RESEARCH IN LOGISTICS & PRODUCTION

ASSESMENT OF SUSTAINABILITY IN DISMANTLING STATION – CASE STUDY

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Abstract Sustainable resources utilization is very actual issue considered in three dimensions: economic, social and environmental. Products end-of-life management is a key element of sustainable development. Automotive industry is a big supplier of different kinds of waste. End-of-life vehicles are becoming problem in most of the Member Countries. Poland is a country with one of the oldest vehicles feet in EU. It results in a growing trend of the number of old and worn cars, which need to be dismantled and recovered. The objective of this paper is to present an assessment of sustainability in disassembly station. Authors present theoretical background of research, case study description and complex analyses of dismantling process in one of the biggest dismantling stations in Poland with application of following tools: VSM maps, diagram SIPOC and RPA method. The analysis allows to identify main problems which exist in this field and to propose some improvement measures in order to improve the sustainability of dismantling operations.

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1. INTRODUCTION

The issue of sustainable development has become a global problem and one of the greatest challenges of the twenty-first century, particularly for the automotive industry consuming resources and affecting people, Environment and Economy.

Products end-of-life management is a key element of sustainable development of vehicles as sources of numerous and different kinds of waste. The returned product might be subject to different reuse options. Figure 1 presents the most common reuse options like: reuse-as-is-is, recycling and remanufacturing.

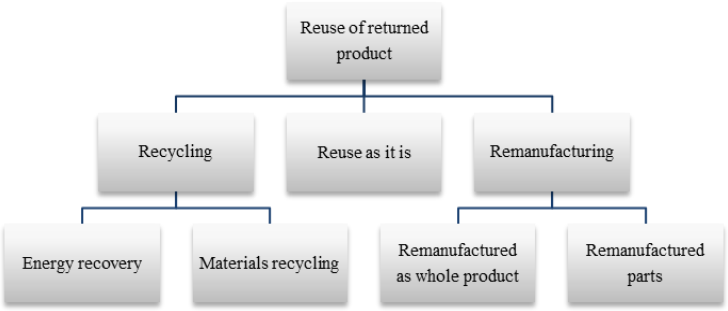

Fig. 1 Reuse options for return products

End-of-life vehicles (ELVs) are a serious problem especially in countries like Poland where old, used cars are dominating. The solution is recycling system with dismantling stations. This paper aims to present and analyze sustainability issues in one of the biggest dismantling station in Poland. The paper consists of five sections. First is presented the background of sustainable development in automotive industry. The next section aims to provide discussion on vehicle fleet in Poland. Section 4 is a description of method used to analyze sustainability in dismantling station using: VSM maps, diagram SIPOC and RPA method. In the last section are presented final conclusions.

2. SUSTAINABLE DEVELOPMENT IN THE AUTOMOTIVE INDUSTRY

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). This concept goes includes simultaneous consideration of the three pillars of development - environmental, economic and social in such a way that the development of one of the element is not a threat to others. Sustainable develop-

ment became one of the greatest challenges for companies around the world, particularly for one of the fastest growing industries – automotive industry. That industry is a burden on the environment and people at all phases of car life cycle from designing, through manufacturing (use of resources) and utilizing (emissions to the environment), at end-of-life phase ending. End-of-life vehicles generate, every year in the EU, between eight and nine million tonnes of waste required correct treatment. In response, the EU established Directive aims at making vehicle dismantling and recycling more environmentally friendly, sets clear quantified targets for reuse, recycling and recovery of vehicles and their components and pushes producers to manufacture new vehicles also with a view to their recyclability (ELV, 2000).

3. CHARACTERISTICS OF THE VEHICLE FLEET IN POLAND

Vehicle fleet in Europe counts 228 million units (ACEA, 2012), of which 17.9 million became polish cars. There is observed upward trend in the number of cars in the hole world each year. In Poland this number increased 3.4 times to the level of 17.9 million of passenger cars in 2011 from 5.3 million in 1990 (PZPM, 2013).

According to ACEA data the average car age in UE is 8.3 year (2012) when in Poland the average age is almost 15 years old ($SAMAR_b$, 2013) in both with an upward trend - the vehicle fleet is getting old. Poland slowly become Europe's automotive heritage park. Only about 10 % of all vehicles are units below the age of 5 years old. About 70% all vehicle fleet are old cars over 12 years, the biggest group is between the age of 12 and 15 (about 4.2 million units). Disturbing is the fact that the number of new cars (up to 2 years) is decreasing each year, amount of old ones is increasing (GUS, 2011). In the EU the age structure of vehicles below the age of 5 years old determines 32,2 % of all units, but cars older than 10 years were 35,6% of population (ACEA, 2012).

Taking into account facts about: age and number of vehicles, technical condition, the number of scrapped cars , 5,0-5,5 % of all vehicles (0.8-1.2 million) should be deregistered. Although an increasing trend in a number of deregistration - 342 352 unregistered vehicles in 2011 ($SAMAR_b$, 2013) not enough number of vehicles get to recycling network created by dismantling stations and car collection points (Ustawa, 2005). Vehicle recycling system in Poland is not working correctly what presents comparisons of the size of the scrapped cars (about 1 million) and the small number of vehicles given to legal dismantling facility (267 889 units in 2011) ($SAMAR_a$, 2013). Almost 70% of all scrapped units is feeding “grey area” – where cars are illegally dismantled for selling spare parts. Those activities are harmful for the Environment.

4. ASSESSEMENT OF THE SUSTAINABILITY

Polish recycling system consists in 2012 of 749 dismantling stations and 120 collection points of vehicles ($SAMAR_b$, 2013). Dismantling station is the "heart" of recycling network aims eliminating the risks of ELV for the Environment, which operates the following activities in ELVs' area (Ustawa, 2005):

- removing items and hazardous substances, including fluids;
- removing all equipment items from the vehicle and parts suitable for reuse;
- removing all components that can be recycled or recovered.

Performing "dismantling business" means many duties regarding: recording, environment protection and waste management regulated by the law. The main issues regulated by the law are inter alia: admission of every vehicle free of charge, established level of recovery (95%) and recycling (85%), station equipment, appropriate land-use and technical operation realized at appropriate sector of dismantling station.

4.1 Dismantling stations – process analysis

The analysed company is one of the biggest dismantling station operating in Poland. About 800 cars are processed in this station each year, what results at about 2.5 dismantled cars per day. The company collects end-of life vehicles what is the core business. Additionally it offers full service in the field of waste management.

The company does not have a clearly defined organizational structure, however, there can be distinguished several functional areas: administration, sales, dismantling, transport with 17 workers.

The company proceeds: complete serviceable vehicles, spare parts and waste that may be recovered, recycled or disposed. The main objective of dismantling ELVs is the recycling of parts and environmental protection at the lowest possible cost per operation. Dismantling station structure consists of: car magazine (area with ELV arranged next to one another with about 120 vehicles capacity), dismantling hall linked to magazine of "big parts", magazines of: tyres, accessories and the paint parts, external storages without any roof placed in a free space. Dismantling station products are: spare parts and waste.

The following research approach was applied to analyse and evaluate the sustainability issues in the dismantling station:

1. Identification of products and process
2. Identification of sustainability issues: social aspects, economic &environmental aspects
3. Rapid plant assessment (RPA – matrix and questionnaire)
4. Process analysis/mapping (to identified process flow and potential bottlenecks)
5. Identification of waste (muda) for RPA low score areas
6. List of improvements potential.

Processes realized by dismantling station are presented in Figure 2. The scope of the processes cover: 1) Dismantling including dismantling all vehicle, removing selected part in Customer order but also dismantling particularly units obtained from dismantling all vehicle. Process is realized in 3 places: area of ELVs' storage, "outside dismantling position" (free space between dismantling hall and ELVs' storage, setting up with support), dismantling hall at a lift. If Customer have a wish and there are technical conditions individual dismantling by Customer is allowed. In result of dismantling there are spare parts supplied to appropriate storage or waste placed in right container. 2) Recipience ELVs'– process providing vehicles for dismantling process, where beside formal issue there are first removing operations (tyres, catalyst, wheels). 3) Storage: waste, spare parts, ELV-s in warehouses and external conditions. 4) Redistribution of spare parts realized directly by selling parts from magazines including ELVs or indirect via Internet, by contact with regular customers and motorist's fans (unique parts).

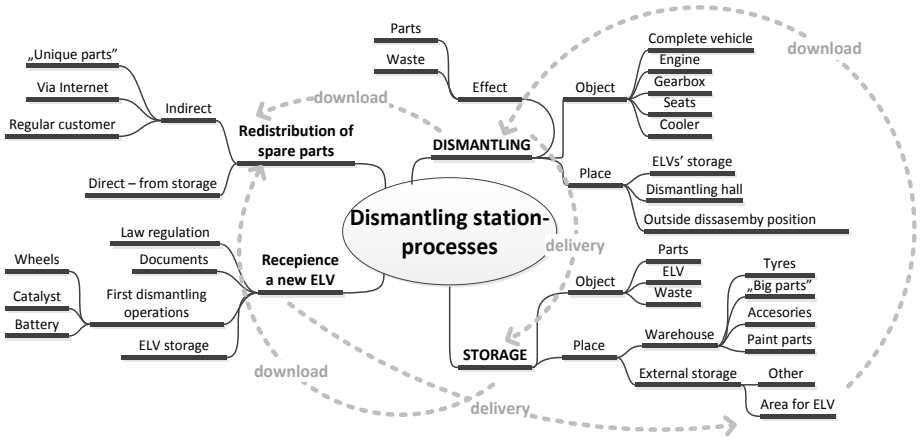

Fig. 2 Process in dismantling station

All processes realized in dismantling station were analyzed from the perspective of importance of pillars of sustainable development (Table 1) with points from 1(small influence) to 5 (great influence).

Table 1 Importance from sustainability perspective of dismantling processes

Process	Pillar of sustainable development			Total
	Environment	Social	Economy	
Dismantling	5	5	5	**15**
Reception of new ELV	3	1	5	**9**
Storage	5	2	4	**11**
Redistribution	1	1	2	**4**
Total	**14**	**9**	**17**	

In redistribution there are little possibilities of sustainability. The greatest influence is observed in dismantling process what influenced all pillars in the maximum dimension (15/15). The storage and reception of new ELV are less important but they have to be considered in connection to dismantling process. For this reason this paper focuses at sustainability assessment in dismantling process in connection to storage and recipience of new ELV.

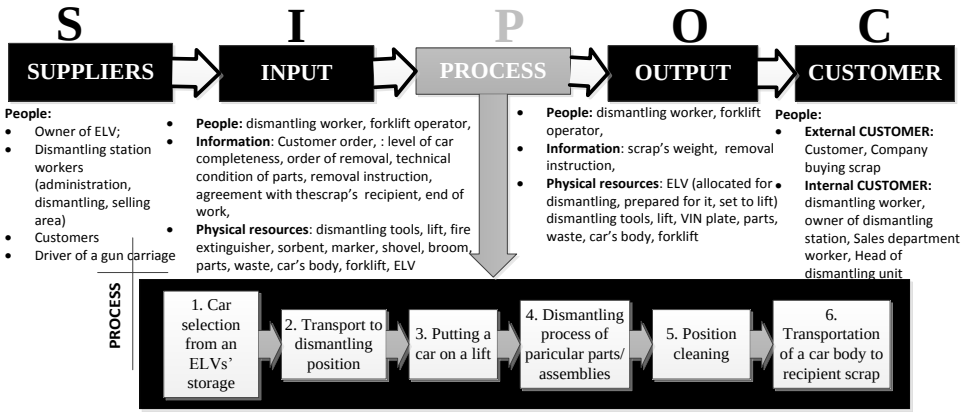

Fig. 3 SIPOC diagram for dismantling an ELV process

Dismantling process of an ELV is very complex and precious from sustainability perspective. Presentation of dismantling process (Fig. 3) is a Six Sigma methodology tool – SIPOC diagram. Process has got many suppliers – not only forklift operator who physically charges an ELV from the storage (effect of ELV reception), but also: customers, owners of ELV and workers of dismantling station. Suppliers should be stimulated in appropriate way. There are many resources at the input and output side. Output refers to storage process of waste and parts for redistribution. Customers of this process are divided in 2 groups: external and internal.

4.2 Dismantling station – social aspects of sustainability

Social aspects are considered in relation to people hired at dismantling station and the local community. Local community is affected by dismantling station in a little way. Plant is surrounded by trees, the dismantling hall and ELVs' storage are placed in the back of the company, away from the street, so the noise are inoffensive. Always there is a risk of breakdown resulted in air and water pollution. Plant has not destructed the landscape – there are no heaps of car waste, tires, car wrecks and general disorder. Additionally, area where station is located is rather industrial one. The other side are social aspects in workers' perspective (Fig. 4).

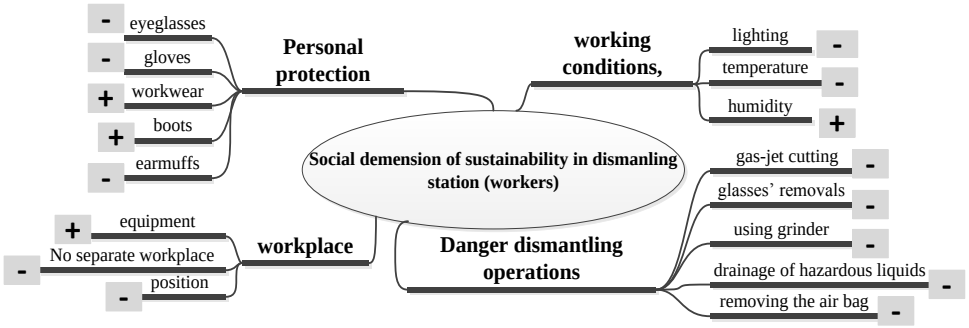

Fig. 4 Social dimension of sustainability in dismantling station

There are considered: danger dismantling operations, working conditions, personal protection means and workplace. Each factor affected worker was given +/- what indicates positive or negative influence from the sustainable development perspective. There is a big area of improvements in this area. If worker equip in proper personal protection means, the level of risks associated with the danger dismantling operations would decrease.

4.3 Economic and environment aspect of sustainability

There is undeniable fact that dismantling station promotes sustainable development particularly due to efficient utilization of resources – it transforms danger waste (ELV) to spare parts demanded by the market and waste determines the object of recycling and disposal in the last resort. Reusing spare parts safe to use helps to save materials and energy needed to produce new one. Processing car waste reduces the number of garbage in landfills, forests and other places where car wrecks are abandoned. Beside efficient utilization there is environmental issue what is directly linked to dismantling operations and waste management, particularly those hazardous.

To obtain efficient resource utilization there should be no waste of resources. Assessment of sustainability from resource effectiveness perspective will be presented with the Rapid Plant Assessment (RPA) – a method derived from Lean conception, elaborated in late 90's by Goodson (2002). It is a tool for assessment of the plant's leanness. The RPA method includes: 1) Rating Sheet (Table 3) – evaluation of 11 areas in plant. The scale for scoring includes 6 options assessed by increased of 2 point for each subsequent grade ("poor" - 1 point, "below average" - 3 points, the maximum - 11 points). This rating sheet helps to identify the categories of strength and weakness. Categories with low ratings are having the potential for improvement, and should be explored first to provide the leanness

(Sundin, 2004). 2) RPA Questionnaire. It provides 20 yes/no questions. The total number of yeses on it is an indicator of a plant's leanness.

During the case study performed in dismantling station it turned out, that some modification of this method are needed in order to better explore the leanness potential by waste elimination. Authors decided to combined the RPA questionnaire with 8 muda (waste types): overproduction (OP), inappropriate processing (IP), waiting for operations (WOP), unnecessary transportation (UT), unnecessary motion (UM), excess inventory (EI), defects products (DP), Underutilization of Employees (UE). An expert method was applied to make this classification. Matrix was elaborated which correlate 20 RPA questions with 8 muda types. The matrix was sent to over 30 experts having experience in lean management. The authors received back 17 answers. Based on the received answers the initial RPA questioner was extended with additional column referring to the muda type.

Table 2 RPA Rating sheet

Rated by: Monika Kosacka		**Rapid Plant Assessment**						**Apr-13**	**Muda**
Tour Date 26.04.2013		**Table 1--Rating Sheet**				**Plant:** _ Dismantling station			
	Ratings →	Poor	Below Average	Average	Above Average	Excellent	Best in Class		
No	**Measure ↓ Score** →	**1**	**3**	**5**	**7**	**9**	**11**	**Scores**	**type**
1	Customer Satisfaction				7			**7**	
2	Safety, environment, cleanliness, & order	1						**1**	**UM**
3	Visual Management Deployment	1						**1**	**UM,IP,OP, EI, UE, DP**
4	Scheduling system		3					**3**	**EI**
5	Product flow, space use & material movement means	1						**1**	**EI, UT, WOP**
6	Inventory & WIP Levels		3					**3**	**EI**
7	People teamwork, skill level, & motivation			5				**5**	
8	Equipment & tooling state & maintenance		3					**3**	**IP,WOP**
9	Ability to Manage Complexity & Variability		3					**3**	**IP, OP**
10	Supply Chain Integration			5				**5**	
11	Quality System Deployment			5				**5**	
	Totals →	3	12	15	7	0	0	**37**	

In RPA rating sheet plant obtained only 37 points. With grey colour there are areas with results below the average, chosen for further investigation regarding muda elimination. After considering the results of RPA sheets identified types of waste in the dismantling station, using a catalogue of muda: overproduction (OP), inappropriate processing (IP), waiting for operations (WOP), unnecessary transportation (UT), unnecessary motion (UM), excess inventory (EI), defects products (DP) , Underutilization of Employees (UE). There are 7 areas where there are different kind of muda, requiring appropriate activity to eliminate them. To better identify resources and material flow in dismantling process there were

made couple maps by Value Stream Mapping (VSM). Due to the limited space there is presented only a map for dismantling whole car (Fig. 5).

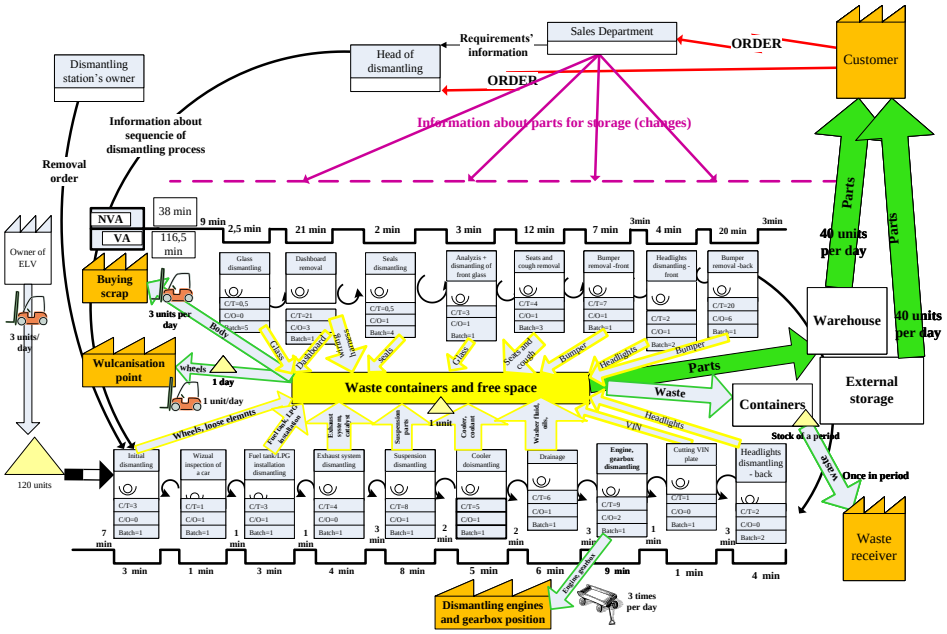

Fig. 5 Value Stream Map for dismantling ELV – at present

Dismantling process was analyzed in the context of places where value is generated in the process. Value - includes everything which customer wants to pay for. The most complex is dismantling all vehicle process with many operations resulting in waste and parts for sale. Actually there is lack of concrete information about list of parts which will be stored. Presently a worker puts components arising at different stages of disassembly directly into containers where they are stored either in the free space on the bench disassembly and around it. There is no order at workplace. Share of non-value-added time in all process time is significant – almost 25%.

5. CONCLUSION

The paper presents the challenges for sustainability development in dismantling station. Social aspects should focus on proper personal protection means, improvement of working condition and workplace including ergonomic position at work and workplaces separated for each dismantling operation with proper equipment. In environmental aspect there is need for right waste management

by proper system of storage (containers), improving drying technology (hazardous liquids). The economic aspect should focus on effective resource utilization (linked to environmental issues). There are following challenges:

- elimination of unnecessary stock;
- reduction of dismantling cycles by eliminating of unnecessary transport and waiting times (5S, Kaizen);

In both, environmental and economic perspective, there is a big need of introduction a remanufacturing process for some parts. At present dismantling station storage a specified catalogue of parts, rest of car parts became a waste. This process let reuse some parts after remanufacturing, what is valuable – there are less waste, part life cycle is extended, what affects cheaper parts for Customer the same as removed from ELV parts. The right policy of waste management and spare parts redistribution is an evidence of sustainability in this dismantling station.

The biggest problem of polish dismantling station is that not enough ELVs are directed to legal stations became a part of national recycling network.

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REFERENCES

ACEA, (2012) “The automobile industry pocket guide”, available at: www.acea.be/images/uploads/files/ACEA_POCKET_GUIDE_2012_UPDATED.pdf (accessed 21 June 2013).

ELV Directive (ELV), (2000), Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles.

Główny Urząd Statystyczny (GUS), (2011), „Transport. Wyniki działalności w 2011r.”, available at: www.stat.gov.pl/gus/5840_748_PLK_HTML.htm (accessed 20 June 2013).

Goodson R. E.,(2002), “Read a Plant – fast”, Harvard Business Review.

Polski Związek Przemysłu Motoryzacyjnego (PZPM), (2013), „Park pojazdów zarejestrowanych w Polsce 1990-2011”, available at: www.pzpm.org.pl/pl/Rynek-motoryzacyjny/Park-pojazdow-zarejestrowanych (accessed 21 June 2013).

SAMAR(a), (2013), „Co i dlaczego Polacy wyrejestrowali w latach 2007-2011?”, available at:www.samar.pl/wiadomosci/co-i-dlaczego-polacy-wyrejestrowali-w-latach-2007-2011-?locale=pl_PL(accessed 21 June 2013).

SAMAR(b), (2013), „Park samochodów 2012 w ofercie IBRM Samar”, available at: www.samar.pl/__/3/3.a/72164/3.sc/11/park-samochod%F3w-2012-w-ofercie-ibrm-samar.html?locale=pl_PL (accessed 21 June 2013).

Sundin, E.,(2004), “Product and Process Design for Successful Remanufacturing”, Linköping Studies in Science and Technology Dissertation No. 906, Production Systems, Dept. of Mechanical Engineering Linkoping Uni., Sweden.

Ustawa z dnia 20 stycznia 2005 r. o recyklingu pojazdów wycofanych z eksploatacji (Dz. U. Nr 25, poz. 202 z późn. zmianami).

World Commission on Environment and Development (WCED), (1987), " Report of the World Commission on Environment and Development", available at: www.un-documents.net/our-common-future.pdf (accessed 22 June 2013).

BIOGRAPHICAL NOTES

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