Surveying Reverse Logistics for Electrical and Electronic Parts of Automobile " Pride " in Iran

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Abstract

The issue of reverse logistics of broken-down cars has been regarded in Iran for many years both economically, and environmentally. This country has made great improvements in recycling a large number of automobile parts; however, as it is reported, no scientific and basic measures are taken to recycle the electric and electronic parts despite their dangerous components in this region. It is a while, that the environmental experts warn to the governors about the end of wasted electric and electronic parts.

The main goal of this project is to survey the reverse logistics of electric and electronic parts of Pride Automobile in waste or broken-down state with the aim of minimizing the reverse logistics costs (such as transportation, …). After designing an arithmetic model to define recycle centers for parts of lead-acid battery as the most important electric and electronic part chosen by the expert group in Pride automobile, scholars describe the reverse logistics process for this part by designing another model and concerning some restrictions by using Lingo software in this paper.

Keywords: reverse logistics, electric and electronic parts, recycling, lead-acid battery

1. Introduction

In recent decades public opinion especially those who are responsible for preserving natural environment and statesmen has turned to this concern that a product will be thrown away in some time after it is delivered to the customer. If the products are capable of returning to life cycle, they won't harm the surrounding environment to a great extent, but some others including waste electric and electronic equipment (WEEE) will do great harms to natural environment and consequently to human life. In another view, high percentages of wasted materials can be recycled which, in its place, can be also economical. From such a group of products one can name the vehicles, which include a large number of parts to be recycled and used again. It is worth conveying that recycling the product via reverse logistics is an acceptable approach, since reverse logistics includes the process of effective planning, executing and controlling the flow of ingredients, the needed materials for production, final products and their related

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information from where they are used to the starting point, with the goal of regaining the value of returned product [1].

2. Review of literature

The first step is to discuss theoretical issues concerning health and environment, then relevant information to the necessity of concerning the end of life vehicle (ELV) and reverse logistics explained in detail.

2.1. Environment and human health

The problems of Environment and human health have been divided into 5 sections by the researchers as followed:

2.1.1. Importance of Health and environment

A flow of pollutants impact water, soil, and air in the process of recycling automobiles. This pollution is so much that impacts other areas despite the recycling centers. All soil threatening factors may damage water underground resources. It is the nature of recycling centers that may pollute the earth, ground, and underground waters if there is any shortcoming or negligence in this process. Especially the liquids that exist in automobiles may pollute the underground water for many years. Moreover, heavy metals like lead may severely affect the underground water resources [2].

2.1.2. Importance of recycling from the economic point of view

According to a research, collecting materials which can be recycled costs 35 dollars for each tone of garbage; whereas the cost of daily burying of the excessive garbage is 80 dollars [3]. According to a study, the material which can be recycled from lead-acid battery has the same quality of the raw material used in manufacturing this product. In this regard, the researcher of this paper announces that %95 of a lead-acid battery can be recycled. Also, the lead used in the battery can be recycled to %98.3 [4].

2.1.3. Importance of reducing harmful material

Managing the harmful material is one of the most important parts of environment engineering which has recently been considered by experts and researchers more than ever. In recent years the problems resulting from lack of proper management in case of waste materials has encountered mankind with diverse environmental disasters. For instance we may refer to the effects of heavy metals (especially Cadmium and Quicksilver) and different kinds of organic materials on human life and natural environment in different parts of the world [5]. The main objective in managing the harmful material is, in fact, to provide a way of reducing its effect on nature. Therefore, according to health regulations, recycling or probably refining the material before burying it in great depths or wells in the ground are of special primacy [3].

2.1.4. Importance of natural resources

Some believe that increasing rate of population, together with continuous production and exploiting natural original sources will empty the earth of them which are the valuable finite resources on the earth. Some others believe the resources on earth are revivable. So, they will increase in adequate amount from this point of view. Concerning the two aforementioned hypotheses it is by all means clear that using a kind of material before some part of it is transformed would be cheaper [3].

2.1.5. Necessities and regulations

According to the rules of Iran Industrial and Special Waste Administrative Management, Manufacturers are responsible for their waste management, but in case it is a normal waste, it is handled by the municipalities and the governors of the rural districts [6]. The importance of recycling old, worn-out automobiles and environmental concerns are to an extent owing to the decision made by the European Union in 2007 that conveys all automobile manufacturing companies should necessarily collect and recycle the broken-down automobiles manufactured by their own firms. Accordingly, all manufactured automobiles in EU member countries should be recyclable avoiding any harmful environmental effects in order to prevent the pollution of nature [2] . Meanwhile, concerning the rule of poisonous materials administered by EU in 2006, 6 poisonous elements such as lead, quicksilver, cadmium, chrome, PBB[1] and PBDE[2] are prohibited [7].

2.2. Research background relevant to the reverse logistics

Although many activities can be considered within the scope of reverse logistics, the most important activities specially those which proposed in this paper are [1]:

- Repair and Replacement
- Product Renovation
- Restructuring
- Recycling
- Reselling
- Regaining

Every year millions of manufactured automobiles enter into the markets in different parts of the world. The industrial world, especially North America, West Europe and East Asia, as pioneers of manufacturing, occupy the highest ranks of actively working in this field. That's why they need and attract a lot of attention. Concerning the dimensions of this industry one can conclude recycling is as well vast and significant. According to the released statistics, about 11 million automobiles of different models are collected and recycled all over the world. Waste iron resulting from the recycling process will provide more than 40% of all iron required by iron industry in different parts of the world. In other words, any broken-down automobile can potentially be used at steel mills and melting centers [8].

2.2.1. Solutions for the problem of dealing with electronic products end of life

1- Selling them as the second-hand products in the market
2- Repairing and selling them as the second-hand products in the market
3- Reviving the waste parts and selling them in the market with a higher price
4- Utilizing safe group parts in reproduction
5- Using small safe and sound parts in assembling larger parts and then producing the main product
6- Recycling the parts
7- Burning the residue
8- Burying the residue

Figure 1 shows the way of manufacturing the products and the solutions to the end of life mentioned above with their number at every stage [9].

[1] Poly Brominated Diphenyl
[2] Poly Brominated Diphenyl Ether

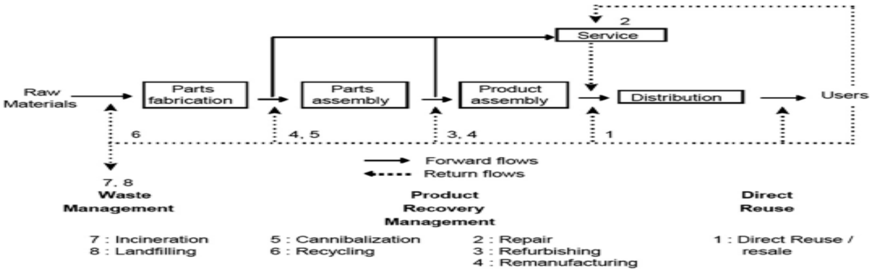

Figure 1: Logistics stages, and the reverse logistics of electronic products

2.2.2. Recycling the broken-down cars

One of the papers focused on the collector and the producer. The collector collects the products by paying to the final users. The reproducer receives the products from the collector by paying some money for the transfer and the price of the product. The remaining parts of products which are not used again can be sold as recyclable materials [10].

It has been defined in a study if an automobile made in 1985 has the percentages of the following combinations (chart 1), 75% of it can be recycled by today's modern technologies [11].

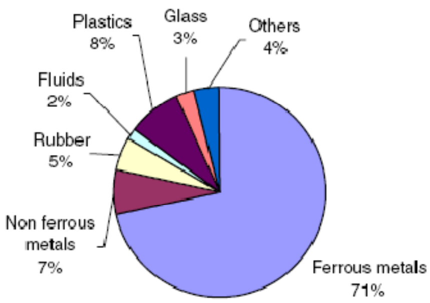

Chart 1: The average of the combination of materials used in an automobile manufactured in 1985

According to recent studies lead-acid batteries installed on automobiles have usually a useful life between 2 to 5 years. They will be discarded and replaced with new batteries at the end of this period. The average weight of an automobile battery is approximately 13 kilos including 8.6 kg of lead, 3.8 kg of sulfuric acid and 0.7 kg of poly propylene. Recycling the batteries should be done carefully and delicately, otherwise it will be harmful to the environment. Burning the batteries releases lead of the battery surface into the air which can result in numerous harms to the nature [12].

2.2.3. Reverse logistics of vehicle in Mexico

In a descriptive research, the establishment status of a closed supply chain for collecting the data on the ELV in Mexico has been discussed. In order to show the process, the activity was executed by means of reverse logistics and modeled by a defect situational equation. The solution to this model is attainable by means of Sitation software. Moreover, this study presents a summary of the current management system for the ELV and the tendency to execute that system in Mexico. The result of combining these three types of collection networks is in accordance with probable scenarios assumed to be 75%, 90% and 100% of the collection. In this study, the regions with the highest ranges of waste automobiles along with the factors affecting total costs in reverse providing cycles has been defined [13].

3. Research methods

This section contains two phases. The first phase deals with examining electronic parts of Pride automobile. The expert group will survey the recycle network for the parts and select one electrical part for further research by means of Expert Choice software. As the desired part is defined and examined, the second phase will deal with recycling methods and normal ways of optimizing the establishing network relevant to recycle centers for that special part in all of Iran.

3.1. Selecting the electrical and electronic part under study by reverse logistics

Recognizing electric and electronic parts in Pride automobile has been the first step in conducting the research which includes 104 decorative and engine electric parts. Since the characteristics of a lot of parts are alike, they are categorized under 17 groups in table 1 to make the process of research more appropriate. For instance all kinds of wires in different parts of Pride automobile, distinguished with separate technical codes, are grouped under the category of “wire”.

To continue the research, one out of 17 groups of parts should be chosen as the most suitable part for the study. In order to do this it seemed necessary to define some criteria and consequently make one part distinct from others according to the priorities. Referring to the first section of theoretical views and reviewing the literature one could define 5 criteria as follows:

- Importance of Health and environment
- Importance of recycling from the economic point of view
- Importance of reducing harmful material
- Importance of natural resources
- Rules and regulations

3.2. Selection of expert team and distributing questionnaires

Following the process of selecting an electrical and electronic part, it was necessary to select a team to guide us in choosing the concerned part according to the aforementioned criteria and help us follow the research process. Accordingly, consultations were made with acknowledged people and a team of five was selected who had enough information and experience about the selected part and its condition in natural environment.

All process was coordinated with members of the selected team; a questionnaire was prepared along with guidelines to fill it and was distributed among members of the team. The questionnaire was designed on the basis of AHP technique and was given to the team to be filled out.

3.3. Selecting the final part

The questionnaire filled out by the expert team, and the related data recorded through Expert Choice software. Concerning the fact that the aforementioned software will select one part for each member according to their knowledge based on the criteria mentioned before and that each member should consider one part for the rest of the process, so the geometric average helped selecting the desired part as given in table 1. In the following table the grant of each part for all members is calculated by equation (1) and the geometric average is defined. According to the data given in table 1, it is observed the battery is considered to be the most important part according the desired scale. Now the rest of the research process is executed on lead-acid battery.

$$X = \sqrt[5]{a*b*c*d*e} \tag{1}$$

Table 1: The result of the questionnaires processing by the Expert Choice software

Row	Part Name	Expert 1	Expert 2	Expert 3	Expert 4	Expert5	X=Geometric Average
1	Lead-Acid Battery	0.095	0.172	0.177	0.161	0.107	0.1379
2	Cassette Radio	0.091	0.173	0.183	0.139	0.097	0.1312
3	Amper	0.08	0.105	0.091	0.122	0.049	0.0855
4	Wiper Motor	0.044	0.073	0.079	0.071	0.051	0.0620

5	Key	0.025	0.099	0.109	0.093	0.028	0.0588
6	Light	0.038	0.077	0.074	0.046	0.049	0.0547
7	Injector	0.074	0.044	0.041	0.042	0.074	0.0529
8	Wire	0.161	0.041	0.045	0.057	0.02	0.0508
9	Dynamo	0.067	0.033	0.032	0.027	0.074	0.0427
10	Horn	0.026	0.042	0.041	0.086	0.036	0.0425
11	Flasher	0.062	0.018	0.019	0.043	0.051	0.0342
12	Door Lock	0.04	0.025	0.025	0.023	0.056	0.0317
13	Imobilizer	0.103	0.014	0.015	0.02	0.057	0.0301
14	Lamp	0.018	0.031	0.014	0.018	0.082	0.0258
15	Heater	0.034	0.016	0.015	0.016	0.068	0.0245
16	Fuse	0.029	0.019	0.021	0.022	0.032	0.0241
17	Lighter	0.013	0.018	0.019	0.014	0.069	0.0212

3.4. Knowing the battery and the ways of recycling this part

3.4.1 Ingredients of a lead-acid battery

The ingredients of the battery are as follows:

1- Layers
2- Separators
3- Electrolyte
4- Cover
5- Terminals and connector cells
6- Battery dry charge

After surveying and examining the common situation of trashing and recycling automobile parts in different sites and consulting acknowledged people, the following activities were held including the existing situation of recycling automobiles, especially that of the battery in Iran.

3.4.2. Fulfilling the case study by corresponding knowledgeable people and the attendants

In this respect consultations were made by two groups of experts. There were correspondences with the president in charge of the standardization of trade union of automobile trashing and recycling centers and directors of Niroo Battery Corporation to get advices on the ways of recycling lead-acid battery. The most important point they referred to are as follows: "There are now about 108 active automobile trashing centers in Iran, 87 of which are registered [14]. More than half of all centers do recycling process as disassembling the automobile parts in addition to trashing the broken-down cars, of which 20 centers are in Tehran and around and the rest are scattered in different parts of Iran. There is not, for sure, a clear statistics on the number of disassembling centers all over Iran. In centers just trashing the automobiles, the broken-down ones are loaded and sent to disassembling centers.

Regarding natural environment preservation, president of the standardization trade union declared that according to act of the cabinet dating 26/11/2005, parts like batteries cannot be recycled around 120 kms away from urban areas since they contain dangerous and harmful materials to the environment[15]. The only responsibility of disassembling centers is just emptying acid of the battery in special plastic bottles to be sent to factories manufacturing batteries. The cover is also sent to Niroo Corporation to be recycled.

One of the directors of Niroo Battery Corporation, which is only authorized battery recycling agent in Iran, declared:

1. The useful life of a battery is approx 2 years.
2. Major products of the company are delivered to registered agents as spare tools.
3. Some part of the trashed batteries is purchased from the agents with a reasonable price.
4. The following procedures are done to recycle a battery:
   - Vacuuming the acid of the battery
   - Washing up the cover
   - Cutting up through the cover
   - Turning over the cover and extracting lead surfaces
   - Second cover washing
   - Turning the cover into Granule
   - Melting down gross lead and separating slag
   - Turning the lead into lead bars

3.5. Modeling the recycle network for batteries in the frame of reverse logistics in Iran

Mr. Cruz-Rivera and Mr. Ertel have designed a reverse logistics network to collect broken-down automobiles in Mexico [13]. Using the aforementioned model in this study and concerning the fact that the goal of conducting this research is to present a model to determine the battery recycle centers all over Iran in a way to minimize the costs of reverse logistics like transportation and … for sending recycled raw material to the manufacturing factories. This model was devised. In this respect we have to mention the following issues:

According to table 2, the number of batteries produced for Pride automobile is approx 1,700,000 per year. The statistics shown in table 2 are drawn from Sazeh Gostar Saipa Corporation as the provider of internal parts for Saipa Corporation. Concerning the average life of 2 years for this part one can estimate that a minimum of 1,700,000 batteries are trashed each year in Iran. It can be concluded that the country is in need of 17 recycle centers by an estimate of establishing recycle centers with the capacity of recycling 100,000 batteries per year.

Table 2: The amount of batteries received from the Supplier (Sazeh Gostar Co.):

Row	Company	Province	Battery produced each year	The ratio of raw material spent
1	Sepahan	Isfahan	1100000	0.65
2	Tavan			
3	Borna			
4	Batrisazi Niroo	Tehran	500000	0.29
5	Niroo Gostaran	Khorasan	100000	0.06
Total			1700000	1

Two models of linear planning have been designed to get the reply for this problem. The first problem output forms the second problem input. So, at first we will outline, and study the first problem as below. After that the second model will be studied as well.

3.5.1. Inputs of the first problem

In the first model 17 recycle centers assigned by considering the percentage of batteries trashed in each province based on the purchase of Pride automobile rate in that province. The provinces which have more trashed batteries, are in the priority of selection as the recycle centers. Inputs are as below:

i = number of provinces in Iran that is 30 provinces

a_i = number of trashed batteries in the province i regarded based on the Pride purchase in that province.

3.5.2. Variable of the first problem

X_i = number of trashed batteries recycle centers needed in each province i

3.5.3. First target function

$$\text{Maximize} \quad \sum_{i=1}^{n} (a_i * X_i) \qquad (2)$$

$$s.t. \qquad \sum_i X_i = 17 \qquad (3)$$

$$0 \leq X_i \leq 2, X_i \in \text{int} \, \forall i \qquad (4)$$

(2) Demonstrates recycle centers we need to have in each province according to the priority of establishing the recycling centers in provinces with more trashed batteries.

(3) Total ratio of battery production should be 17 in each province according to what captioned in section 5.3.
(4) Regarding the necessity of caring for environment pollution, 2 recycle centers have been considered for each province according to the scholars attitude.
After solving the above captioned problem by Lingo software, 9 provinces of Tehran, Isfahan, Khorasan Razavi, Fars, Khouzestan, Mazandaran, Kerman, East Azarbayejan (with 2 centers) and West Azarbayejan (with 1 center), have been assigned for establishing the 17 recycle centers. Therefore, according to the offered model, the provinces including the recycle centers will recycle their trashed batteries, and they will send extra trashed batteries if there are any to the nearest recycle center. Now scholars design another linear planning model regarding the assignment of recycle centers to meet the main goal that is minimizing the cost of dispatching the recycled raw material to the lead-acid battery manufacturers. This model assigns that which recycle centers will send recycled raw material to which battery manufacturing factories.

3.5.4. Inputs of second problem

k = number of recycle centers all over the country including 17 centers.

j = number of battery making provinces including 3 provinces (table 2).

D_{kj} = distance from the recycle center "k" to the battery-making provinces "j"

C_{kj} = cost of transportation from the recycle center "k" to province "j" in KM (based on rail or road transportation)

3.5.5. Variable of the second problem

$$Z_{kj} \begin{cases} \mathbf{0} \longrightarrow \text{Not sending raw material from the recycle center "k" to the factory "j"} \\ 1 \longrightarrow \text{Sending the raw material from the recycle center "k" to the factory "j"} \end{cases}$$

3.5.6. Second target function

$$\text{Minimize } \sum_{k=1}^{m}\sum_{j=1}^{l}(D_{kj} * C_{kj} * Z_{kj}) \quad (۵)$$

$$s.t. \quad \sum_{j} Z_{1j} = 1,\ \sum_{j} Z_{2j} = 1,\ \ldots\ \&\ \sum_{j} Z_{17j} = 1 \quad (٦)$$

$$\sum_{k} z_{k1} = 11\sum_{k} z_{k3} \quad (٧)$$

$$\sum_{k} z_{k1} = 2.2\sum_{k} z_{k2} \quad (٨)$$

$$\sum_{k} z_{k2} = 5\sum_{k} z_{k3} \quad (٩)$$

$$D_{kj} \geq 120 \quad (١٠)$$

$$0 \leq Z_{kj} \leq 1 \& Z_{kj} \in \text{int} \forall k, \forall j, \quad (11)$$

(5) States that the recycled raw material should be sent to which factory in Isfahan, Tehran and Khorasan Razavi to minimize the total transportation costs.

(6) Each battery recycle center should send the recycled raw material to one battery manufacturer. So, only 17 consignments will be dispatched between the recycle centers, and the battery manufacturers.

We have to consider that the amount of the recycled batteries is 100000 annually, and the manufacturing capability of each factory is different. So, we can conclude that according to table no. 3.

(7) Number of recycled raw material dispatches to the first factory should be 11 times as the third factory.

(8) Number of raw material dispatches to the first factory should be 2.2 times as the second factory.

(9) Number of raw material dispatches to the second factory should be 5 times as the third factory.

(10) Based on the government board approved laws (section 2.4.3) the distance of poisonous material recycle centers should not be less than 120 km from the center of the cities. It is also applicable for the batteries recycle centers.

(11) The variable of this problem is 0 or 1.

By using this model, we can determine that each center should send the recycled material to which Lead-Acid manufacturing factories to minimize the transportation costs.

4. Findings and Conclusions

The devised model has been solved by giving inputs to Lingo software such as the distance from the center of each province to the three battery producing provinces of Tehran, Isfahan, and Khorasan Razavi, the ratio of the trashed batteries determined in each province based on the information from purchasing Pride automobile in each province, and the transportation costs including rail or track shipment of the trashed batteries between the centers of provinces to the battery consuming centers. The answer offered in the table below:

Table 3: sending recycling material to battery manufacturers

Khorasan Razavi	Isfahan	Tehran	Departur / Arrival
0	0	1	Tehran 1
0	0	1	Tehran 2
0	1	0	Isfahan 1

0	1	0	Isfahan 2
1	0	0	Khorasan Razavi 1
0	1	0	Khorasan Razavi 2
0	1	0	Fars 1
0	1	0	Fars 2
0	1	0	Khouzestan 1
0	1	0	Khouzestan 2
0	0	1	Mazandaran 1
0	0	1	Mazandaran 2
0	1	0	Kerman 1
0	1	0	Kerman 2
0	1	0	Eastern Azarbayjan 1
0	1	0	Eastern Azarbayjan 2
0	0	1	Western Azarbayjan 1

5. Conclusion

In this study issues were discussed with respect to relevant environment and health concerns and the process of reverse logistics in broken-down automobiles. Some models close to that of this study were selected and interpreted, like the paper on “Reverse logistics network design for the collection of End-of-Life Vehicles in Mexico”, which is very similar to the model presented in this study. In further steps field work was executed on Pride automobile, especially on electric and electronic parts. In this respect, after battery was selected as the desired part based on the defined criteria and the data resulting from Expert Choice software. The rest of the field study dealt with surveying lead-acid batteries in Pride automobile. Finally the study ended in surveying battery recycle network as one of the major factors in reverse logistics in Iran with the aim of minimizing the costs of transportation, and etc. by presenting two models to find the number of recycle centers for battery, and the way of distributing recycled raw material to the manufacturing companies in Iran.

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