USING RFID FOR WASTE MINIMIZATION IN THE AUTOMOTIVE INDUSTRY

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Abstract: Radio Frequency Identification (RFID) technology opens a broad scope of new applications in various areas. One important area with already running RFID examples is the logistic sector in the automotive industry. Based on these examples this paper discusses the opportunities for a supply chain optimization between Brazil and Germany with a special focus on economic, environmental and social aspects in the area of automotive waste and reverse logistics. This shall lead to a future concept where RFID technology enables also an economic waste minimization for closing the product life cycle loop in the automotive industry.

Keywords: Automobile industry, Closed loops, Data processing, Environmental engineering, Embedded systems, Garbage, Manufacturing systems, Transponders.

1. INTRODUCTION

Since the Earth Summit (United Nations Conference on Environment and Development) 1992 in Rio de Janeiro the idea of Sustainable Development becomes increasingly stronger, this means that no healthy society or economy can exist in a world with so much poverty and pollution.

The traditional concepts of economic and social development do not consider the real importance of the environment. The satisfaction of the main necessities of the people and an environment in good conditions as also a healthy economy for all people in the world must be aimed. This cannot be reached just by only one country. For a sustainable development a world partnership is necessary (Aachener Stiftung, 2005).

Sustainable development incorporates three dimensions economic, ecology and social, and aims to an integration among these dimensions. Based on that for the companies there are four challenges in relation to sustainable development (BMU, 2002, p.6):

– Environmental challenge: Increase of the ecological effectiveness;
– Social challenge: Increase of the social effectiveness;
– Economical challenge in the environmental and social management: Improvement of the ecological efficiency and / or social efficiency;
– Integration challenge: The meeting of the three previous challenges as also the integration of the environmental and social management in the conventional economic existed management.

1.1 Reverse Supply Chains and Reverse Logistics

According to Leite (2003, p.4), reverse supply chains can be defined as the stages and means through which the goods produced, or parts of them, “return to the productive cycle (...), reacquiring value in secondary markets by reuse or the recycling of their constituent materials". If the return of these materials to the business cycle is not economically viable, there are options for final disposal, such as landfills and waste dumps.

Traditionally, logistics has involved location, the necessary facilities, taking care of transport and inventories, coordinating the movement of material and the integration of logistics activities and ensuring an adequate information system in order to make the various flows of materials and merchandise efficient throughout the logistical chain.

The European Working Group on Reverse Logistics (REVLOG) defines reverse logistics as "the process of planning, implementing and controlling backward flows of raw material, in process inventory, packaging and finished goods, from manufacturing, distribution or use point, to a point of recovery or point of proper disposal" (REVLOG, 2005).

Reverse logistics may become a primary subject for decision techniques. Nevertheless, while copious studies examine the opportunities of cost reductions and capacity improvement provided by the supply chain management, reverse logistics have still not received the deserved attention (Dekker, 2004) (Dyckhoff, 2004).

This situation is changing fast and the driving forces behind reverse logistics can be summarised in three main topics: economics, legislation and business outreach. With these topics certain controversial issues such as the increased price of input materials and/or disposal charges, stricter legislation (mainly in relation to product responsibility) and the adoption of values or principles that compel companies to become engaged with reverse logistics can be identified (Dekker, 2004) (Dyckhoff, 2004).

1.2 The Solid Waste Management in Germany and in Brazil

In 2000, 150,000 tons of solid waste was daily produced, representing approximately 0.90kg per inhabitant. For the sake of comparison, each inhabitant of Germany (2000) generated 0.90kg waste each day, while the amount in Japan (2001) was 1.12kg per inhabitants, in the USA (2004) 2.0kg per inhabitants, and in Canada each inhabitant produced 1.7kg waste each day (Boranga, 2005).

In Brazil, only 5.5% of the household waste collected was recycled (IBGE, 2000). A recent study published by CEMPRE, an NGO (Non-Governmental Organisation) for Brazilian business committed to furthering recycling in the country), shows that between 2000 and 2004 the amount of collected domestic waste sent to dumps or landfills dropped from 94.5% to 90.0%.

It also showed that there was a significant increase in recycling, which stood at round 8.0% (Saneamento Ambiental, 2004). However, this figure is still very low if compared to countries as Germany (50% in 2000) and Japan (15% in 2001) (Calderoni, 2004). Even considering the development of the last years, it can be concluded many possibilities of material reuse and waste recycling have still been ignored in Brazil.

Since 1999 with the approval by the Brazilian Ministry of the Environment of a basic proposal document for a National Politic for Solid Waste, the country has been trying to implement new legislation in relation to solid waste.

However, many individual legislations specific to different types of solid waste have been approved in the last years. In relation to the automotive industry the main legislation about solid waste in Brazil are mainly related to the destination of tires, batteries and lubrificant oils.

In Brazil there are 100 million of old tires in waste dumps, empty plots of land, rivers and lakes. Each year million new tires are produced. On 2nd December 1999 was published CONAMA Resolution no. 258, which obliged that the tire industries and trade to recycle 25% of the production in 2002, 50% in 2003 and 100% in 2004 (Imbelloni, 2005b).

It is estimated that there are 12 million of automotive batteries in Brazil, those contain plumb und acids. When not correctly disposed of, they can cause pollution to soils and water courses. On 22nd July 1999 CONAMA Resolution no. 257 was published, which obliged the industries and trade to receive and to dispose correctly the old batteries (Imbelloni, 2005a) (CEMPRE, 2005).

With the CONAMA Resolution no. 362, which was published on 2nd June 2005, the management of used lubrificant oils became stricter, concerning all actors involved in production, sales and use (CEMPRE, 2005).

In the European Union a specific commission for the automotive industry was created which elaborated a directive regarding "end-of-life vehicles" (ELV Directive). This directive was approved by the European Parliament in October 2000 and established different environmental aims, e.g. to increase reuse and recovery to a minimum of 85% by an average weight per vehicle and year by 2006, and by 2015, to 95% (Kozminska, 2002) (Medina; Gomes, 2003).

According to Kozminska (2002, p.1), "the storage and treatment of all 'end-of-life vehicles' must be in accordance with the general requirements of EU legislation and will only take place in authorised Treatment Centres".

The German recycling capacities for selected polymer parts (bumpers, hub caps and front grilles), which are mentioned in German Directive of end-of-life vehicles, were estimated as 7,000 through 11,000 Mg/a bumpers, 450 through 690 Mg/a front grilles, and 340 through 520 Mg/a hub caps (Woidasky; Stolzenberg, 2003).

The directive encourages the possible measures to “reuse of components which are suitable for reuse, the recovery of components which cannot be reused and giving preference to recycling when environmentally viable” (Kozminska, 2002. p.1).

1.3 German and Brazilian Automotive Industry

Germany is one of the most important automotive producer countries, where, in 2004, 5.6 million vehicles were produced and employment was given to 5.3 million persons (one of each group of seven employees) (VDA, 2005a). In the same year 2.2 million vehicles were produced in Brazil, giving employment to 102,000 employees (ANFAVEA, 2005).

In 2004 the automotive industry in Brazil had a share of 10.6% in industrial GDP[1] (ANFAVEA, 2005). In Germany this share was around 10.5 % (VDA, 2005a).

The increasing strictness of the relevant legislation and the rise in the awareness of consumers has obliged vehicle manufacturers to look for technological innovations to continually improve their environmental performance.

The German automotive industry has been concerned about environmental issues and has concentrated many efforts mainly by (VDA, 2005a):

- Emission reduction of the vehicles;
- Reduction of fuel consumption;
- Saving of resources;
- Recycling of vehicles;
- Ecological friendly Production.

The Brazilian Ministry of the Environment and the Brazilian Automotive Industry Association (ANFAVEA) are looking together for alternatives to make the recycling of vehicles in Brazil economically feasible. According to estimations of ANFAVEA, this could happen by the implementation of a programme that would recycle between 80 thousand and 160 thousand vehicles, which could make the processing and destination of the different parts cheaper, mainly of those containing hazardous substances. (MMA, 2005).

ANFAVEA has also estimated that there are five million vehicles in Brazil which are older than 15 years that could be involved in the recycling programme. (MMA, 2005).

2. RFID TECHNOLOGY: FIELDS OF APPLICATION

2.1 RFID

Transponder technology is an automated identification technology, which is based on data exchange via electro-magnetic fields. The core of any RFID system is the 'Tag' or 'Transponder', which can be attached to or embedded within objects. A RFID reader sends out a radio frequency wave to the 'Tag' and the 'Tag' broadcasts back its stored data to the reader.

The system basically works with two separate antennae, one on the 'Tag' and the other on the reader. The data collected from the 'Tag' can either be sent directly to a host computer (e. g. via a Wireless Local Area Network – WLAN) through standard interfaces, or it can be stored in a portable reader and later uploaded to the computer for data processing.

Industry is currently focused on the improvement of the Begin-of-Life (BOL) for products via RFID. But the Mid-of-Life (MOL) and the End-of-Life (EOL) phase is also becoming increasingly more attractive for developments on RFID based applications.

2.2 Reverse Logistic and RFID

The development towards increasingly complex logistics systems has driven companies to develop aggressive strategies of relationship and supply chain management. Similar developments are occurring within the field of reverse logistic.

It is proving to be a challenge for many companies to enlarge their management systems to include actions that consider the driving forces behind reverse logistics (economics, legislation and business outreach). Among these issues, product responsibility is a very important topic for the companies (Dekker, 2004) (Dyckhoff, 2004).

As already cited, in the European Union a directive was approved regarding “end-of-life vehicles” (ELV Directive), which significantly extended product responsibility by the automotive industry, by the establishment e.g. by 2006 an increase reuse and recovery to a minimum of 85% by an average weight per vehicle (Kozminska, 2002) (Medina; Gomes, 2003).

The optimization of reverse supply chains can improve, for example, the reuse and recycling of waste, through the elaboration of plans including the definition of:

[1] Gross Domestic Product.

a) the objectives of the reverse supply chains,
b) the integration level and the type of the reverse supply chains,
c) the characteristics of the waste materials and the definition of the target market for the recycled product,
d) the location of the recycling facilities and
e) the control and information systems for the reverse supply chain operations (Leite, 2003) (Dekker, 2004).

Due to the fact that RFID technology enables the storage of a higher amount of data directly on the logistic (or product) item, this technology is an important key element for the logistic supply chain optimization (mainly optimization of *item e* – the control and information systems).

The RFID tag system works just as effectively in environments with excessive dirt, dust, moisture and poor visibility, also to be found in the recycling industry (following RF-ID.com 2003).

This technology can be used for process optimization in existing reverse logistics processes. This can improve the recycling rate due to the higher quality of the input material and lower logistic costs (around 30% of the total turn over in the reverse logistics area). Additionally, new business concepts are feasible, e. g. the usage of CDK (Completely Knocked Down) transport carrier systems for automotive production waste or ELV parts.

2.3 Reverse Logistic RFID applications between EU - Brazil

According to VDA (2005), automotive companies are currently carrying out pilot installations or plan to do so in the near future. They expect that the introduction of RFID will improve supply chain tracking and boost the efficiency of local processes, for example in store management, production or the management of load carrying units.

The next step is expected to be towards the complete process integration of RFID technology. An important precondition for this is the necessity for global standardisation, for example with regard to data structure and the definition of frequencies.

First applications were tested for the improvement of CDK processes. These are processes for delivery of automotive plants with assembly parts. In cooperation with *DaimlerChrysler* a logistic operator in Bremen (*BLG*) has tested different RFID based tracking and tracing solutions for shipping of assembly parts on their logistic facilities in Bremen.

For a pilot test BLG selected a distribution centre in Bremen which provides automotive plants in Brazil with production parts. The packing material, which enter the distribution has to be tagged with passive transponders in before. Fork lifts which pick up the packing material are equipped with a passive RFID reader system, an active positioning system and WLAN. Additionally containers are equipped with active tags. This allows a seamless tracking and tracing of warehouse goods by using a warehouse management system which is connected to the fork lifts and containers.

Results gained from these tests were challenging and enables *BLG* in being a reliable partner if other stakeholders in the logistic supply chain in Germany and Brazil start to introduce RFID technology, too (see Kaller 2005, S. p.10).

A second application example is based on the *Volkswagen* transport carrier systems used in the supply chain between their automotive plants in the EU and their plants abroad (Brazil, China, Mexico and South Africa). The current situation bases of a high rate of missed carriers and a low cycle rate. The first successful pilot installations are running and based on this, *Volkswagen* is evaluating an expansion of these installations in combination with new business models (see Kaller 2005, p.17-18).

The starting step for this expansion can be the introduction of a daily rental model which uses the RFID enabled seamless tracking and tracing of carrier systems. In a second step the carried packing material can be detected by using the RFID system. The last steep would be the integration of external service providers which use the carrier system in the reverse supply chain for alternative products (see Kaller 2005, p.17-18).

3. CONTROL AND INFORMATION SYSTEMS FOR THE REVERSE LOGISTICS

3.1 Integration Concept for Plastic Recyclables: Project PROMISE

PROMISE is an international research project in the IMS program (Intelligent Manufacturing Systems) with industry and academia consortia in Australia, Europe, Japan and the United States. The project concerns the whole information flow from Design, Production, Use-Service-Maintenance or MOL (Middle-of-Life) and Retirement or, as most commonly is called, EOL (End-of-Life). It will develop appropriate technology, including product lifecycle models, Product Embedded Information Devices (PEIDs) with associated firmware and software components and tools for decision-making based on data gathered through a product lifecycle.

One PROMISE demonstrator (A3) deals with the tracking & tracing of plastic recyclables emanating from the automotive industry (see figure 1).

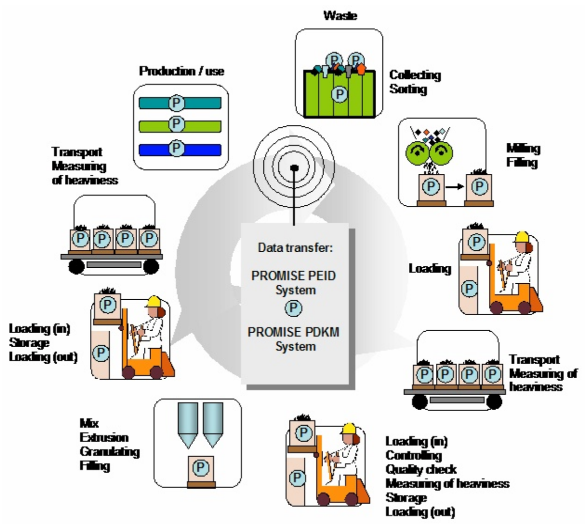

Fig. 1. PROMISE A3 demonstrator.

As such, plastic recyclables represent heterogeneous goods which, in logistics processes, are transported employing a variety of containers. For that reason, an efficient solution to PEID integration within the scenario for such plastics can be achieved by the adoption of an approach which implements the core PEID immersed in the material as shown in Figure 1.

The aim of the scenario is to improve the information flow throughout the EOL phase of the chosen product (e.g. car bumpers) and the BOL of the resulting recycled material (e.g. granular plastic), bridging the information gaps present in the state-of-the-art and completing the information loop.

On that basis, it aims to optimise processes within these phases by providing real-time product and context information to a number of back-end systems, and by integrating DSS into the existing back-end in order to more effectively and efficiently handle these processes.

3.2 PROMISE A3 Technical Infrastructure

Figure 2 describes the technical infrastructure for the logistics information management system based on the PEID device which is tagged to the container.

The core PEID establishes a wireless connection available to arbitrary devices. PDAs (Personal Digital Assistances) are used as an example of such devices. PDAs or other Hand-Held Devices can be employed e.g. by shop floor personnel to carry out a number of operations upon information transmitted by the PEIDs. Furthermore, the PDAs will be used as relay stations to backend systems such as the Warehouse Management System (WMS).

The advantages of the proposed approach include:
- Platform independence;
- No information breaks;
- Paperless handling;
- Flexible system;
- Easy integration of additional stakeholders;
- Highly economic due to reusable PEIDs;
- Data filter enables filtering of reliable data.

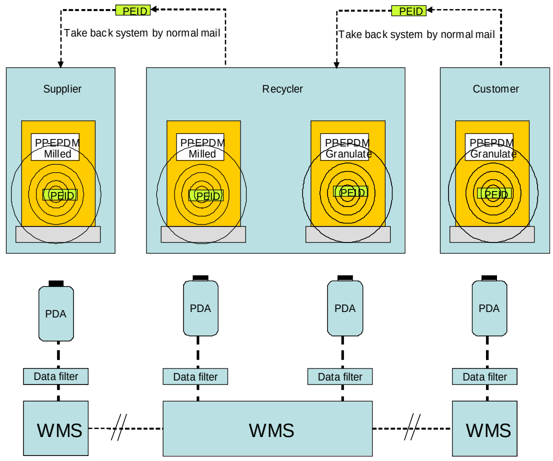

Fig. 2. Information management concept.

4. CONCLUSION

Reverse logistics begins to receive the deserved attention of the companies due to driving forces as: economics, legislation and business outreach. These topics include certain controversial issues such as the increased price of input materials and/or disposal charges and stricter legislation (mainly in relation to product responsibility).

Due to the fact that RFID technology enables the storage of a higher amount of data directly on the logistic (or product) item, this technology is an important key element for the logistic supply chain optimization.

RFID technology can improve the recycling rate due to the higher quality of the input material and lower logistic costs (around 30% of the total turn over in the reverse logistics area). Additionally, new business concepts are feasible.

If international standards are accepted and used by all stakeholders in the supply chain, new reverse logistic channels will become economically feasible. The closing of the information loop, enabled by technologies such as RFID, will lead to a closed product life cycle loop for saving natural resources and reducing waste fractions.

ACKNOWLEGEMENTS

The authors wish to acknowledge the European Commission and the PROMISE consortium for their support.

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