of site requirements, or waiting for each individual tag to be read. EMS has emerged as the global leader in providing RFID solutions in this rapidly expanding industry.

6. Conclusion

Though the RFID technology had been used in many fields, the researches are still continuing. The RFID system will be smaller and smaller . The microcontroller contactless identification system and access control have been studied. An on-chip RFID receiver stage will arrive. The collision is a big problem in the RFID technology. Some researches told us how to avoid it. Before any applications of the RFID technology, the correct systems and optimizing ranges must be properly selected. There is optimization read range in RFID systems. The RFID technology will bring great changes in manufacturing industries and the smart parts in Manufacturing will be possible. It will help people get complete information and control every process in machining, supply, maintaining and retail etc. The RFID technology will play more and more important roles in the Manufacturing and the Wireless Internet Manufacturing [4] in the future.

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