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Analyzing the Status of the Collection, Transportation, Processing and Recycling the Wastes in Automotive Industry (Case study: Sazeh Gostar Saipa Co.)

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ABSTRACT

The present study is conducted to analyze the status of collection, transportation, processing and recycling wastes in Saipa Automotive Industry. Statistical analysis of electrical waste in Saipa factory indicated that that the highest amount (in terms of weight) belonged to the electric cables and along with electric boards they include more than 40% of the total waste. After the electric cables that are among the wastes of all salons (painting, assembly and cutting) (with a total weight 1713 Kg), electrical boards have the largest share of this type of waste. In addition Backlighting lamps have the last rank in terms of waste volume. Also the results of the comparison with respect to a target with highest priority of recycling Saipa electrical waste as a technical, economical and ecological way include recycling CRT, Backlighting and batteries with a total weight of 0.394, recycling boards and switches, plastics and hydrocarbon materials, cables and refractory fibers and finally metals as the least important ones (weight 033/0). CRT and batteries recycling units require separate space and some advances. Finally, it is proposed to divide the collected and separated wastes into precious and non-precious waste and define three separate processes form them. Then these wastes, especially the ones with high priority in control, are transferred to recycling section or out of the plant. Precious electronic wastes include switches, batteries, BL lamps, electric boards, refractory ceramic fiber, hydrocarbon materials and electrical cables.
KEYWORDS: Waste, Recycle, Saipa, Electric Wastes.

INTRODUCTION

The development of the electronics industry has greatly improved life quality but due to the increasing rate of this industry and reduced life of electronic parts (due to the emergence of new technologies) the out of date wastes of electronic parts are increasing every day (Talebnejad and Mahdizadeh, 2011). In this regard, the most important issue is the impact of waste on human health and the environment because the of the toxic elements such as lead, cadmium and mercury (Farvandi et al., 2009). Transportation and inappropriate disposal of industrial waste, part of which is also hazardous wastes, create many problems for humans and the environment which makes the effective control and enforcement of a sound management of waste a necessity for health, environment and resource management (Raghime et al,. 2004). Proper disposal management of waste has been focused by human beings for centuries and it has been over 90 centuries that humans have tried to dispose waste from his living environment in different ways (Abdoli, 2006). The variety of producing wastes caused by human and machines activities necessitates more attention to the problem of fundamental and scientific disposal management and being aware of the conditions of collecting, disposal and burial of waste has become an inescapable necessity for health programs and to stop wasting national funds (Khodadadi et al. 1388). Unsafe disposal of urban, industrial and hospital waste products is one of the environmental problems. In our country only 8% of urban wastes are recycles and composted while the remaining 92% is buried (Ebrahimi Moghaddam, 2011). The lack of proper solid waste management system and waste disposal in different areas and poor design has caused concern about the entrance of the buried toxic materials to the environment.

Disposal management because of the difficulty of separating and inadequate research in the field of recycling process is faced with challenge. The chain of recycling materials from E-waste has three main steps: collecting, destroying and performing the preliminary or final recycling process (Huwaidi, 2012). Therefore analyzing the recycling, collection and transportation of industrial waste methods are among the necessary and important environmental issues and to control pollution and public health we should have detailed knowledge of the pollution and industrial waste and their distribution in the environment (Daliri and Allahyari, 2008).

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The main objective of this study was to identify and introduce the main sources of distributing the production of electrical and electronic waste is Saipa as well as to provide practical solutions for reducing the production of electronic and electrical wastes in Saipa automotive industry.

MATERIALS AND METHODS

The present study is descriptive applied case study. Analyzing the status of electronic waste of Sazeh Gostar Saipa was performed by flow of materials costing method. This method which is based on Management System ISO 15041 is designed to remove the issue of the distance between quality and economy and is focused on flow of materials in the process of tracking and wasted materials, overt and covert losses of production process including all materials and non-consumer waste and measures them based on physical units (Number, grams, square meters, cubic meters, kilowatt and ...) and converts them into monetary units (Kavianpoor, 2013).

After analyzing the total amount of waste and its compounds, in order to determine the measuring and sampling strategy, assembly and production salons were selected to calculate the amount of electrical waste in terms of weight for a week. The model related the quantitative results obtained in all centers which is the main result of the implementation material costing which is a clear picture of the production process and its performance. In this model it is possible to observe the input, the amount of product, loss and all costs including energy, and depreciation and systems costs... which is effective in identifying weaknesses and strengths. After the analysis of any type of electronic waste an appropriate measure to reduce the loss of the waste has been proposed.

In order to provide appropriate solutions for electronic waste disposal in Sazeh Gostar Saipa Analytic Hierarchy Process (AHP) was used. In order to achieve effective criteria for selecting best practices first effective methods to reduce waste in the procurement of raw materials, production, transportation, processing, recycling and disposal considered by the foreign and domestic sources were collected by review of the literature. After the extraction of the criteria used in the process of locating and according to various criteria and aspects of the application of the results, these criteria were modified within Delphi questionnaire framework and given to 15 experts and directors in order to judge and select the criteria and sub-criteria in the waste disposal process.

Criteria prioritization and screening was performed after analyzing the views of experts on the subject. Respondents were selected among experts with over 5 years of experience in manufacturing, engineering, quality control, HSE and executive management. The respondents were asked to grade the importance of the criteria and sub-criteria and each one of the respondents chose one of the 5 degrees of importance (not important with factor 1, less important with factor 3, important with factor 7 and very important with factor 9) that each one had its own weight. The number of options for each degree of importance indicated the score of that degree of importance. Then the weighted score for each criterion was calculated and the percentage of the obtained score out of the maximum attainable score for each criteria and sub-criteria was determined. Also the arithmetic mean of the importance of each criterion was calculated separately and was considered for the final judgment. Screening of the criteria was performed by the criteria graph of importance so that based on the relations between the two components the degree of importance of the criteria and the percentage of importance of the criteria was calculated and the vertical axes the weighted average of the importance of the criteria and criteria in the process of locating were entered which were certainly the eligible sub criteria for the selection. A prerequisite for the application of criteria and sub-criteria is having at least half the numerical value of each vertical and horizontal vector. So for a better selection of the criteria, the criteria that had more than half of the numerical value of each vector were used. Finally the weight of each criterion was calculated according to the rate of incompatibility.

RESULTS AND DISCUSSION

Different types of Sazeh Gostar Saipa detected E-wastes in the first half of the year 2014 are based on Table 1 the risk of which for humans and the environment in accordance with standard instructions waste electrical and electronic equipment (WEEE) is as follows:

Table 1: Electric waste type and grading based on Standard WEEE

Row	Types	The degree of risk
1	Battery	very dangerous
2	Electronic boards	Dangerous
3	Cartridge Toner	Dangerous
4	Refractory plastics	Low risk
5	Cathode ray tubes (CRT)	Dangerous
6	Switches	Dangerous
7	Backlighting lamps	Dangerous
9	Electric cables	Low risk
10	Refractory ceramic fibers	Dangerous
11	Hydrocarbon Organic Products (Including hydrocarbons, hydrofluorocarbons, hcfc, CFC)	very dangerous

Based on the above table, some types of electrical waste such as CRT, Switches and Backlighting lamps because their components containing mercury (Hg), are placed in extremely dangerous group and they should be promptly isolated and factory waste decontamination operations should be carried out. Electric Waste volume (In the table 2) is presented in the following table based on their production centers (salons). Statistical analysis of the waste in the factory showed that the highest (Weight) belongs to electric cables and along with electric boards include more than 40% of waste.

Table 2: The type and amount of major wastes based on their production salons (Kg)

Salon	Waste	Weight of waste	The wastes of each vehicle	Total waste of each vehicle	Wastes in one hour	Total wastes in one hour
Assembly	Switches	4/823	082/0	385/0	42/0	993/1
	Battery	8/902	091/0		58/0	
	BL lamps	2/107	011/0		083/0	
	Electronic boards	4/1345	134/0		97/0	
	Electric cables	4/679	067/0		36/0	
Press	Refractory ceramic fibers	262	026/0	137/0	123/0	714/0
	Refractory Plastic	284	028/0		131/0	
	Electric cables	8/827	083/0		46/0	
painting	Cartridge Toner	4/664	066/0	108/0	35/0	556/0
	Hydrocarbon materials	211	021/0		107/0	
	Electric cables	8/205	021/0		099/0	
Total				63/0		263/3

The above table shows that after electrical cables that are among the wastes of each salons (total weight 1713 Kg), electric boards have the largest share of this type of waste. In addition, Backlighting lamps have the last rank in terms of waste volume. Total electrical waste in the first half of this year for a vehicle was less than 1 kilogram (630g) and a total of 3200 g electric waste is produced in all salons within 1 hour. Table 3, presents the electrical wastes during the investigation in terms of month.

Table 3: Electrical wastes during the first half of 2014 (Iranian year)

Month / Type	Electric Cable	Electric board	Battery	Switches	Other
April	4/185	2/166	8/109	2/130	4/117
May	2/284	4/232	3/114	4/751	398
June	8/287	5/213	6/268	1/204	2/248
July	6/297	4/164	1/103	96	9/142
August	6/385	1/272	107	3/103	3/324
September	1/276	1/297	1/201	1/206	2/191
Total	1713	4/1345	8/902	4/823	1421

Figure 3-1presents the percentage and ratio of electrical waste during the six months

Figure 3-1 the ratio of electrical waste during six months in 2014 in percentage

According to the pie chart above, the highest percentages of wastes are related to electric cables and electric boards (27 and 22 percent) and the lowest percentage is associated with Backlighting lamp (2 percent).

After the separation of waste process introduced at the table 3-, the mechanical and refining processes should be performed. Mechanical processes are performed to separate recyclable materials and pollutants that generally include breaking, grinding, magnetic separators, air separators, spiral flow separators and… units. In these processes the produced dust must be filtered before being released (Cui & Forresberg, 2003). The materials in electrical wastes can be recycled in raw mode and for this purpose they should pass through a variety of processes such as pyrometallurgy and electrochemical processes. The main materials derived from the refining process, include metals, plastics and glass (Das et al., 2009).

Accordingly the options selected by the experts were selected as two main criteria according to the purpose which is presented in the following diagram (figure 3-2).

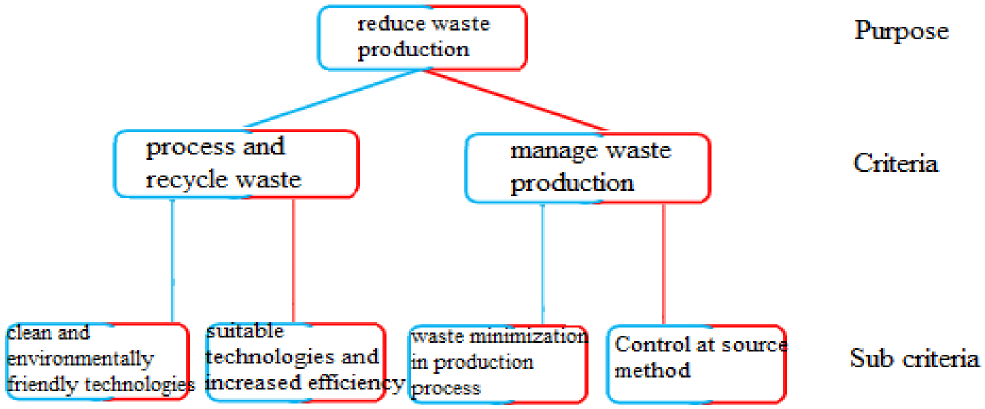

Figure 3.2. Information layers classification (Criteria and Sub-criteria)

According to the figure after screening the proposed criteria and selected information layers include: waste production management which emphasizes on waste reduction during the production process for which two sub criteria of control at source method and waste minimization in production process were included. Also the second criterion is the process and recycle of waste that reduces and reuses the produced wastes. As the chart suggests both layers are integral parts of waste reduction and increased efficiency.

The main goal is to provide waste control programs to maximize efficiency and reduce waste production but since this is not realized because of technical and economic issues, recycling and processing are discussed as the second purpose. In this part a combination of weight factors and sub criteria are presented. The relative weight and incompatibilities of sub criteria regarding the purpose of choosing methods to reduce waste in Saipa automobile factory is presented in the table below:

Table 4: The relative weight and the rate of incompatibility of sub criteria

Row	Sub criteria	The relative weight	The incompatibility rate
1	Minimization of waste in the production process	281/0	03/0
2	Appropriate technology and increased productivity	247/0	04/0
3	Control at source	235/0	05/0
4	Clean and environmentally friendly technologies	123/0	04/0

Given that the incompatibility factor in all criteria was below 10%, prioritization of these criteria is approved. Based on the above table it became clear that waste minimization in production process with the relative weight of 0.281 is the most appropriate criteria for all environmental, technical and economic aspects but environmentally clean technologies with the relative weight of 0.035 was the last priority among six proposed criteria.

Also the proposed options for processing and recycling of Saipa electrical waste with an emphasis on the decline in production include the following cases (WEEE standard classification):

A. Metal recycling (iron, aluminum and metal parts)
B. Recycling plastic and hydrocarbon materials
C. Recycling cables and ceramic fibers
D. Recycling switches
E. Recycling Boards
F. Recycling batteries, Backlighting lamps and CRT

Based on the relative weight of criteria and their compatibility rate (Table 4) and the final weight of options the priority of waste reduction options in Sazeh Gostar Saipa is presented in table 5.

Table 5: The final weight of electronic waste reduction management in Saipa

Options / Criteria	1	2	3	4	Average
D	406/0	389/0	360/0	424/0	394/0
F	297/0	314/0	311/0	296/0	230/0
E	111/0	118/0	126/0	129/0	121/0
B	102/0	088/0	103/0	073/0	091/0
C	047/0	064/0	052/0	057/0	055/0
A	039/0	027/0	048/0	021/0	033/0

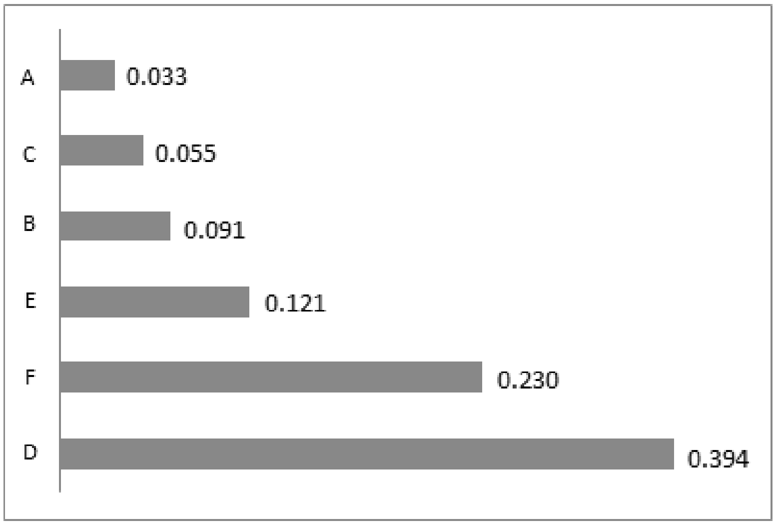

Figure 3: Prioritizing waste control options in Saipa factory

Based on the above table we can see that the results of comparing options versus the target to choose the most prior electric waste recycling methods as a technical, economic and environmental approach are recycling CRT, Backlighting and batteries with the final weight of 0.394, recycling boards and switches, plastics and hydrocarbon materials, refractory cables and fibers and finally the metals as the least important one (0.330).

CRT and the batteries recycling units require separate space and its advances. Boards are the third priority with the weight of 0.121 that include much of the outdated electronic equipments and recycling boards is one of the most important recycling methods and in our country due to low investment the hydrometallurgical techniques is applied (Farvandi et al. 2009). In order to isolate boards in this study it is possible to use mechanical and manual methods. In order to recycle plastic materials a part of which is derived from the separation of Cable covers three main methods are used: A) regenerative and raw material in the petrochemical industry, B) Granulation and using them to produce new products and C) using them as fuel (Guo et al., 2009). So in order to perform the processing operations of e-waste a recycling plant is required. Farvandi et al. (2009) suggested the electronics recycling process to be performed in three stages:

- The first stage recycle (General) At this stage of recycling the metal parts, plastic and cables are concerned, after the initial separation of waste, the crushing plastic and metal parts is important that is done by grinding, magnetic separator and the press machines. This phase includes the third priorities with weights lower than 0.1.
- The second stage recycle (recycling the boards): Due to the high amount of the boards and the importance of recycling this stage is important. In this study the boards are in the third priority which is consistent with these categories and phasing.
- The third stage recycle (professional): The technical nature of recycling of batteries, CRT and Backlighting raise the cost of recycling that in the third World countries exporing the raw materials is more important.

Before recycling operations three stages should be carried out, each of which are discussed here:

A. Collection: Before attempting to perform recycling, collecting the wastes from the units and salons is important. Before attempting to perform recycling for the initial preparation the wastes must be separated based on their nature in the source. Currently, storage and waste collection has no clear process in Sazeh Gostar. In assembly line most produced wastes are the packaging and transportation equipment and materials. Most electrical wastes (Table 3-1) include switches, batteries, BL lamps, boards and electric cables most of which are prior in control and processing therefore their accurate collections is very important. There are 240 or 60 lit reservoirs in this salon that the general and small wastes which are not the result of production process are stored in them. The stored wastes along with the waste from cleaning the floor are transported to the waste depot in the south side of the area and stored in a rolling tank. In the cut and painting sections there are residuals including refractory ceramic fibers, plastic materials, cartridge toner, hydrocarbon materials and electric cables some of which are dangerous to the environment and human health, therefore they must be placed in the sourced separately and sent to be recycles. These materials are placed in one cubic meter tanks. These containers transferred to and stored in the north side of parking lot. It should be noted that there are some 60 or 240 lit tanks in these salons that the general and small wastes which are not the result of production process are stored in them. The stored wastes along with the waste from cleaning the floor are transported to the waste depot in the south side of the area and stored in a rolling tank.

Transferring the collected and separated wastes are divided into precious and non-precious wastes and a separate process is defined for them. Then these wastes specially the ones that have a high priority in controlling are rapidly transferred to the plant recycling or out of the plant. Valuable electronic wastes include switches, batteries, BL lamps, electric boards, refractory ceramic fiber, refractory plastic materials, hydrocarbon materials and electrical cables.

4. Conclusion

The results can be classified as follows:

- Some types of electrical waste such as CRT, Switches and Backlighting lamps because their components containing mercury (Hg), are placed in extremely dangerous group and they should be promptly isolated and factory waste decontamination operations should be carried out.
- Statistical analysis of electrical waste in Saipa factory indicated that that the highest amount (in terms of weight) belonged to the electric cables and along with electric boards they include more than 40% of the total waste. After the electric cables that are among the wastes of all salons (painting, assembly and cutting) (with a total weight 1713 Kg), electrical boards have the largest share of this type of waste. In addition Backlighting lamps have the last rank in terms of waste volume.
- Total electrical waste in the first half of this year for a vehicle was less than 1 kilogram (630g) and a total of 3200 g electric waste is produced in all salons within 1 hour. the highest percentages of wastes are related to electric cables and electric boards (27 and 22 percent) and the lowest percentage is associated with Backlighting lamp (2 percent).
- After screening the proposed criteria and selected information layers include: waste production management which emphasizes on waste reduction during the production process for which two sub criteria of control at source method and waste minimization in production process were included. Also the second criterion is the process and recycle of waste that reduces and reuses the produced wastes. Both layers are integral parts of waste reduction and increased efficiency. The main goal is to provide waste control programs to maximize efficiency and reduce waste production but since this is not realized because of technical and economic issues, recycling and processing are discussed as the second purpose.
- Given that the incompatibility factor in all criteria was below 10%, prioritization of these criteria is approved. Based on the above table it became clear that waste minimization in production process with the relative weight of 0.281 is the most appropriate criteria for all environmental, technical and economic aspects but environmentally clean technologies with the relative weight of 0.035 was the last priority among six proposed criteria.
- the proposed options for processing and recycling of Saipa electrical waste with an emphasis on the decline in production include the following cases (WEEE standard classification): A)Metal recycling (iron, aluminum and metal parts) B)Recycling plastic and hydrocarbon materials C)Recycling cables and ceramic fibers D)Recycling switches E) Recycling Boards F) Recycling batteries, Backlighting lamps and CRT
- the results of comparing options versus the target to choose the most prior electric waste recycling methods as a technical, economic and environmental approach are recycling CRT, Backlighting and batteries with the final weight of 0.394, recycling boards and switches, plastics and hydrocarbon materials, refractory cables and fibers and finally the metals as the least important one (0.330 CRT and the batteries need separate space and advances).
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- Transferring the collected and separated wastes are divided into precious and non-precious wastes and a separate process is defined for them. Then these wastes specially the ones that have a high priority in controlling are rapidly transferred to the plant recycling or out of the plant. Valuable electronic wastes include switches, batteries, BL lamps, electric boards, refractory ceramic fiber, refractory plastic materials, hydrocarbon materials and electrical cables.

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