RFID TECHNOLOGY IN THETEXTILE INDUSTRY

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Abstract:

RFID (Radio Frequency Identification) is a wireless communication technology that is used in physical markers (RFID tags) to mark products. RFID is being increasingly applied in everyday life and thus is competing with widely used bar codes.
RFID technology can be used to build systems aimed at automatic identification of tagged objects. In production-commerce plants in the textile sector it can enable strict control over both production and storage/sale processes. The best thing about RFID technology is that it is functional, with no need to 'see' the tag by the interrogator.
When a tagged object enters the reading zone of an interrogator, the interrogator signals the tag to transmit its stored data to the controller via radio waves.
Unlike bar codes technology, RFID can be much more effective in the process of production and storage of certain objects.
Undoubtedly, both production and commerce companies in the textile branch will significantly benefit from RFID applications.

Keywords:

Textile, RFID technology, automatic identification, tag

Introduction

RFID (Radio Frequency Identification) is a wireless communication technology that is used in physical markers (RFID tags) to mark products, as well as in bar codes technology. RFID technology has been in use for more than 50 years. It was devised during the Second World War when radio frequency transponders were first installed on aircraft in order to identify the planes and state whether they were friendly or not. In the 70s RFID tracking technology was implemented in the US Nuclear Weapons Laboratory at Los Alamos, and in early 80s initial applications were used to identify cattle and to track railway cars[1,8].

Nowadays RFID technology has many different applications. These include systems for:
- tracking cars,
- access control, such as keyless entry and employee identification,
- quick product identification during purchase-sale,
- automatic toll collection at the entrances to turnpikes, bridges or tunnels,
- animal tracking, with no need for physical capture, for instance in forests or mountains,
- vehicle tracking in cases of theft,
- vehicle protection – immobilizers,
- infant identification in hospitals.

RFID is being increasingly applied in everyday life and thus is competing with the widely used bar codes. The question appears: Does the application of radio transponders in the description of products or semi-finished products (objects in general) enable the implementation of IT systems in their identification without supervision? Possible and very useful applications include automatic management of semi-finished products on production lines or automatic product identification in stock-rooms or shops [1,3,4,8].

Nowadays the only barrier slowing down the process of the RFID implementation is the price of RFID transponders, which are much more expensive than popular bar code transponders. This is particularly visible in the Polish economy, where RFID technology is applied only in limited fields. However, the technology is successfully used and can be applied in several sectors of the economy, including textile industry plants. Table 1 shows the comparison of traditional bar code technology with RFID technology [1,9].

Table 1. Comparison of bar codes vs. RFID system characteristics.

Parameter / System	Bar codes	RFID system
Data transmission	optical	electromagnetic
Memory / data size	up to 100 bytes	up to 128 kbytes
Tag writable	no	possible
Position of scan / reader	line-of-sight	non-line-of-sight possible
Read range	up to a few metres (line-of-sight)	from 1 centimetre to a few metres, depending on the system
Access security	low	high
Environmental susceptibility	dirt	low
Anticollision	Not possible	possible
Price	< $0.01	$0.1 to $1 for active tags

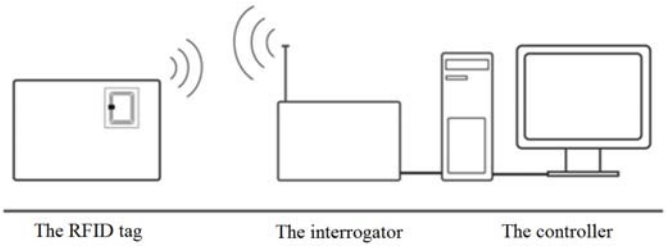
How RFID technology works

RFID systems consist of three basic components: a tag (also called a transponder), an interrogator (other names: a reader

or a read/write device), and a controller (sometimes called a host) [1,9] (IT system tip) (picture 1).

- The RFID tag (picture 1) is a complex component composed of :
  - a semiconductor microchip,
  - an antenna,
  - a battery (optional).

  The RFID tag is set in material which protects it from the external environment. Examples of material can be: plastic cards, pills, labels etc., depending on the application.
- The interrogator (picture 1) is a reading or sometimes read/write device which is composed of an antenna, an RF (Radio Frequency) electronic module, and a control electronic module. It picks up the information recorded in the passive tag or collected in the active tag.
- The controller (picture 1) is a device which most often takes the form of a PC or a workstation running database and control software.



Picture 1. Scheme of RFID system.

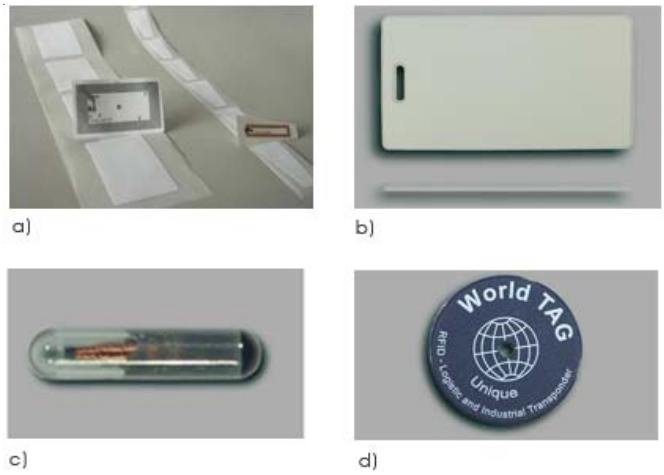
The RFID tag and the interrogator communicate information between one another via radio waves. When a tagged object enters the read zone of an interrogator, the interrogator signals the tag to transmit its stored data to the controller. Specific action is taken, depending on the kind of software installed in the controller. For instance, the controller may use the data to inventory the objects in a database, or it can use the information to redirect the object on a conveyor belt system [1,2,3,5].

RFID tags

The basic function of an RFID tag is to collect, store and modify data and send them to the interrogator. An electronic chip and an antenna are encapsulated in a package protecting it from the external environment. The package may take different forms, depending on the conditions and functions of the tag use. For example, tags used in the systems of automatic toll collection take the form of plastic cards. In systems of prison management RFID tags are attached to prisoners and warders' shirt cuffs. In drug production RFID tags are fastened to the edges of plastic boxes to track them on conveyor belts [3,4]. Examples of the packaging of tags are shown in picture 2.

Taking the method of power supply into account, RFID tags can be divided in two groups: passive and active [1,15].

Active RFID tags contain an on-board power source, such as a battery. The batteries can last from two to seven years. Owing to batteries, active tags can transmit information over much longer ranges, up to 30 metres. Furthermore, these types of tags typically have larger memories, up to 128 kbytes. However, they are much larger and more complex than their passive counterparts, making them more expensive to produce [1,3,15].



Picture 2. Packaging of RFID tags: a – label, b – plastic card, c – glass capsule, d – counter.

Passive RFID tags have no an on-board power source. Instead, they derive power to transmit data from the signal sent by the interrogator, which is much less than if a battery were on-board. Thus the effective range of these tags is much shorter than that of active tags, sometimes under 0.6 metres. Because of this, they require interrogators with more powerful antennas. Moreover, they have less memory capacity, on the order of a few kbytes. Some passive tags do have batteries on-board but use them only to power additional on-board electronics, for example temperature sensors. This is a common practice in the food industry, where RFID tags are used to monitor the temperature of the product during shipment and storage.

Another differentiating factor between various RFID tags is memory type. Accordingly, tags can be [1,3,4]:

- Type R/O (Read/Only) are tags programmed during collecting data. The unique serial number of the tag composes the data recorded. The tag can only be read, because its serial number is static and cannot be altered.
- Type WORM (Write Once, Read Many Times) is just as explained.
- Type R/W (Read/Write) are tags that have multiple read/write functions and capabilities.

Radio wave transmission between RFID tags and interrogators occurs, similarly to radio communication and radio broadcasting, on the following bands [1,12]:

- LF (Low Frequency), band between 125-134 KHz, not used in radio broadcasting
- HF (High Frequency), 13.56 MHZ, radio stations' band
- UHF (Ultra-High Frequency), band between 860–960 MHZ, used by the mobile telephone industry
- Microwaves – band 2.5 GHz and above, used in microwave ovens.

RFID interrogators

RFID interrogators equipped with radio-receiving antennas in order to communicate with RFID tags. The antennas send and receive a beam of electromagnetic radiation in the appropriate frequency. RFID interrogators enable data transmission between RFID tags and IT systems. The transmission can be divided in three phases [5,6,11,18]:

Phase 1 – an interrogator sends a beam of radio waves, which causes an induction current in a tag, which in turn powers the electronic system of the tag.

Phase 2 – the charged tag sends back its unique factory-made code or data previously written by a user.

Phase 3 – with WORM and R/W tags , data is written via radio waves of appropriate modulation. In fact, data transmission is a bit more complicated. Read or written data is reversely verified (proper algorithms of correctness of the data read/ write process are used).

There are two types of RFID interrogators: stationary and portable. The right choice depends on the application.

Stationary interrogators are used in furnishings (Picture 3). They are most commonly applied on production lines, in pikes (at stock-room entrances) or directly, i.e. on fork trucks [2].

Picture 3. Stationary interrogators and RFID antenna.

Picture 4. Portable interrogators.

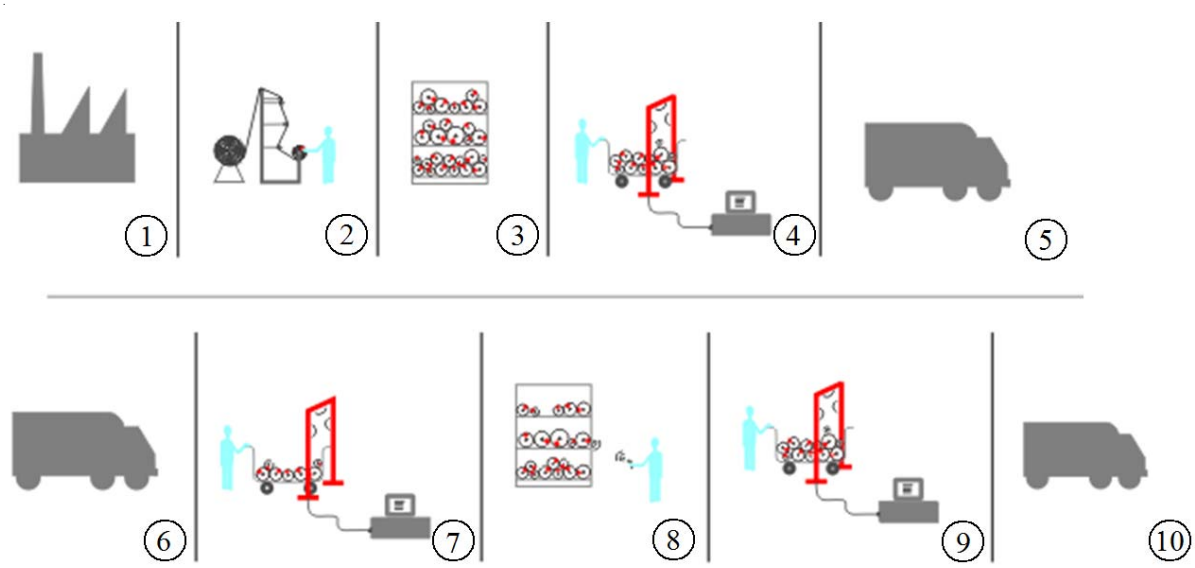
Portable interrogators interface with portable data terminals (Picture 4). The mobility of these interrogators is a real advantage - they may be used in any area of a production line or stock-room. The system's user, for example a stock-room or production worker, directly or indirectly (depending on terminal version: on-line, off-line) verifies or modifies data in the IT system [4, 7, 17]. A terminal working on-line communicates directly with the IT system via WiFi net, while a terminal working off-line writes data in its memory and then sends it to the IT system via a communication dock.

Example of RFID application

RFID technology can be used to build systems aimed at automatic identification of tagged objects. In production-commerce plants in the textile sector it will enable strict control over both production and storage/sale processes. The best thing about RFID technology is that it is functional, with no need to 'see' the tag by the interrogator. Unlike bar codes technology, RFID can be much more effective in the process of production and storage of certain objects.

The scheme below shows how RFID technology could be adapted in a fabric production/storage/sale textile factory.

Hypothetically, there is a production unit with stock-rooms and wholesale units in the factory. Let's concentrate on the description of the final production stage (picture 5 (2)),i.e. quality control sector, where fabrics are prepared for ready use in rolls and are labelled with RFID tags. When the proper amount of rolls is ready, they are sent to factory wholesalers. The rolls are loaded on vans in small quantities (picture 5 (5)) by fork trucks which take them from the production stock-room (picture 5 (3)). The rolls leaving the stock-room can be controlled by RFID stationary interrogators through their antennas set in the pikes in the stock-room door (picture 5 (4)). When the truck with fabrics crosses the RFID pike, data from labels on the rolls is automatically read and sent to the IT system, which prepares stock documents, for instance, MM or WZ. In comparison, when the rolls of fabric are labelled with bar codes, every single label has to be scanned by a



Picture 5. Example of RFID application in a textile factory where: 1 – production, 2 – standardization section, preparation of fabric for ready use, labelling the fabric with RFID tag, 3 – stock-room, 4 – RFID pike monitors fabric release, 5 – transportation of fabrics, 6 – delivery of fabrics to a wholesaler, 7 – acceptance of fabrics at RFID pike, 8 – wholesale stock-room, 9 – release of fabrics at RFID pike, 10 – transportation.

stock-room worker operating a bar code reader, and thus the operation lasts much longer than with RFID technology. RFID pikes placed at stock-room exits prevent the unauthorized distribution of tagged rolls, i.e. constitute theft protection.
Such a combination of RFID pikes can be set in factory wholesalers (picture 5 (7,9)) such that all the stock-room operations on fabrics can be automatically monitored. In addition, portable RFID interrogators (picture 5 (8)) can be used during periodic stock-takings; making cataloguing much more effective.

RFID technology for identification of textile products

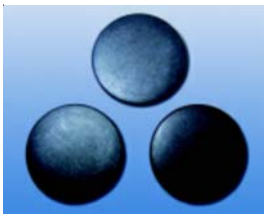
An Italian textile manufacturer, Griva, has applied RFID tags as a part of a new system to control production units and stock-rooms. The tags are attached to the outside parts of cores of rolls with fabric (Picture 6). This has several advantages. First, the process of fabric stock-taking in stock-rooms is much more effective. Secondly, the effectiveness of all production and storage processes is higher. Moreover, it enables tracking a given object at every stage of its production process. Finally, Griva achieved a return on its RFID investment within only nine months [19].

Now, Griva is trying to convince its customers to apply the same systems in order to improve its production and commercial activity.

Picture 6. Roll of fabric with RFID tag attached [19].

A German company which makes RFID tags, KSW Microtec, has unveiled two new labels. One can be ironed or sewn directly onto the fabric of a garment. The other is mounted on a polyester substrate and sewn onto a garment. The new flexible 13.56 MHz labels can withstand temperatures of up to 40 degrees Celsius. They have a life-expectancy of 10 years and are not affected by tumble-drying, ironing or other cleaning processes. KSW is also working on a label that can withstand temperatures of up to 60 degrees Celsius. The company wants to apply its technology to tag uniforms for the US army.

Texas Instruments plans to offer its customers an RFID tagging system in a form of plastic rings (picture 7) [14] that can be sewn or stuck onto a garment cleaned in factory laundries. This will enable automatic identification of the cleaned garments, which will further improve laundry service.



Picture 7. RFID tags made by Texas Instruments company [14].

Another RFID application is a uniform-tracking system to control the use of clean hospital garments. The system uses RFID plastic tags (picture 8) and has operated in some German hospitals since 2005 [20]. Hospital employees use their RFID-enabled personnel badges to open clean uniform storage closets and take the garments they need. The system tracks the process of clean uniforms distribution and thus, indirectly, helps to better manage proper sanitary conditions in hospitals.

Picture 8. RFID badges to track access to clean hospital garments storage closets [20].

Conclusions

In summary, RFID technology can have many different applications. In IT systems it helps to improve automatic product or semi-finished product identification during the process of their manufacturing and further on. In the textile industry, which is recognised as an attractive segment for RFID solutions, it is very useful in tracking textile products at every stage of their existence. However, implementation of the technology is still limited, mainly because of the price of RFID tags. Nevertheless, the technology of RFID tags production is developing and this may lead to a reduction in prices (market prices of the materials used for the production of tags are reasonable and the costs of tags application can also be lowered when the same tags are used several times). When the price barrier is overcome, RFID growth should be a matter of time.

RFID technology can be used for the identification and monitoring of a single product in textile factories. However, because of the harsh environment in textile production (high temperatures, chemicals, physical processing), RFID tags have to be properly packaged in order to be protected from damage during the production process.

RFID implementation gives new opportunities to tracking the whole course of a product's existence, from manufacturing and storing through to sale and utilization.

Undoubtedly, both production and commerce companies will significantly benefit from RFID applications.

References:

[1] *V. Daniel Hunt, Albert Puglia, Mike Puglia „ A Guide to Radio Frequency Identification" John Wiley & Sons 2007*

[2] *K. V. Seshagiri Rao, Senior Member, IEEE, Pavel V. Nikitin, Member, IEEE, and Sander F. Lam "Antenna Design for UHF RFID Tags: A Review and a Practical Application" IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, vol. 53, no. 12, December 2005*

[3] *Klaus Finkenzeller "RFID Handbook: Fundamentals and Applications in Contactless Smart Cards and*

Identification" John Wiley & Sons 2003 ISBN:0470844027

[4] Patrick J. Sweeney II " RFID for Dummies" Wiley Publishing, Inc 2005

[5] Paul Goossens "The Radio Frequency Spectrum" Elektor electronics, 2/2005

[6] Pavel V. Nikitin, Member, IEEE, K. V. Seshagiri Rao, Senior Member, IEEE, Sander F. Lam,

[7] Vijay Pillai, Member, IEEE, Rene Martinez, and Harley Heinrich "Power Reflection Coefficient Analysis for Complex Impedances in RFID Tag Design" IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, vol. 53, no. 9, 2721 –2725, September 2005

[8] Raghu Das "RFID Explained" IDTechEx, 2004.

[9] David Williams "The Strategic Implications of Wal-Mart's RFID Mandate" www.directionsmag.com, July 2004.

[10] Item-Level Visibility in the Pharmaceutical Supply Chain: A Comparison of HF and UHF RFID Technologies, Philips Semiconductors et al, July 2004.

[11] Susy d'Hunt The Cutting Edge of RFID Technology and Applications for Manufacturing and Distribution, , Texas Instrument TIRIS.

[12] ANSI (American National Standard Institute), IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields. 3kHz to 300 GHz, New York 1992

[13] www.rfid.zebra.com/RFID_webinar.html, Zebra Technologies.

[14] http://www.rfidjournal.com/article/view/534/1/1

[15] http://www.elektronikab2b.pl/content/view/538/108/ lang.pl/

[16] http://www.hitron.pl/files/IDG.pdf

[17] http://www.spedycje.pl/aktualnosci/wiadomosci/3932/ wiara_w_rfid.html

[18] http://www.rfid.net.pl/rfid_technologie/ identyfikator_rfid_tag_transponder_etykieta_2.html

[19] Mary Catherine O'Connor Griva applies an EPC RFID tag to each roll of fabric it processes, resulting in lower labor costs, increased production and a rapid ROI. http:/ /www.rfidjournal.com/article/articleview/3515/1/1/ July 30, 2007

[20] Mary Catherine O'Connor At St. Olavs, an RFID-based system tracks work garments, saving space and labor costs while improving inventory accuracy. http:// www.rfidjournal.com/article/articleview/3022/1/1/ Feb. 6, 2007

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