ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2006, Tome IV, Fascicole 2, (ISSN 1584 – 2665)
FACULTY OF ENGINEERING HUNEDOARA,
5, REVOLUTIEI, 331128, HUNEDOARA

RFID TECHNOLOGIES IN PRODUCT DISASSEMBLY PROCES

Ilija COSIC, Zoran ANISIC, Milovan LAZAREVIC

UNIVERSITY OF NOVI SAD, FACULTY OF TECHNICAL SCIENCES,
DEPARTMENT FOR INDUSTRIAL ENGINEERING AND MANAGEMENT, SERBIA

ABSTRACT:
All the statistics regarding the production of certain types of products and their disposal into the waste dumps (cars, computers, pc-monitors...) point to a need for finding a solution more quickly and for reacting specifically to reduce and control the quantity of such waste, because the waste is being made in ever-increasing quantities. With this purpose in mind, production systems for the processing of such waste are designed and put into use.
Disassembly is just one of the activities in managing the life span of a product and lately it has attracted a lot of attention in literature, considering its central role in rehabilitation and recycling of products. The necessity of solving this problem in the area of disassembly is gaining importance. This is due to ecological, legal and economical reasons. Economical side of the problem of disassembly is seen in the need for a design of the disassembly system in a way that the end result of its work is larger than the resources invested for its proper functioning.
Starting with the strategies for managing products in the end of their life cycles, the problem of shaping the production system to refine the products in the end of the life cycle is considered.
KEYWORDS:
Disassembly, Recycling, RFID technologies

1. INTRODUCTION

All the statistics regarding the production of certain types of products and their disposal into the waste dumps (cars, computers, pc-monitors...) point to a need for finding a solution more quickly and for reacting specifically to reduce and control the quantity of such waste, because the waste is being made in ever-increasing quantities. With this purpose in mind, production systems for the processing of such waste are designed and put into use.

Disassembly is just one of the activities in managing the life span of a product and lately it has attracted a lot of attention in literature, considering its central role in rehabilitation and recycling of products. The necessity of solving this problem in the area of disassembly is gaining importance. This is due to ecological, legal and economical reasons. Economical side of the problem of disassembly is seen in the need for a design of the disassembly system in a way that the end result of its work is larger than the resources invested for its proper functioning.

The end result of the disassembly is not always specific, but is frequently changed, depending the state of the product, especially when we realize that we are talking about technologically outdated products.

Starting with the strategies for managing products in the end of their life cycles, the problem of shaping the production system to refine the products in the end of the life cycle is considered.

2. STRATEGIES FOR MANAGEMENT OF PRODUCTS IN THE END OF THE LIFE CYCLE

Strategies for management of products in the end of life cycle represent the strategies, which are used to conduct the general direction of products, and only suggestions are given for the management of a product in the end of a life cycle. Studies related with the strategies of the products end of life cycle are very numerous. The most accepted, and in its character, the most comprehensive classification of the products end of life cycle is: [2]:

- Re-use of used products;
- Reconstruction of used products;
- Usage of already used products for spare parts;
- Recycling with disassembly;
- Recycling without disassembly;
- Dumping of the used products.

Re-use of already used products is a strategy, which organizes the return of discarded products, which are still in function. If such an interest exists, already used products are sold in the market.

Reconstruction of used products is applied for them modernized or to upgrade their performances. The purpose of this strategy is to attain a product, which is in quality less or very similar to the quality of the new products. The quality of the reconstructed products depends on the determined depth of disassembly. If a product is disassembled to the level of parts and a control and a replacement of all the parts is conducted, the used products are brought to a high level of quality, required for the new products.

Also, it is possible to conduct the modernization of products, by replacing certain modules with contemporary ones, after applying the disassembly.

Using already used products for spare parts is already being applied frequently. In certain companies, out of date products are being collected in an organized manner (ex. Xerox). The purpose of this strategy is to take a relatively small part of parts/sub modules from a used product and use them for the above-mentioned strategy, or in another purpose, and the rest will be used for material recycling;

Recycling with disassembly is a strategy used for separating different parts from different material, before its conversion in the process of disassembly. The purpose of this strategy is to use the materials from the used products and parts, by separating them in the procedure of disassembly into the component parts and with appropriate selection, depending on the determined type of material. These materials can then be used in the production of original or some other products.

Recycling without disassembly is a procedure, which is used to compact a compress the product, and then attrition it and sort it by type of material.

Disposal is, from the ecological point of view, the most inconvenient strategy for disposing of products on the waste dumps. Having the above-mentioned strategies in mind it is necessary to design an appropriate production system in accord with them.

3. STRUCTURES OF THE PRODUCTION SYSTEM FOR PRODUCT PROCESSING IN THE END OF THE LIFE CYCLE

The choice of proper strategies is conducted according to an algorithm shown in the next Figure (1). Algorithm gives a logical queue (most favorable towards the worst option) of the choice of strategies.

Also, easily identifiable are the needs for certain subsystems chosen by proper strategies in the framework of the complete production system for processing.

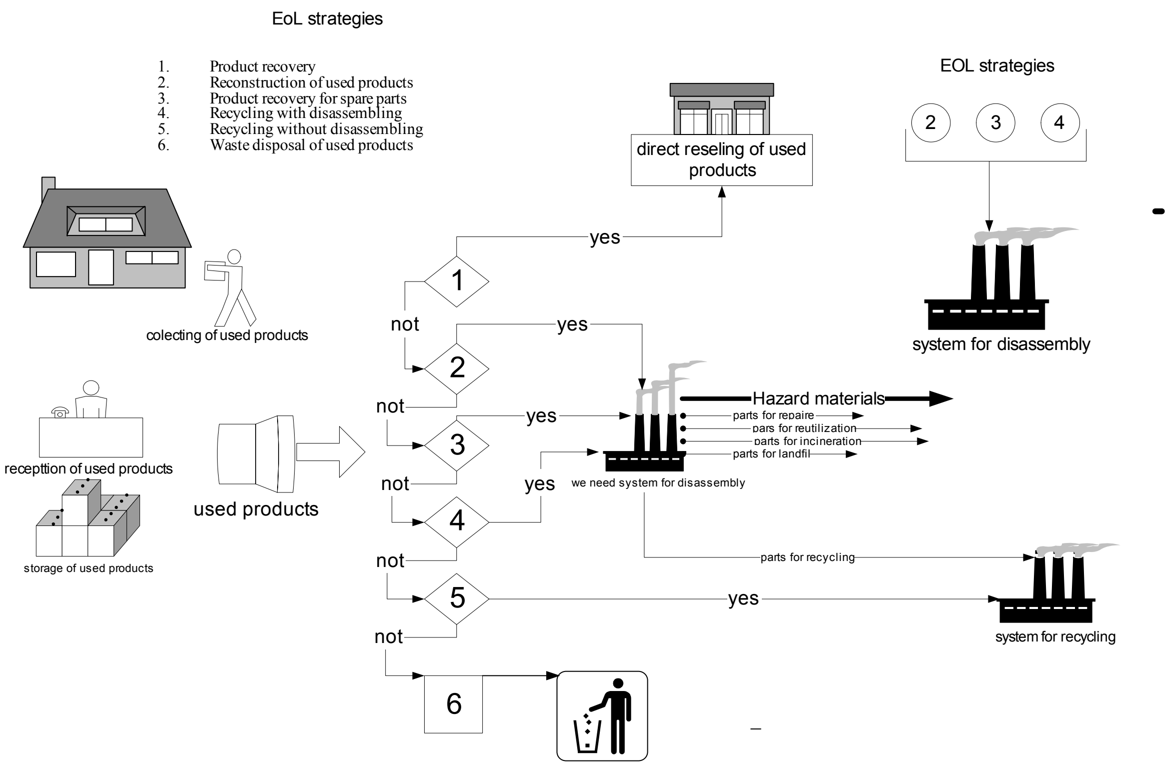

Figure 1.Algorithm for selection of a proper strategy

In general, the production system for product processing in the end of life cycle, has, in its character a quite complex structure (Figure 2), and that is:

- Disassembly subsystem;
- Reassembly subsystem;
- Recycling subsystem;
- Waste incineration subsystem;
- Hazardous waste storage subsystem;
- Wasted storage subsystem.

The choice of strategies 2, 3 and 4 (.) indicates the need for designing the disassembly system

Production system for product processing, in accord with chosen strategies for product management in the end of the life cycle, is shown in the Figure 2.

In the most general case, if for the given product (qj), all three variants of strategies are chosen as possible, which comprise in themselves the need for disassembly (strategies 2, 3 and 4), then the production system for processing of such products contains in it self all the elements as in the previous Figure. In case we choose only the strategy number 4, then a subsystem for repair doesn't exist.

When choosing strategies 3 and 4 a subsystem for repair possibly exists. Depending on the type of product and the type of repair, the repair subsystem doesn't have to be specially separated. It is important to notice that in the procedure of the product disassembly, during the parts selection, a flow of materials must be planed for the parts that are headed for the reassembly. In other words, it is often very possible to conduct, in a same place, within one subsystem where the disassembly is conducted, a second assembly of the product. A subsystem is being shaped for disassembly/reassembly, with a developed procedure for disassembly, selection of parts/subsystems and then, the reassembly of the required elements. In this case a line for disassembly and a line for reassembly (assembly) are completely overlapping. Outside of, in this way designed line, subsystems for repair can also be designed (disassembly/reassembly) of more important subsystems.

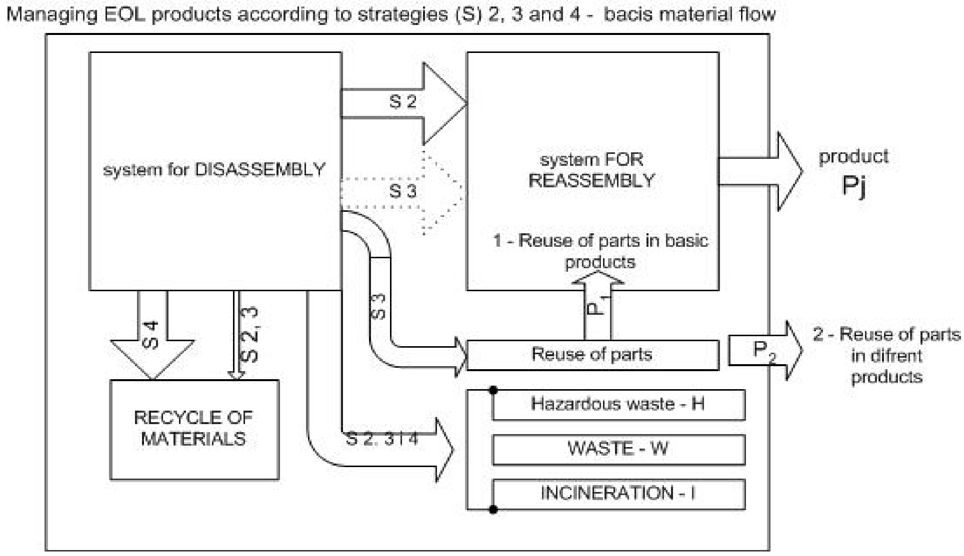

Figure 2. Production system for processing the products in the end of the life cycle

4. PRODUCT DISASSEMBLY

Disassembly is defined as a process of separating a product into its principle parts or subsystems, including the analysis on the state of products and the selection of dismantled parts. That is always an assembly of operations, which are conducted on the technological systems for disassembly with the help of certain tools and sets.

The procedure of conducting operations in the disassembly is conducted according to an adequate procedure, which is designated for every work place in particular. The procedure implies, in the most general case, the following:

- Conducting the operation with the help of appropriate tools and sets;
- Analysis of the state and the diagnosis of the disassembled components (part/subsystem); and
- Selection of the disassembled components (part/subsystem) according to previously conducted analysis of the state and the diagnosis.

It is important to emphasize that not all parts are necessary to pass through the phases of state and diagnosis analysis.

This applies in the case when in a selection scenario (procedure) for the disassembled part it is not foreseen to have more possible variants of selection, but only one (for example R). In this case, right after the process of disassembly, a selection of the components is conducted according to the previously determined scenario.

After choosing the proper strategy for a given product and a sequential execution of certain procedures (operations) of disassembly, it is necessary to conduct a selection of the disassembled components (parts/subsystems).

In essence, we distinguish the next possibilities for the selection of components after the process of disassembly:

- dangerous components – materials (H (hazard));
- material recycling (R);
- reusable (P);
- complete, (D);
- incinerate (S or I (incineration));
- waste disposal (W (waste)).

5. THE APPLICATION OF RFID TECHNOLOGY IN A (SUB)SYSTEM FOR DISASSEMBLY

In the (sub)systems of disassembly, we often find obstacles for different reasons. One of them is a problem of a lack of any kind of information regarding the newly arrived products for processing (disassembly) and their distribution, after the operation, from specific work places. Before and after conducting certain disassembly operations, information are crucial to efficient and effective decision making and for general management of the work processes.

Improvement of the quality of transferring information for conducting certain operations of disassembly, and then for the analysis of the state, diagnosis and selection of the disassembled components into appropriate flows, is one of the steps for general improvement of the processes for managing products at the end of the life cycle.

With the aim of faster distribution of real information to according information flow nodes, it is necessary to use RFID technologies.

5.1. RFID TECHNOLOGIES

Radio Frequency IDentification (RFID) is a technology that enables automatic reading of multiple objects at the same time, without the need for individual scanning. The tag keeps in it self an EPC code of every object that is read with the help of a remote reader.

EPC is at the moment a 96-bit numerical code written on a "smart tags" memory chip which is fixed to individual products and physical objects. In this way, AUTO ID makes the dynamical gathering of data possible, where identification of products is built in every product giving them a unique print (Figure 3.).

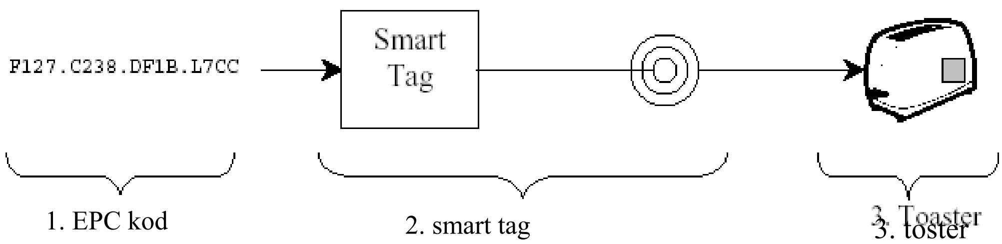

Figure 3.Unique toaster identifier

In every of the mentioned phases of the work process it is possible to upgrade the process by applying the RFID technologies.

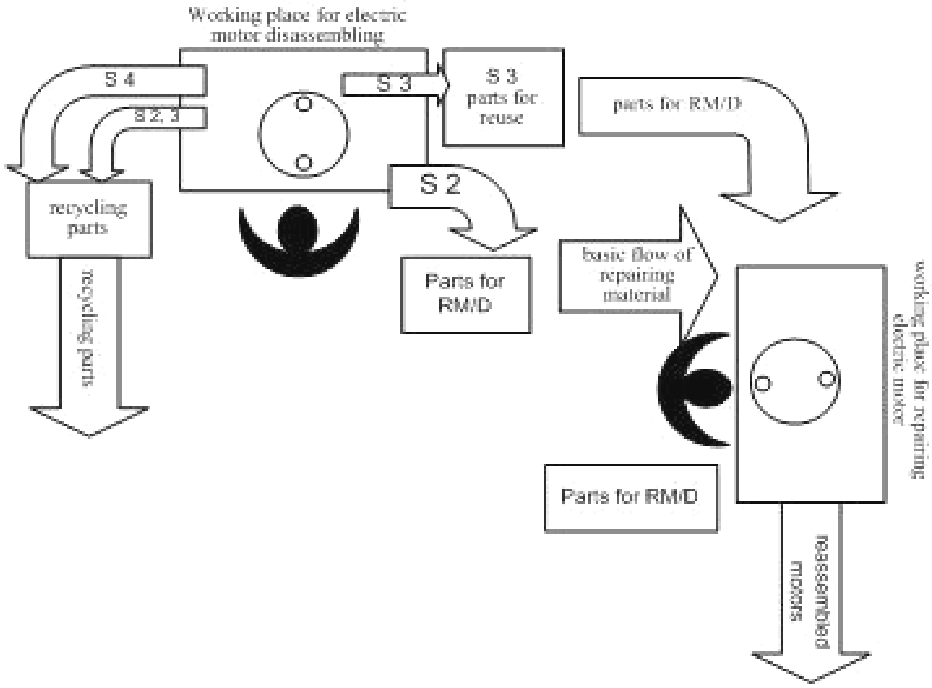

Figure 4. Material flows during the processing of an electric motor

The complexity of the tasks need to be performed and the flows of material that can be made in the process of the product disassembly is often present (Figure 2. and 4.)

Problems are mostly noted in:

- giving instructions for performing technological process of disassembly;
- selection process of disassembled components (parts/ subsystems/ materials);
- divergences – dissipation of the flows of materials is obvious and especially characteristic for the disassembly processes;

following the flows and the status in the material warehouse for disassembled components (parts/subsystems/materials);

It is in these parts of information flows that it is possible to apply RFID technologies with the goal of: speeding data, improving quality and availability of certain types of information.

5.2. RFID TEHCNOLOGIES IN THE DISASSEMBLY SUBSYSTEM

An example of applied RFID technology is shown in the next Figure. In the control station 1 (Figure 5.) one of the various strategies is being selected for the chosen product. After selection, it is necessary to put a transponder (tag) to the base part of the product, which corresponds to the class and type of the product, for which the strategy has been chosen, with its EPC code. After that, the product is being stored on the assembly line and then moves to the processing phase.

In the first workstation, the RFID tag reader (2) takes over the signal from the tag and from uploads a set of instructions form the database for the technological procedure of disassembly, in the form of a visual presentation on the monitor in front of the worker. Instructions are in a step-by-step form. They are activated by taking appropriate types of tools, and after returning them to their station, the next step is activated. If some task is being executed without the tools, then initiating the next instruction is done manually. After the operation (set of operations) designated for that workstation is completed, the set of instructions ends.

The product is then placed on the assembly line, and then on some of the other workstations, after reading its signal from the RFID tag, the identification (recognition) of the object for that work place is being performed. If the object is supposed to be processed in that work station, the signal light flashes and the worker takes the object from the assembly line. After that the process is continued as in the previous operation with a set of instructions designed for that work place and for that product. If all the workstations are busy, the object is circling on the assembly line until the moment some of them are free. The transponder – tag has to be on the base part all the time. The base part is the last that leaves the disassembly process.

If on some of the workstations a disassembly of some component (part or subsystem) is being conducted, which can be used again according to strategy number 3, then an appropriate tag is put on that component in that workstation. The tag carries in it self an EPC code that corresponds the component on which it is being put. By placing the component with a tag on the assembly line, it is transported to the place 3 where the product (after reading the EPC code from the tag) is being redirected to the component warehouse for later use.

Products for which strategy number 2 is selected, are moving all the time, from phase to phase, together with all the disassembled parts in the appropriate transport unit (for example a palette or a box – so-called kit). After completing all of the disassembly operations (required for executing overhaul-reconstruction of the appropriate degree) the whole palette with all its disassembled components is being redirected toward the overhaul subsystem, that is, toward the preparation warehouse for the product reconstruction.

Materials that go to the recycling (so called secondary materials), are being directed to appropriate containers for the secondary material with the help of the sensors which can recognize different types of materials, and the help of executive organs (3) which thrust them into the appropriate containers. On every of the containers (5) there is a tag-transponder, which corresponds to the type of material for which the container is designated.

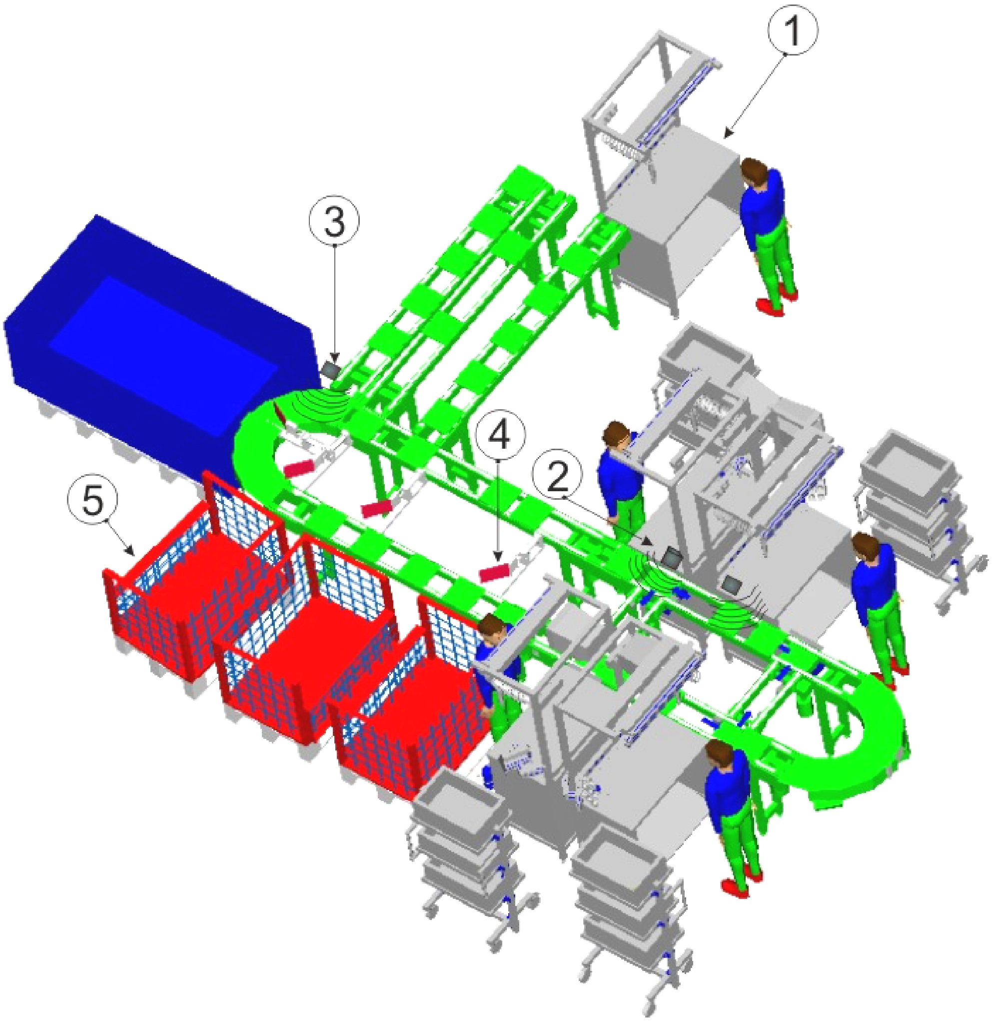

Figure 5. Appliance of RFID in the disassembly process and selection of disassembled parts of the products

This enables a complete control of all the material flows which are in the process and put of it. Numerous data is easily available, regarding the number of product that are headed for overhaul, number and type of parts for later use which are in a warehouse (or headed to it) and the quantities and types of materials for recycling (types and quantities of secondary materials).

Also, a system designed in this way has an increased degree of flexibility in the sense of possibilities to accept and process different types of products. Because, one of the basic problems in the work of the disassembly system is that it is very rare that only one type of product can come into it, unless this way of the systems functioning is strategically planed.

Savings in time and surfaces required for the selection of components (parts/subsystems/materials) are also very visible.

6. CONCLUSION

The appliance of RFID in the disassembly will be even more easy when some manufacturers start to build into their products (for example, electro-products which succumb to the WEEE directive) tag-transponders with, for every product unique, EPC code (Figure 6).

Figure 6. EPC in certain elements of the product [5]

In this way, it will be possible to gather necessary information for the disassembly process very quickly, about the structure and the composition of the materials in the product. These informations are necessary to define the technological procedure of disassembly completely and without any difficulties. All the products of the older generation, which currently arrive to the disassembly subsystems, carry with them exactly this problem – the lack of information.

Until now, RFID technology has been suppressed from the wider application in production and production processes for various reasons. Some of them are: the success of the bar-code, higher expenses due to RFID tags, privacy and security measures, lack of consensus on standards etc. However, some things are changing (for example, the tag prices are falling, the limited possibilities of bar-codes in different conditions is being noticed...) and slowly, the advantages of the advanced technology are being understood.

The improvements, which arrive with the use of the RFID technologies, are multiple. As stated above, the possibilities of managing, using the RFID technology multiply raises control and supervision of the whole process.

REFERENCES

[1] Catherine M. Rose: Product End-of-Life Strategy Categorization Design Tool, Accepted for publication in Journal of Electronics Manufacturing (Special Issue on electronic product reuse, remanufacturing, disassembly and recycling strategies), 1999.

[2] Nedeljko Sredić, M.A.: Managing products at the end of the life cycle-researching capabilities for recycling – doctor dissertation, 2005

[3] Martin Strassner, Elgar Fleisch: The Promise of Auto-ID in the Automotive Industry, Massachusetts institute of technology, 77 Massachusetts avenue, bldg 3-449, Cambridge, ma 02139-4307, USA, Published February 1, 2003.

[4] Michel Baudin, Arun Rao: RFID applications in manufacturing, *RFID applications in manufacturing,* Consultant, MMTI – Manufacturing Management & Technology Institute

[5] Duncan McFarlane, RFID in Manufacturing, Research Director Auto ID Labs @ Cambridge Institute for Manufacturing, University of Cambridge