END OF LIFE MANAGEMENT OF AUTOMATION DEVICES

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Abstract: End of Life Management (EOL) is currently a hot topic in the electronics industry. Currently mostly IT equipment and goods of consumer electronics are considered. In the nearest future automation equipment have also to be taken into account. There are three possibilities depending on the age and kind of the device: Resell – Reuse – Recycle called the "3R`s".For recycling fully or semi-automated disassembly will gain in importance in the nearest future especially for automation devices. Developers of automation devices have to take into account EOL because of regulations and laws as well as according to ethical codes contributing to protection of the environment.

Keywords: Automation Devices, End of Life Management, Recycling, Disassembly, Ethics.

1. INTRODUCTION

The world is facing an ever growing stream of electronics waste (e.g. computers, printers, telephones, household-machines and cellular telephones) as a result of both the rapidly increasing number of new applications for electronics as well as the accelerating pace of technological development and ever shorter service life.

In Europe there is now a clear societal need for take-back and recycling of electronic products. "Closing the loop" would serve several (partly interlinked) goals, such as:

- reduction of the amount of materials and environmentally relevant substances going to landfill,
- control of environmentally relevant substances (inorganic) or annihilation of such substances (organic).
- Recycling of components and materials so that they keep maximum value, contributing to a sustainability.

The closed product life cycle would consist of two main streams (Fig. 1):

- The "traditional" product life chain (such as production, distribution and use). Introducing environmental concerns in this stream is called "Eco-design" – including assembly.
- Re-using and recycling products, components and materials (such as take back, re-use and recycling). Operation of this stream is called "End-of-life Management" – including dis-assembly.

The tremendous increasing amount of electro-mechanical and electr(on)ic products, such as computers, printers, telephones, household-machines and others, to be recycled (and also to be disassembled), makes it necessary to partially automate this disassembly process to increase the efficiency. The need for such semi-automated solutions can be estimated from the German electrical and electronic equipment market, where more than 2 million tons per year of electronic scrap are expected for the next decade.

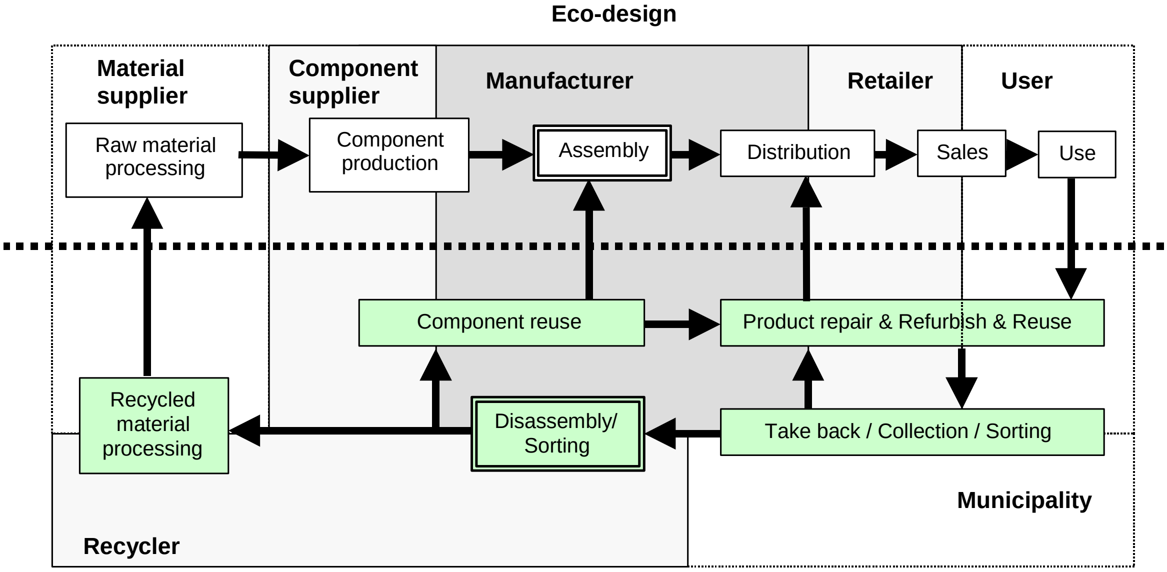

Fig. 1. End-of-life Management (Kopacek, 1999)

Within the EU the electronic waste has already reached staggering 10-12 million tons a year. In some branches there is a tremendous growth, like the German PC market, where 2,8 million PCs have been increased to 45,2 million (+25.2%According to a recent study for the US market and estimated that if the current German pace of discarding 3-4 million computers per year continues, disposal costs would alone reach a staggering 200-300 million ECU per year.

2. ETHICS IN END-OF-LIFE MANAGEMENT

Ethical problems arise frequently for engineers since their products have great influence in the world. An engineering solution can change the fabric of society, it can change the face of the planet, and it can perform immense amounts of good. Thus, it is important that engineers, perform their work diligently and with the utmost care. The way to ensure that as few fatalities happen as possible is to adhere to the engineering codes of ethics and to practice a craft responsibly. Since the fundamental process of engineers is design, it is important that they design with ethics as guide. We must be aware that every design has consequences, be they social, political or environmental. Engineers must be able to deal with these consequences by either avoiding or minimizing them. For this they must look to ethics, where there are established lines of thought and procedures for dealing with these type of problems. In ethics, there are the tools needed to shoulder the heavy load placed upon engineers.

The process of engineering is the process of creating solutions that can simultaneously achieve the goals of the problem and remain within certain constraints. These goals and constraints are referred to as “design drivers”. The three most common “design drivers” are

- the cost of the solution,
- the schedule of the project and
- the features of the solution.

These drivers can act as either goals or constraints, depending on the situation.

Ethical considerations can similarly be viewed as “design drivers”, either constraints or goals. Ethical behaviour is either something to be sought or something used to limit the design space. The technical features are analogous to the moral issues at stake in an ethical case.

There are several approaches to the environment that must be understood to really accomplish environmentally-friendly design. Currently, most engineering codes of ethics the components of the environment are given value because they are viewed as important of humankind.

There are three main components to consider in the environmental effects of a design. They correspond to the three tenets espoused in most environmental literature:

- reduce,
- reuse, and
- recycle.

Each of these tenets have been applied to designs to minimize their environmental impact (Harris, 1995).

3. DISASSEMBLY - STATE OF THE ART

For devices, especially for electric and electronic products, there exist several end-of-life options, namely (Kopacek 1999):

- Product re-use
  - refurbishment
  - second hand markets
  - legal and guarantee issues
- Product take-back
  - collections scenario's
  - sorting
  - logistics
- Disassembly
  - disassembly technology and processes
  - component sorting
  - material identification
- Component re-use
  - quality assessment
  - second hand market
  - legal and guarantee issues
- Recycled material processing
  - process technology
  - economies of scale

Disassembling, as the first and most important point in the recycling process, will be a part of the industry with a high rate of expansion. Currently disassembling for recycling, if it is done anyway, is mainly a manual and sometimes also a mechanized process. But with the enormous increasing amount of products to be recycled and therefore also to be disassembled, such as automotives, computers, printers, telephones and other electronic devices, all sort of household- and homeworker-machines, it is necessary to automate this aim to increase the effort. High flexibility and low-cost of disassembly processes will be necessary. The automation potential will be one of the most important productivity factors for this new production process and becomes a new challenge for engineering. The two main goals are

(a) to reduce the costs of disassembling for optimizing the recycling processes and
(b) to create a humane working environment in disassembly factories.

Because of the particular characteristic and requirements of disassembling tasks, fully automated disassembling needs structures and methods for a semi-automated disassembling with both, use of manual and automated (e.g. robotised) workplaces to meet the requirements of a new life cycle strategy.

Until now a very high standard in the field of automation and robotics have been reached, but the focus was only on assembly. Few parts of scrap are recycled after disassembling, however, the degree of automation is still very small - only some pilot or demonstration projects have been realized mainly in research institutes. However also for the disassembly processes high flexibility, high accuracy, vision sensors and low-cost will be necessary. The automation potential will be one of the most important productivity factors for this new production process and becomes a new challenge for engineering.

Information technology can support the decision making process in product design, disassembly process planning and disassembly system development. Using information technology for decision-making processes, for disassembly system controlling, programming etc. can significant increase the quality, decrease production costs and support the enterprises to become more competitive in a global market.

Computer aided design enables modeling and designing products in variants, evaluating them according to assemblability, virtual prototyping, planning and simulation, and creating the product database needed for assembly/disassembly process planning. Assembly operation determination and optimal disassembly operation sequence can be accomplished automatically based on the product data. The product database supports also the disassembly process. Assembly system development based on interactive or automated selection of component data, automated creating the lay-out, presentation of assembly process in virtual environment supported by simulation are becoming tools for shortening the assembly system development phase and decreasing the investment risk.

Use of Ethernet in disassembly system control and connection with Internet will support development of reconfigurable assembly systems, long distance programming and tele-maintenance. New organization structures like virtual enterprises, production in networks need also permanent data exchange via Internet.

4. AUTOMATION DEVICES.

In this chapter a short overview on the history and the devices of automation will be given.

In automation we have the two worlds

- Process automation – automation of continous processes and
- Manufacturing automation – automation of discontinous processes.

In the classical field of process automation we had in former times pneumatic, hydraulic, electric or combined devices. These devices were mostly analogue. Not only because of the change from analogue to digital today electr(on)ic devices are dominating especially in information processing.
In manufacturing automation most of the automation devices were electrical and digital from the beginning.

In process automation a “classical” control loop consists of:

- Devices for information collection – measurement devices (sensors)
- Devices for information processing – control devices
- Devices for information application – acutation devices (actors)

A sensor system consists of

- the sensor itself
- the transducer and
- the amplifier

In case of a digital control system in addition

- sample elements and
- analogue – digital (A/D) and digital/analogue (D/A) converters

are necessary. In process automation sensors for e.g. temperature, force, mass, momentum, pressure, position, angle, speed, acceleration. In manufacturing automation mostly sensors for position, speed and acceleration are of interest. Most of the sensor systems are electr(on)ic and nowdays fully integrated – embedded sensors.

The control devices – controllers – were in former times analogous pneumatic, hydraulic, electric or combined. Today mostly electrical, digital controllers in form of PLC`s or microprocessor controllers are used partially in form of process control systems as well as for control of manufacturing systems.

The classical actuators in process automation are control or butterfly valves, usually electrically, pneumatically or hydraulically driven. In manufacturing automation linear or rotatory axes with electrical or pneumatical drives – sometimes digital – are used.

Furthermore an automation system in process and manufacturing automation have also peripherical devices like control cabinets, racks, cables, keyboards, screens (CRT, TFT,…).…

5. END OF LIFE (EOL) MANAGEMENT OF AUTOMATION DEVICES.

Currently there are only first steps in this subject for automation devices. EOL is mostly concentrated on devices for Information Technology (PC`s and perpherical devices) and electr(on)ic products from the consumer sector, e.g. TV sets, washing machines, …..

Not only because of the WEEE directive producers and users of automation devices have to deal with this subject. Usually some of these devices contain hazardous materials like

- Lead - used in solder
- Cadmium – used in batteries
- Antimony – used as a flame-retardant
- Beryllium – used in connectors
- Chromium – used for metal plating
- Mercury – used in bulbs.

In the future these substances must be replaced by others because recycling could be complicated and expensive. First ideas are currently available for lead-free soldering.

In Table 1 some of the automation devices are listed and classified according to two criterias:

a. the complexity of (automatized) disassembly - recyclability:
   1….easy, ….., 5….complicated
b. the economics of disassembly (reusable components,…..) and reusability:
   1…economic, ……, 5….noneconomic.

<u>Table 1 Recyclability and Reuseabiloity of selected components of automation devices</u>

Automation Deviceces			1	2	3	4	5
Sensors		complexity			x		
		economy			x		
Embedded		complexity					x
		economy					x
PLC’s		complexity		x			
		economy		x			
PC’s		complexity		x			
		economy	x				
Controller electrical		complexity	x				
		economy		x			
Motors		complexity				x	
		economy					x
Cylinders		complexity		x			
		economy	x				
Valves		complexity		x			
		economy		x			
Printers		complexity			x		
		economy			x		
Keyboards		complexity				x	
		economy		x			
Screens	CRT	complexity				x	
		economy		x			
	TFT	complexity			x		
		economy			x		
Contronll Cabines		complexity				x	
		economy				x	
Racks		complexity				x	
		economy					x
Cables		complexity				x	
		economy					x

Fig. 2 gives a graphical interpretation of Table 1. On the horizontal axis the 5 categories of disassembly complexity and on the vertical axis those of disassembly economics are shown. Concerning the reusability the best solution would be a device easy to disassemble (1) and with a lot of reusable components (1).

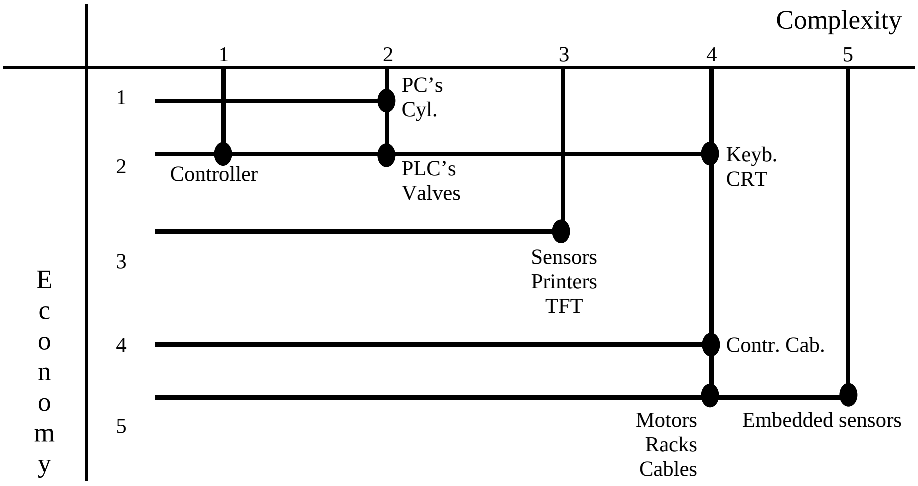

Fig.2. Relation between complexity and economy

According to the current available technologies for disassembly PC`s and PLC`s, controller, valves and cylinders are economic – sensors, printers and TFT screens only partially. The main problem is to find the limit for economic disassembly. It depends from the market for used parts and the technical equipment available.

6. SUMMARY

The paper is a first trial to give first ideas for EOL especially automatized disassembly of automation equipment. After an introduction the necessity of automatized disassembly is shortly outlined. An overview on important automation equipments is given.

The main part tries to give a first catalogue on the reusability and recyclability of automation devices. Both depends from unpredictable factors e.g. market demand for used components, available disassembly technologies, ….. In the nearest future developers of automation devices have to take into account EOL because of regulations and laws as well as according to ethical codes contributing to protection of the environment.

7. LITERATURE

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