AUTONOMOUS SOLID WASTE SEPARATION SYSTEM DESIGN

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ABSTRACT

AUTONOMOUS SOLID WASTE SEPARATION SYSTEM DESIGN

This study presents the design of a municipal solid waste separation facility that uses physical properties to separate solid wastes into their types. This facility will be autonomous and automatic. There will not be any human personnel nor any sensors to separate solid waste in this facility. Only physical properties like size and density are used to remove materials so this facility will be more robust and efficient than current facilities. All recyclable materials will be taken from a waste stream that contains minimal useless waste.

The capacity of the facility will be calculated and the facility will be designed for the city of İzmir. The design of a municipal solid waste separation facility includes examining and recent separation facilities in the world and in İzmir, seeing problems at their source in İzmir and taking suitable separation machines with suitable capacity by examining systems to make a process flow chart.

ÖZET

İNSANSIZ KATI ATIK AYRIŞTIRMA SİSTEMİ TASARIMI

Bu araştırma katı atıkların fiziksel özellikler kullanılarak bileşenlerine ayrıldığı bir evsel katı atık ayrıştırma tesisi tasarlanmasını kapsamaktadır. Bu tesis tamamen otonom ve otomatik olacaktır ve hiçbir şekilde çöplerin ayrıştırılmasında insan ve sensor kullanılmayacaktır.

Çöplerin ayrıştırılmasında sadece boyut ve yoğunluk gibi fiziksel özelliklerin kullanılması nedeni ile tesis daha kararlı ve verimi daha yüksek olacaktır. Kullanılabilecek her türlü geri dönüşüm maddeleri alınacak, böylece kullanılamayacak haldeki çöpün minimum olması sağlanacaktır.

Tesisin kapasitesi hesaplanacak ve İzmir'e uyarlanacaktır.

Katı atık ayrıştırma tesisinin tasarlanması, mevcut katı atık ayrıştırma tesislerinin incelenmesi, sorunların yerinde görülmesi ve kullanılabilecek ayrıştırma sistemlerinin incelenerek en uygun olanların uygun kapasitede alınarak, bir sistemin oluşturulması aşamalarını kapsamaktadır.

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CHAPTER 1

INTRODUCTION

From the time when people first gathered together to live in communities, the disposal of solid waste has been an environmental problem. This problem has been growing while civilization has been advancing. Today, solid waste becomes one of the biggest problems in the world. It is not only hazardous for people but also hazardous for all animals and plants. The increase in population and urbanization is also largely responsible for the increase in solid waste. Massive mountains of solid waste are produced each day by our consumer society. It is estimated that about 10 billion tons of solid waste are produced every year in the world and are dumped into the surroundings.

Solid waste is unwanted materials thrown away in solid form, coming from normal community activities. It is a mixture of complex and basic materials. Solid waste consists of organics materials, glass, papers, metal, wood, stone … etc. All these materials have different properties from each other. Some of them are very dangerous for nature but some of them are not. Some of them are easily destroyed by nature but some of them are not. The organic materials can be annihilated by nature quick and easily but other materials like plastic takes too long to disintegrate. For example, a paper handkerchief disintegrates in at three months, a coke can breaks down in ten years or a glass bottle is decays in four thousand years (Pehlivan 1995). In addition, nature is also harmed when raw materials are removed and then are used for producing products that people use and turn into solid waste. For example, forests are destroyed for making paper or petrol is used to produce plastic.

To live in a non-polluted environment and to decrease of the use of environmental sources, the reusable part of solid waste can be reused. Paper, glass and metal can be used again and again so that the amount of pollution can be decreased in the world and the sources of the world will not be consumed too much. Also, recycling prevents the emissions of many greenhouse gases and water pollutants, saves energy, supplies valuable raw materials to industry, creates jobs, stimulates the development of greener technologies, conserves resources for future generations and reduces the need for new landfills so that more land can be available for agriculture. To enable the forementioned, different methods are used in the world. There are many recycling, recovery and reuse techniques that prevent problems of solid waste. Some of them are Material Recovery Facility, Mechanical Biological Treatment, Advanced Thermal Treatment, Composting, etc. All of them have different processes for the disposal of solid waste.

In order to obtain recyclable materials, composting materials or other reusable materials, these materials must be separated from solid waste. There are two ways to separate them from solid waste; one is to separate at the source and the other one is to separate in a facility. There are different types of waste separation facilities in the world. One of them is a Material Recovery Facility. A Material Recovery Facility (MRF) is important for this thesis because in this project, an autonomous mixed waste separation facility will be designed. In this facility, human and sensors will not be used and it will be a fully automatic facility. Solid waste will be separated into its components by the physical properties of the materials. For these reasons, this facility will be robust and also it will be safe for human life.

In this study, the facility that will be designed will also be adapted for the city of Izmir because the population of this city is more than 3 million and every year many people immigrate to this city. Therefore, Izmir has a big solid waste problem. In this thesis, a solution will be offered for solving the problem of Izmir.

1.1 What Is Solid Waste

Solid waste is all garbage, refuse, trash and other discarded solid materials resulting from residential, commercial, agriculture and other human activities, it is also includes liquid waste contained within solid waste but does not include sewage and other human waste.

In this thesis, solid waste is separated by materials like paper, plastic, organic, etc. To separate these materials from each other, composition and categorization of the solid waste must be known. After finding this information, it can be known which processes will be used to separate solid waste into its components. If materials that are in solid waste are known, their properties can be found and they can be used in order to create a method for separation.

1.2 Categorization of Solid Waste

Solid waste is categorized by its sources which are given below:

a) Household solid waste
b) Industrial waste
c) Agricultural waste
d) Waste from treatment facilities
e) Hospital waste
f) Radioactive waste

Household solid waste is collected from settlement areas and commonly consists of food and other materials like bottle, newspaper …etc. Household solid waste has a higher ratio of water. It also has a big amount of ash in the winter season. Not only does household solid waste include big amount of organic materials but also cafes, restaurants and especially food facilities produce solid waste that has many organic materials. Different from the above, industrial waste is produced by factories and every industry has a different type of waste. Toxic waste and chemical waste are two types of industrial waste. Hospital waste is a dangerous waste because it damages nature so that it must be collected and disposed by special ways. Finally, common agricultural waste has plant parts, branches, wood, leaves …etc. Dead animals and animal products are also accepted as a part of agricultural waste.

In our facility design, we will only deal with household solid waste and agricultural waste because other waste types are very dangerous so in order to dispose dangerous waste, facility needs special precautions and processes. This should be a subject of a different thesis.

1.3 Composition of Solid Waste

Solid waste is very complex. It can include everything but it has commonly same things in it. These materials are given below as a list (Statewide Waste Characterization Study 2004):

1) Paper
2) Glass

3) Metal
4) Electronics
5) Plastic
6) Organic materials
7) Construction and demolition
8) Household hazardous waste
9) Special waste (Ash, industrial sludge, treated medical waste, bulky items, tires)
10) Mixed residue

1.4 Market Specification

Raw materials that are gotten from material recovery facilities must in some form be resold to industry. To earn more money, recyclables must have quality and no contaminants. A common problem in the quality of many recovered materials is contamination by broken glass. Broken glass mixes into cartons, plastic containers, cans and other targeted products, which lowers the product quality and therefore the product value. Due to the problematic effects of glass contamination, the proposed MRF will be designed to minimize glass breakage within each unit operation and during transport (Dubanowitz 2000).

Table 1.1 Sample market specifications
(Source: Dubanowitz 2000)

Material	Market Specification
Paper	• Separated by grade • Baled (size and weight specified) or loose • Dry or including some wet • Clean or some degree of contamination
Ferrous Containers	• Flattened, unflattened or shredded • Labels removed or not removed • Clean or with a degree of contamination • Including bimetal or no bimetal • Loose, baled or densified (weight and size specified)
Aluminum Containers	• Flattened, shredded, baled or densified • Free of moisture, dirt, foil, lead, glass, etc.
Plastic Containers	• Baled, granulated or loose • Separated by color or type or mixed • With or without caps
Glass	• Separated by color or mixed • Size of cullet (specified) • Degree of contamination

1.5 Solid Waste Management in Turkey

In this project, a solid waste separation facility will be examined which will be used for separating waste materials in order to create raw material for the recycling industry. This facility is designed for use in Turkey so some background information will be provided about solid waste management in Turkey.

1.5.1 Solid Waste Statistics in Turkey

These statistics are taken from The State Institute of Statistics (SIS). The State Institute of Statistics has published three main reports about solid waste statistics. The first research was published in 1993 about compositional variations in the household solid waste in Turkey. The second research was published in 1999 about municipal solid waste. The last research was published in 2004 about municipality waste indicators (SIS). This research was published in Turkey's Statistical Year Book 2004 under the subtitle, "Environment". The results of these three major studies are summarized in Table 1.2, Table 1.3 and Table 1.4

Table 1.2 Household of solid waste (HSW) composition in Turkey
(Source: SIS, 1993)

Season	HSW (kg-person/day)	Organic and Wet (%)	Ash and Slag (%)	Recyclable (%)
Summer	0.6	80.21	2.61	17.18
Winter	0.5	46.2	45.89	7.9
Average	0.57	68.87	17.04	14.09

According to Table 1.2, 0.57 kg solid waste is produced in one day by one person in Turkey and a big amount of this waste is organic waste, Furthermore, only 15% of the waste is recyclable waste. Because of these numbers, organic waste composting is very important for Turkey. In addition, Turkey's solid waste is wet so it is not economic to burn waste for getting energy.

Table 1.3 Municipal solid waste in Turkey

(Source: SIS, 1994)

Season	Municipal Solid Waste (kg-person/day)	Treatment of Solid Waste		
			1994	2001
Summer	0.9			
Winter	1.0	**% Landfill**	4.7	15
Average	0.97	**% Composting**	1.1	2.0

Table 1.4.a Municipality waste indicators

(Source: SIS, 2004)

	2001	2002
Total number of municipalities	3215	3215
Number of municipalities receiving waste services	2915	2984
Rate of population receiving waste services in total population (%)	77.44	76.34
Amount of waste collected (000 tones/year)	25133.7	25373.1
Amount of waste capita (kg-capita/day)	1.31	1.34
Amount of waste capita in summer season (kg-capita/day)	1.28	1.32
Amount of waste capita in winter season (kg-capita/day)	1.32	1.34

Table 1.4.b Waste disposal plants

(Source: SIS, 2004)

Number of landfill	12	12
Capacity (000 tones)	261282	277195
Amount of waste disposed of (000 tones/year)	8304.2	7061.4
Number of composting plant	3	4
Capacity (000 tones)	299.3	664.3
Amount of waste disposed of (000 tones/year)	218.1	383.1
Number of incineration plant	3	3
Capacity (000 tones)	43.9	43.9
Amount of waste disposed of (000 tones/year)	11	9

According to Table 1.4, by 2001 the total number of waste disposal plants in Turkey was 19. While 25.373.100 tones of waste was collected only 7.453.500 tones could be recycled at facilities. Only 29.4% of solid waste was disposed in 2001.This shows us that a big amount of solid waste could not be used and was thrown away which not only caused pollution but was also an economical loss for the country.

The characteristic of the solid waste changes from city to city. To establish a separation facility for a city, the characteristics of the solid waste of the city must be known. The composition of solid waste for some big cities in Turkey is given in Table 1.5.

Table 1.5 Municipal solid waste composition in major cities in Turkey (%, weight)
(Source: Metin, Eröztürk, Neyim 2003)

	Bursa	**Istanbul**	**Izmir**	**Adana**	**Mersin**
Population(1997)	1,958,529	9,198.809	3,114,859	1,682,483	1,508,232
Organic	53.1	43	46	64.4	63
Recyclable	36.4	33.9	31.0	25.2	29.4
Paper/board	18.4	7.8	12	14.8	18.42
Plastic	11.6	14.2	12	5.92	6.69
Metal	3	5.8	3	1.4	1.25
Glass	3.4	6.2	4	3.08	3.08
Other	10.5	23.1	23	11.4	7.6

According to Table 1.5, the composition of solid waste is very different in each city. However, organic materials are found much more than other material in all cities. The average amount of recyclables is 30% in the solid waste. These show us that materials obtained from solid waste is significant. Organic materials can be disposed of at compost facilities for making manure for agriculture. Recyclable materials can be used as raw materials at recycling facilities. According to this information, throwing away solid waste that we produce not only pollutes nature but also destroys a possible income for Turkey’s economy.

A survey conducted by municipal authorities in the Aegean coast of Turkey indicates the difference between big cities, small towns and touristic towns. The results of this study are shown in Table 1.6. The data summarized in Table 1.6 shows the variation in municipal solid waste as well as the compositional characteristics of waste.

Table 1.6 Municipal solid waste (MSW) data in Aegean Coast of Turkey (Sorce: Metin, Eröztürk, Neyim 2003)

City	MSW (Kg/day -capita)	Waste composition (%)						
		Glass	Metal	Plastic	Paper & Board	Organic	Ash & Slag	Other
Çanakkale	1.12	2	1	3	7	80	4	3
Kuşadası – Aydin	2.3	3.65	1.85	5.8	14.8	68		5.9
Manisa	1.95	1.09	2.1	4.45	1.52	62.61	20.32	7.91
İzmir	0.96	4	3	12	12	46	9	14
Balikesir	0.89	3	5	3	8	67	9	5
Muğla	1	2	3	2	4	20	20	49
Average	1.37	6	4	8	12	49	12	9

The comparative analysis of these tables reflects the typical variation of MSW based on the demographic, social and economic differences. If overall figures are required to reflect the compositional characteristics of MSW in Turkey, organic components can be assumed to be 50-55%, whereas recyclable materials and others (ash and slag, dust etc.) can be assumed to be 20-25%. However, some correction is always required to accommodate the statistical variations arising from the specific nature of waste sources: for example, seasonal changes and demographic facts. In other words, significant alterations may be presented in tourist sites due to the condensed population and the type of consumption during the tourist season.

There is one big question, what do municipalities do to solid waste in Turkey? The answer is given Figure 1.1. As it is seen, about 40% of solid waste is sent to municipalities' landfill. 15% of solid waste is sent to the metropolitan municipalities' landfill. About 2% of solid waste is buried. 1.37% of solid waste is burned. About 1% of municipal solid waste is sent to compost facilities to make compost for agriculture and parks. 33% of solid waste is used for orderly storing.

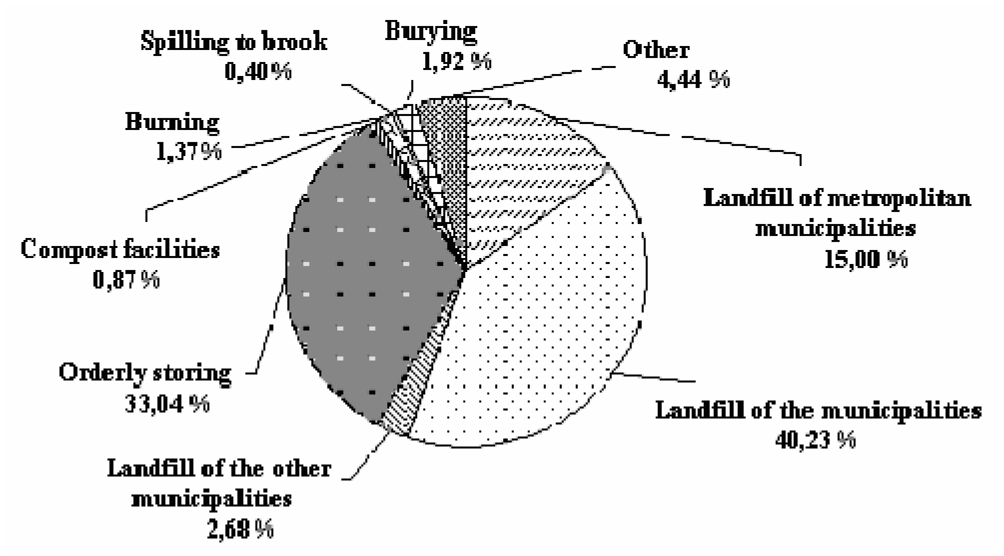

Figure 1.1 Municipality solid waste ratios for disposal process

(Source: SIS, 2001)

1.5.2 Solid Waste Recovery and Recycling in Turkey

Solid waste recovery has been practiced for a long time in Turkey. Paper, glass, plastic and metal has been recycled in industry since the 1950s. Turkey is one of the biggest metal recyclers in the world. Also, nonferrous metal recycling is widespread at the industrial level, including aluminum, copper, lead and silver.

In Turkey recyclables are mostly collected from household solid waste by individual collectors (scavengers etc.). These individual collectors purchase the used packaging from commercial units and markets and then sell them directly to the industrial recycling facilities. In addition, collecting from waste bins is also a widespread activity. Because of these types of collections, it is difficult to specify figures reflecting actual collection and recovery. Estimates made by experienced individuals working in this field indicate that the total amount of MSW recovered in Turkey is over one million tons per year. This estimation, together with the data showing the amount of packaging and recyclable materials placed into market, is shown in Table 1.7. As shown Table 1.7, packaging waste recycling in Turkey is above 30%.

Table 1.7 Amount of packaging waste (tons/year) in markets and estimated recovery and recycling figures for Turkey in 2000

(Source: Metin, Eröztürk, Neyim 2003)

	Placed into market (tons/year)	**Amount recovered (tons)**	**Recycling (%)**
Paper and Board	1,850,000	700,000	36
Glass	350,000	80,000	25
Plastic	550,000	170,000	30
Metal	150,000	50,000	30
Total	2,900,000	1,000,000	35

1.5.3 Separate Collection of Household Solid Waste

Separate collection has been done since 1990s in Turkey. Currently more than 60 municipal recovery programs are operational nationwide. In separate collection, paper, glass and plastic are put in plastic bags, than these bags are collected from the houses, hotels or markets one day a week. These bags are sent to the material recovery facility (MRF). In the MRF this waste is separated into its components. Figure 1.2 shows us output of two MRFs in Kadıköy and Bakırköy.

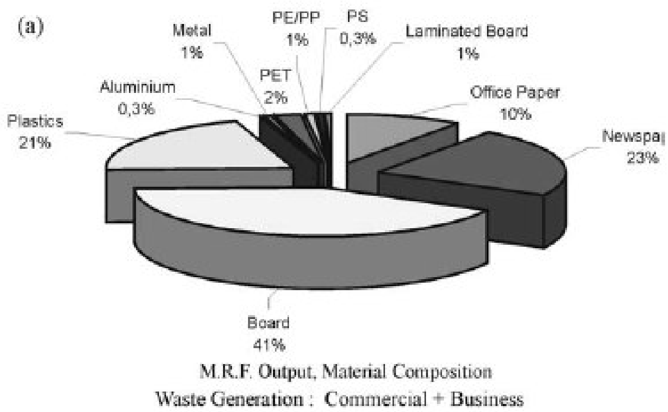

Figure 1.2.a. Detailed compositional distribution of composition of recovered material, Kadiköy MRF output

(Source: Metin, Eröztürk, Neyim 2003)

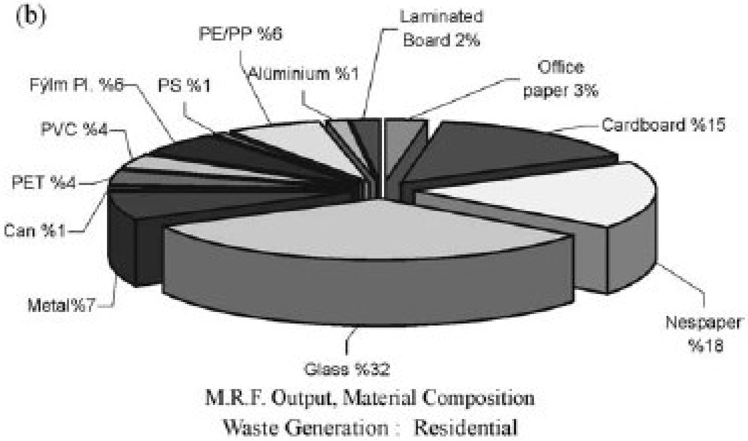

Figure 1.2.b. Bakırköy MRF output, average of 3 years of operation. Indicative of MRF output

(Source: Metin, Eröztürk, Neyim 2003)

After separating solid waste, recyclables are sold to the recycling facilities as raw materials. Table 1.8 shows the sales value of sorted materials from solid waste by MRFs.

Table 1.8 Sales value of sorted material with different collection source

(Source: Metin, Eröztürk, Neyim 2003)

Material sources	Paper and Board	Plastics	Metal	Glass	Average revenue $/ton	Total revenue $/month
Sales value $/ton	80[a]	150[a]	120[a]	35[a]	96.25	
Residential	% 38	% 21	% 9	% 32	83.9	170,000
Commercial	% 72	% 26	% 2	b	99	200,000
Composite	% 70	% 18	% 3	% 9	89.75	182,000

a An average value is calculated based on the annual sales volume of sorted material: Paper and board in category 4, Plastics in category 5, Metal in category and glass in categor2.

b Glass is being collected through a bin system. Therefore glass is only accounted for in door to door residential collection program.

1.6 Solid Waste Management in İzmir

There is no separate collection for solid waste in İzmir. Only a few small projects are done by district municipalities and private organizations but these projects are very poor for a city that has a population of more than three million. For example, a separate collection waste project has been operating for one year by CEVKO and İzmir Metropolitan Municipality. Waste in İzmir is collected in two containers: their sizes being 400 L and 800 L volumes respectively. Next, the waste is collected at transfer stations and transferred to waste facilities and landfills with transfer trailers which have 35 tons capacity and 50 m^3. İzmir has two landfills in Harmandalı and Menemen, two compost facilities in Uzundere and Menemen and three solid waste separation facilities in Menemen, Uzundere and Harmandalı

.

1.6.1 Solid Waste Statistics in İzmir

Solid waste per capita in İzmir is 1 kg /day. This information will be useful for future projections of solid waste in İzmir. Current, 2005 solid waste statistics are given below.

Table 1.9 Waste data for İzmir in 2005

(Source: İzmir Metropolitan Municipality, 2006)

Amount of Household Solid Waste (tons)	846.193,817
Amount of Industrial Waste (tons)	59.197,469
Amount of Dangerous Waste (tons)	3.344,950
Amount of Chemical Mud (tons)	23.397,650
Amount of Biological Mud (tons)	3.371,169
Other (tons)	7.078,350
Total (tons)	967.933,705

After considering the amount of solid waste produced in İzmir, another important data that should be looked at is the composition of the solid waste. It is vitally important to know the composition of the solid waste because it determines which products will be obtained from a facility. Furthermore, understanding how many products can be obtained is dependent on knowing the composition of solid waste. This information is given in Table 1.10.

Table 1.10 Material group analyses of solid waste in İzmir
(Source: Kucukgul, 2000)

Material Group	Low Income (%)	Average Income (%)	High Income (%)	Commercial Zone (%)	Industrial Zone (%)
Organic	74,8	60,9	50,9	18,4	41,5
Paper	5,6	11,4	14,6	11,8	16,6
Glass	2,7	4,8	6,9	14,8	3,1
Tin	1,5	2,2	3	9,3	4,8
Plastics	8,1	11,9	15,6	16,2	8,2
Wood	0	0,2	0,2	0,1	0,1
Textile	3,7	2,5	1,9	8,2	22,9
Batteries	0	0	0	0,6	0
Combined Packaging Materials	0,9	2	2,2	8,4	0,8
Foam Materials	0	0,1	0	0,3	0,7
Large Dimension Plastics	0,2	0,3	0,8	7	0
Stone, faineance, porcelain	1,1	0,6	0,1	2,5	0,7
Diapers and sanitary pads	1,1	2,9	3,1	4,8	0,1
Others	0,2	0,4	0,6	2,6	0,5

Table 1.11 Solid waste produced and processes in İzmir

(Source: Urut, 2003)

	Population	Produced amount of SW (ton/year)	Processed amount of SW (ton/year)	
			Processed	Processing ratio
1994	2.358.335	825.417	360.752	44
1995	2.416.958	845.935	448.202	53
1996	2.477.038	866.963	588.550	68
1997	2.538.611	888.514	561.141	63
1998	2.601.716	910.600	695.792	76
1999	2.666.389	933.236	758.476	81
2000	2.732.669	956.434,2	755.439	79
2001	2.800.597	980.202	807.420	82
2002	2.870.214	1.004.575	764.371	76

Table 1.11 and Table 1.12 show us how solid waste can be used in İzmir. According to these numbers, only small amount of solid waste is being used in İzmir.

Table 1.12 Recycling ratio of household solid waste in İzmir

(Source: İzmir Metropolitan Municipality. 2006)

Material	Recycling ratio (%)
Glass	14
Paper	48
Plastics	13
Metal	7

Total household solid waste produced in İzmir in 2005 was 846.194 tons but only 10.017 tons of this solid waste was recycled (İzmir Metropolitan Municipality, 2006). The ratio of recycling solid waste is given in Table 1.12.

1.7 Solid Waste Management in the World

Solid waste is a very big problem for humanity. What can be done for solving this problem? What can be done to benefit from this problem? In this chapter, it will be explained what is being done world-wide to solve the solid waste problem.

Solid waste that is collected from houses, shops and factories can boost the economy considering its composition and the different processes which it needs to go through. There are a lot of alternatives to solid waste management. These alternatives are given in Figure 1.3. Notes for Figure 1.3:

(a) Additional components of commercial waste which are not shown include ONP, ferrous and aluminum cans, clear, brown and green glass, and PET beverage bottles. Collection options for commercial waste are not shown but are analogous to options 1 and 3.

(b) The components of multi-family dwelling waste are the same as those listed for residential waste. Collection options are not shown but are analogous to options 1, 3, 4, 7, 11, and 12.

(c)The components of commercial waste are: office paper, old corrugated containers, Phone Books, Third Class Mail, ferrous cans, aluminum cans, clear glass, brown glass, green glass, PET beverage bottles, newspaper, other recyclable (3), non-recyclables (3).

(d) Transfer stations (truck and rail) are not shown due to space limitations. They are included in the alternative system.

According to earlier studies, all materials can be recycled using different processes for different types of waste. Getting high efficiency from the recycling process depends directly on the people who are involved in the process; their desire for success and their goals. What are these processes and facilities? Solid waste processing facilities are given below:

1. Material recovery facilities
2. Composting facilities
3. Waste to energy facilities
4. Storage facilities

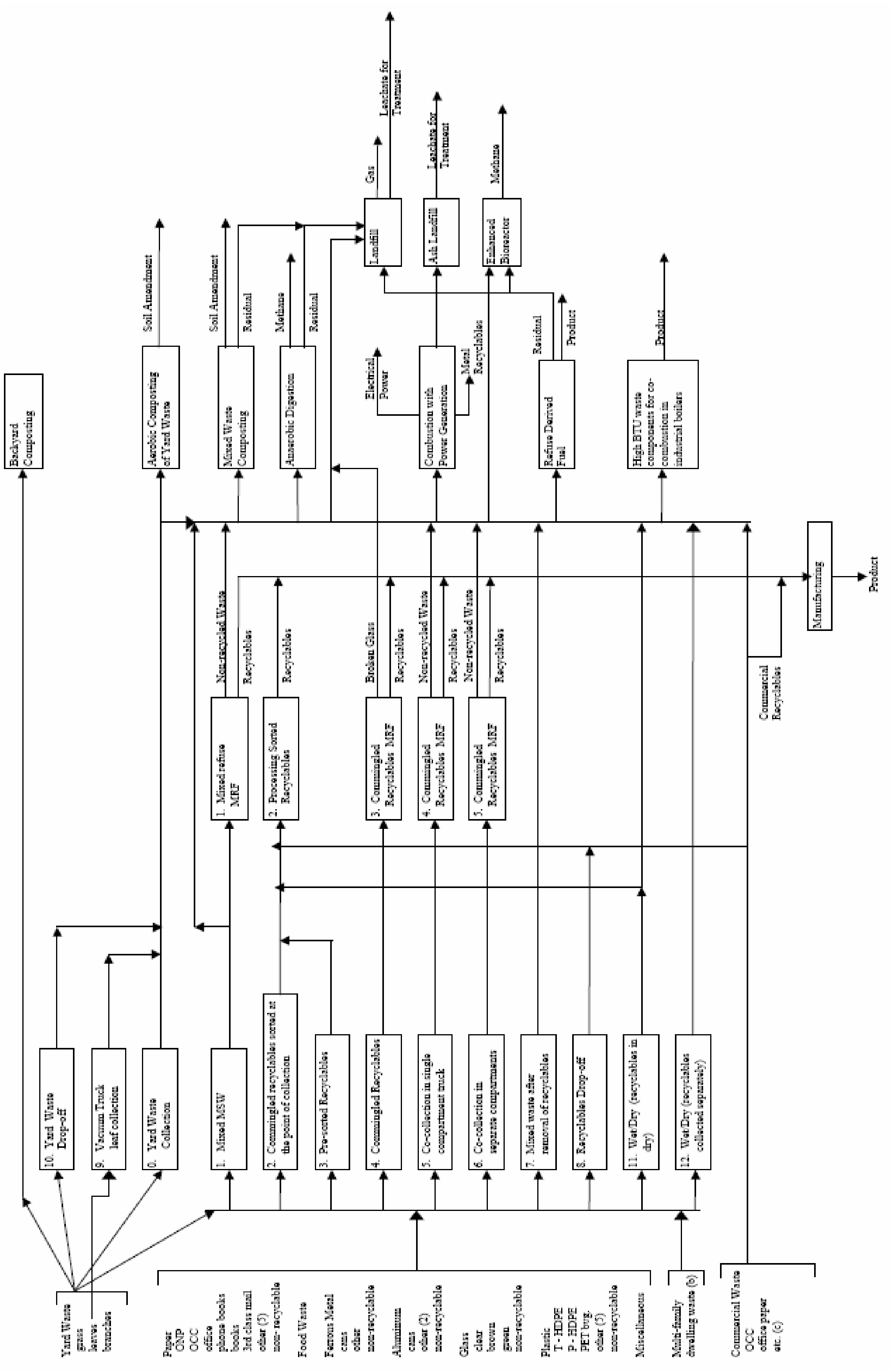

Figure 1.3 Alternatives for solid waste management

(Source: Barlaz, Ranjithan, Weitz, Nishtala 1995)

1.7.1 Material Recovery Facilities

There are different types of facilities referred to as Material Recovery Facilities (MRFs). These include:

- Waste separation and recovery facilities, they are also known as dirty MRFs that process mixed municipal solid waste to recover recyclables.
- Recycling processing facilities, which complement recycling programs by providing the means to sort, process, and prepare recyclable materials for the market. These are often referred to as clean MRFs because they do not sort mixed municipal solid waste, only mixed recyclables.
- Specialized MRFs, which accept a specific type of recyclable material or waste for processing, such as construction debris.

1.7.2 Waste Separation and Recovery Facilities

This facility is often called as a dirty MRF. It is called with this name because it accepts mixed municipal solid wastes. MRF can use many methods and different equipments to separate individual recyclable materials from the waste stream.

A low technology MRF is called a "dump and pick" operation dependent largely on hand sorting. Mechanical systems in such facilities may be limited to conveyors.

Medium to high technology facilities commonly use conveyors, screens and magnets to separate components of the waste. Some facilities also use air classifiers (devices that use forced air to separate the light burnable fraction from the remaining inert material) and shredders. Computerized equipment is also sometimes used to recover and segregate aluminum, paper, glass, and plastic.

Generally, residues left after recyclables are removed must be sent to landfill. Some may be compostable and some may be suitable for a Waste to Energy Facility.

1.7.3 Recycling Processing Facilities

At these facilities, recyclable materials are separated by type and processed further to meet market requirements. These facilities are called as clean MRFs because they do not include mixed municipal solid waste in their sorting process. Source separated solid waste is accepted from these facilities. Processing at such facilities often involves:

- Baling Newspaper: Some additional processing to remove glossy papers, magazines, or other contaminants may be used to upgrade the quality of the newspaper. If newspaper is mixed with lower grades of paper, it may be shredded and then baled.
- Segregating and Baling Corrugated and Office Paper: Typically, a trommel screen is used to remove contaminants. Hand sorting may also be used to segregate grades of paper or remove contaminants.
- Metals Separation: Hand sorting is typically used to segregate aluminum, steel, and bi-metal cans. Magnets may be used to separate ferrous metal cans from non-ferrous (aluminum) cans. Air classifiers may be used to remove aluminum cans and plastic containers from heavier materials.
- Glass Sorting and Processing. Glass is often sorted by color to increase its value. Glass is typically sorted by hand to separate colors and remove contaminants. After sorting, glass is crushed into small pieces (cullet). Metal caps, rings, and labels are removed by screening the cullet.
- Shredding and Baling Plastics. Intact plastic containers occupy a large amount of space relative to their weight, making it inefficient to transport these materials long distances without processing. Processing may include specialized sorting equipment and shredding, baling, perforating, and/or granulating the plastic to reduce its volume.

Residues from recycling processing facilities include contaminants that are mixed in with the recyclables, non-recoverable, or not easily marketed materials (such as broken, mixed colored glass) and materials that cannot be handled by sorting equipment. The amount of residue depends on the processing efficiency of the facility, the degree of separation by generators and the collection method.

1.7.4 Specialized Facilities

These facilities are called as Aggregate Recycling facilities. Recycled aggregates are materials such as concrete, bricks etc recovered as waste from construction, demolition and/or refurbishment projects.

There are three main techniques used in processing aggregates for recycling:

- Crushing and grinding
- Screening
- Material sizing and combining

Prior to processing, the material needs to be pre-sieved and separated to remove contaminants from the useable material. Magnetic separation and picking belts are commonly used for this.

Once the material has been pre-sieved, it needs to be reduced in size to comply with the various standards for recycled aggregates. This involves crushing, grinding and cutting the material:

- Crushing - primary crushing breaks large material into smaller lumps (100 to 250mm). Secondary crushing breaks them into much smaller lumps
- Grinders – reduce crushed material into powder
- Cutting – produces particles of definite size and shape

1.7.5 Composting Facilities

Composting is the controlled decomposition of complex organic materials by microorganisms such as fungi and bacteria. Although decomposition occurs naturally, composting facilities are designed to speed up the rate of biological decomposition by managing key parameters, including moisture content, oxygen, temperature, and the ratio of carbon to nitrogen. In general, composting systems are designed to produce a stable end product quickly. The rate of decomposition depends on the type of material, local climatic conditions, system configuration, and operating procedures. Most composting operations can produce an end product in one to six months (Planning for Resource Sustainable Communities, Vol. 1).

Composting facilities use four basic methods to introduce air:

Windrow System: This system is the least technologically advanced and the oldest form of composting. It is also the least expensive. Elongated piles of material are aerated by natural convection. Hot air in the centre of the pile rises, creating a partial vacuum which draws in cooler air from the sides, thus circulating air. Once constructed, the piles need to be turned or mixed to vent excess heat.

Aerated Static Pile: Blowers are used to move air through the pile, which is left untouched until the active stage of composting is complete. When temperatures in the material exceed the optimum, the thermostatically controlled blower forces air into a perforated pipe at the base of the pile.

In-vessel System: the vessel can be anything from a silo to a concrete trench. Because these systems are confined in a structure, it is possible to collect and treat odours from sludge or MSW, which may be anaerobic when delivered to a facility. In-vessel systems usually make use of forced aeration, similar in operation to an aerated static pile. Silo-type systems rely on gravity to move material through the vessel, and the lack of internal mixing tends to limit the silos to homogeneous materials like sludge. Other in-vessel systems can include internal mixing that physically moves materials through the vessel, combining the advantages of the windrow and aerated static pile methods

Vermicomposting: There is vermicomposting, the use of worms to achieve controlled composting of organic wastes. It is beginning to be used in some commercial-scale facilities in other states. Worms digest organic materials from the feedstock and produce

castings. In addition to significantly reducing the quantity of waste material, the castings can be used as a soil amendment or organic fertilizer. Compared to other composts, worm castings have a finer texture, do a better job of enhancing the soil, have typically higher levels of nitrogen, potassium and phosphorous, and have more microorganisms to fight diseases in plants. Vermicomposting has been used to compost kitchen scraps, and has been demonstrated as a viable solid waste management tool used on site by businesses, institutions, and farms as well as commercial composting of source-separated resources.

The following table (Table 1.13) offers a summary of some of the different types of composting technology available and their capacities.

1.7.5.1 Mixed Solid Waste Composting

Paper, food scraps, wood waste, and yard waste make up the compostable portion of the mixed municipal solid waste stream. However, because mixed waste also includes non-biodegradable items such as plastics and metals, the quality of the compost product will depend on the degree to which non-compostable items are removed in the process. Thus, a municipal solid waste composting facility would generally be co-located with a MRF.

Table 1.13 Composting technologies

(Source: Planning for resource sustainable communities, vol.1)

Technology		Capacity
Type	**Name**	
Enclosed windrow	Plus grow (UK)	3,000 – 23,000tpa, 12.5tonnes per day per bay (35m^3). 12 tonnes of compost collected bi-daily from each bay
	VKW (Austria)	Varies depending on size of plant. Capacity can be 4,200m^3 Annual loads can be up to 270,000tpa
	Agrivert	250m^3 (120 tons), existing plants range between 5,000 to 200,000 tpa
Rotating Drums	TIM Envirpro (Denmark)	6000L per fortnight
	Bedminster (USA)	60t of MSW and 30t of sludge in each compartment. Larger plants can produce up to approximately 200,000tpa
Static Batch Tunnel	GiCom (Netherlands)	Ipswich installation: 12,000 tpa for 3 tunnels, this is smallest for economic reasons (largest so far 300,000tpa)
	Traymaster (UK)	1000t per tunnel
	Clamp (UK)	Each clamp - 250m^3 (150tonne)
Containerised (mobile) batch tunnels	Alpheco Aergestor (UK)	Maxi: 30-40m^3; Midi: 10-12m^3 From 300 to 50,000 tpa dependent on plant size, material, retention times
	GMT (USA)	Two sizes – 30.6m^3 or 38.2m^3, 1-100 tonnes per day, each CompTainer can process approximately 260-460 tpa
	Stinnes Enerco (CN)	Input batch 7 tonnes, up to 50,000tpa
Silos/Vertical Composting	TEG Environmental (UK)	2 – 7 m^3 per silo/day, 500-600 tonnes per year Standard plant is 12 silos (6,000 – 7,200tpa)
	VCU (New Zealand)	Each chamber 25m^3. Max of 4 tonnes per day per chamber
Other batch systems with active Aeration	Ag-Bag (USA)	CT-5: 2.4tonne (3.5m^3), CT-10: 4.1tonne (7.5m^3), CT-5: 25,000 + tonnes per yr; CT-10: 100,000+ tpa (600 ton per day)
	GORECover (USA)	In Europe vary from 1,500tpa to 147,000tpa
Closed in-vessel	Fast Fermentation System	1.5 tonne vessel, from under 0.5 tonne per day up to 40 tonnes per day, 14,600 tpa
	The Rocket Accelerated Composter (UK)	Machines range from 15-100l per week up to 200-500l per week, 780-26,000l per year for one machine

Preprocessing of mixed municipal solid waste before composting typically involves:

• Materials classification - where large non-compostable and bulky items (such as white goods and tires), glass, metals, and other abrasives are removed to protect machinery, improve the quality of the final product, and increase recycling. Other non-compostable materials that are not removed in the preprocessing stage are removed during post-processing.

• Size reduction - by grinding or shredding to reduce particle size and facilitate handling and decomposition. Not all processes use grinding before decomposition; some processes allow non-biodegradable glass and metals in the feedstock and use these materials to grind the waste as it tumbles in an enclosed vessel (rotating drum process).

• Mixing - adding water and air to the mixture as it begins to decompose. The more homogenous the mixture, the less likely it will be to develop anaerobic pockets that can cause temperature differences, reduced product quality or odor problems.

Following preprocessing, mixed waste is composted in windrows, static turned-aerated piles, or vessels; cured, screened, and marketed as a soil amendment.

1.7.5.2 Yard Waste Composting

Yard waste consists of leaves, brush, tree trimmings, grass, garden waste, shrubs and materials generated by nurseries, landscapers, utility and public facility maintenance operations, and individual citizens.

This type of composting usually does not require presorting process. Only size reduction is applied in this composting. Before the waste is ground, impurities such as plastic bags, wire or rope may be removed by hand. Reducing the size of brush and tree trimmings facilitates handling and speeds up the composting process.

1.7.6 Waste to Energy Facilities

Waste-to-energy (WTE) facilities dispose of solid waste or recover energy through mass burning, refuse-derived fuel incineration, pyrolysis, or any other means of using combustion heat. A volume reduction of 90 percent is typical for these facilities; the unburned waste fraction (ash) continues to require landfill disposal or may, in certain circumstances, be recycled into useful products such as bricks or concrete.

1.7.6.1 Refuse Derived Fuel

Refuse Derived Fuel (RDF) can be generated from an MBT (mechanical biological treatment) plant, and is basically a high calorific waste derived from MSW (municipal solid waste) that can be incinerated as an alternative fuel source, typically:

- Plastics
- Paper / cardboard
- Wood
- Textiles

RDF has a higher calorific value than MSW (generally double) because it has removed the majority of inert non-combustible components (such as glass, metals, sand, bricks etc) and has a lower water content. RDF is typically limited to solid municipal waste sources, but similar fuel sources can be derived from industrial and commercial waste streams

1.7.6.2 Mass Burn Indicators

Mass burn incinerators burn mixed municipal solid waste at very high temperatures with limited preprocessing to remove large items such as stumps and appliances. In some cases, additional preprocessing is added to remove materials for recycling or other materials such as metals, that may cause ash contamination, damage equipment, or contribute to toxic air emissions. MRFs are often a front-end element of a mass burn facility.

1.7.6.3 Pyrolysis

Pyrolysis is the process of decomposing materials with heat in an oxygen-deficient atmosphere. In a pyrolytic gasification facility, waste is preprocessed to remove materials, such as metals, that cannot be decomposed. The waste is then dried and transported to a chamber where it is exposed to radiant heat tubes in an oxygen-free atmosphere. The heat reduces the waste into basic components: gases, (methane, ethane, hydrogen, and carbon monoxide); liquids (oil and tar); and solids (char and carbon black). The gases can be cleaned and used as a fuel for other purposes or transferred back to the chamber where they can be used to heat the radiant tubes. Solid residues are sent to a landfill.

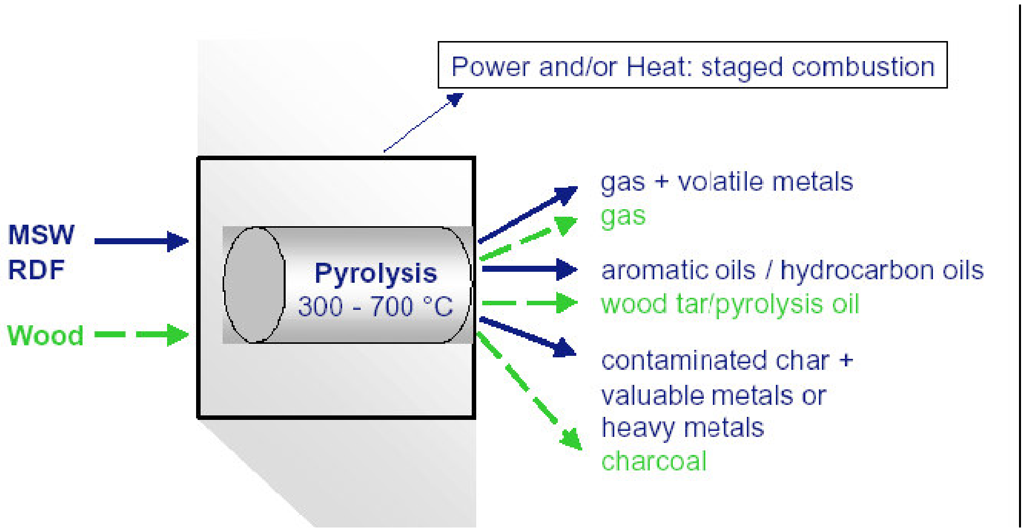

Figure 1.4 The pyrolysis process

(Source: Sipila, 2002)

1.7.6.4 Anaerobic Digestion

Anaerobic digestion is a process where bacteria in an oxygen deprived container breaks down organic waste. The container is heated to help the bacteria perform their task, with two main temperatures used:

- Mesophilic (approximately 37° C)
- Thermophilic (approximately 56° C)

The process releases a mixture of gases, the main components being carbon dioxide and methane. This gas is called 'biogas' and can be used as a fuel due to its combustible nature. The process also produces compost "digestate" (that can be used a soil conditioner) and a nutrient-rich liquid "filtrate" (that can be used as a fertiliser). The quality of the compost that is produced depends on the quality of the waste stream. The anaerobic digestion process can be used on different types of waste. Initially the process was used to treat animal manures (and currently still is in some parts) and has been developed to treat sewage sludge. More recently, the process has been used to treat the organic waste produced by households (termed Biodegradable Municipal Waste (BMW)) (Stenstrom 1981).

1.7.7 Storage Facilities

Two other types of facilities that can be used for storage and treatment for recycling are required to meet the standards of the State's regulations. These are solid waste surface impoundments and waste piles.

1.7.7.1 Surface Impoundments

These are solid waste facilities designed to hold an accumulation of liquids or sludges and are most often found as an accessory facility to an industrial business. State requirements include liners, methods to avoid washout under flooding conditions, and slopes designed to maintain structural integrity under conditions of a leaking liner or erosion factors. Some facilities may be required to have groundwater monitoring or leachate detection, collection and treatment systems.

1.7.7.2 Waste Piles

Under the recycling facility standards, the regulations define waste piles as any non-containerized waste used for storage or treatment. The regulations apply “to facilities engaged in recycling or utilization of solid waste on the land.” These can include non-containerized composting or the accumulation of waste in piles for recycling. The definition is a bit unclear. Under the MFS, permits are not required for a number of things that might be considered as a waste pile such as “wood waste or hog fuel piles to be used as fuel or raw materials stored temporarily” and being actively used, or where single family residences or family farms are engaged in composting of their own waste.

CHAPTER 2

PROBLEMS OF EXISTING FACILITIES

There are some problems which should be solved at solid waste separation facilities that are built to separate reusable materials from municipal solid waste. A facility that can solve these problems will be described in this thesis. These problems are given below.

The first problem is to protect human health because people are used to separate some recyclable materials from the solid waste stream at solid waste separation facilities. In these facilities, the solid waste stream moves on a conveyor and people work on both sides of the conveyor and these people pick recyclable materials with their hands from the waste stream and throw them into some boxes (Figure 2.1). There are different boxes for different materials. As it is seen here, people separating recyclable materials from solid waste stream are indirect contact with the solid waste. Because of this contact, some health problems are occurring. This is due to the fact that there can be all types of materials in the solid waste stream. There can be anything from dead animals to hazardous chemicals. For this reason, people should be taken out of solid waste separation process.

There is another problem arising from the use of humans in the separation process. People separate recyclable materials by using their eyes, so some materials are not separated because contaminants obscure these materials. Other materials are not clear to the human eye and these materials are not separated. Also, people are responsible for sorting big volume materials. For this reason, small volume recyclable materials can not be separated and this causes a decrease in efficiency of the facility.

Another problem is moving materials in front of people slowly and with small volume. Using people decreases the separation speed of a solid waste and the amount of separated materials per day in a separation facility.

Another problem caused by the use of people is economical loss because salaries, food ticket moneys and insurance moneys are expenses for facility. However, using machines instead of people prevents these expenses.

In order to prevent all of these problems, people will not be used for separating waste from the solid waste stream in the facility designed for this thesis.

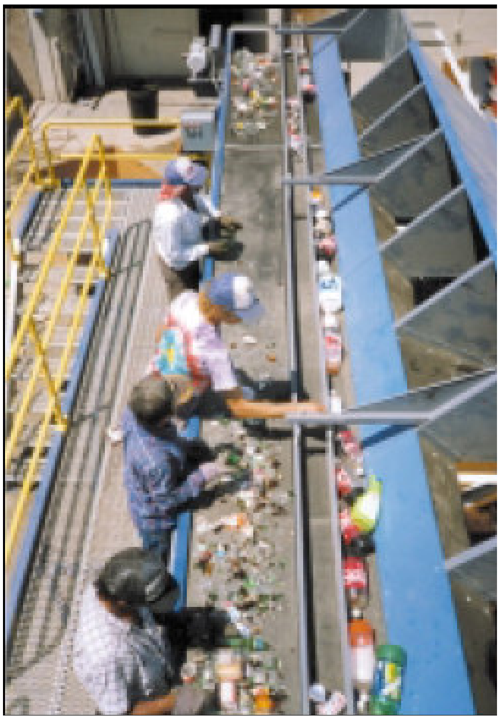

Figure 2.1 People are separating recyclables

(Source: marathon company sorting line catalog)

Also, sensors will not be used at the designed solid waste separation facility.

Figure 2.2 Optical sorting machine

(Source: WEB_1, 2005)

The first reason for not using sensors is due to the fact that machines using these sensors are very expensive. This causes an extreme increase in the building cost of the facility. An optical sorting machine is shown in Figure 2.2.

Another reason is that it is difficult to repair these machines. These electronic machines can be broken down easily due to the harsh conditions of solid waste separation facilities.

Separation with sensors is slower than separation using physical properties because waste must move slowly and small amount in order to be understood by sensors. This decreases the speed and capacity of the facility.

If people and sensors are used to separate waste in a separation facility, waste can not be separated into its elements completely and the efficiency of the facility can be low. For these reasons, sensors and people are not used in the waste separation facility designed for this thesis. Because, physical properties will be used for waste separation, this facility will be more robust and more efficient. It will also have more capacity due to the increase in speed.

CHAPTER 3

EXISTING FACILITIES

The purpose of this project is to design a facility that can separate mixed waste into their components. Then these components will be sent to other facilities that will use them. For this reason, examples that will be given below will be about separation of the solid waste. Material Recovery Facilities will be given as examples. It will be explained how waste is sorted in these facilities.

3.1 Separation Facilities in the World

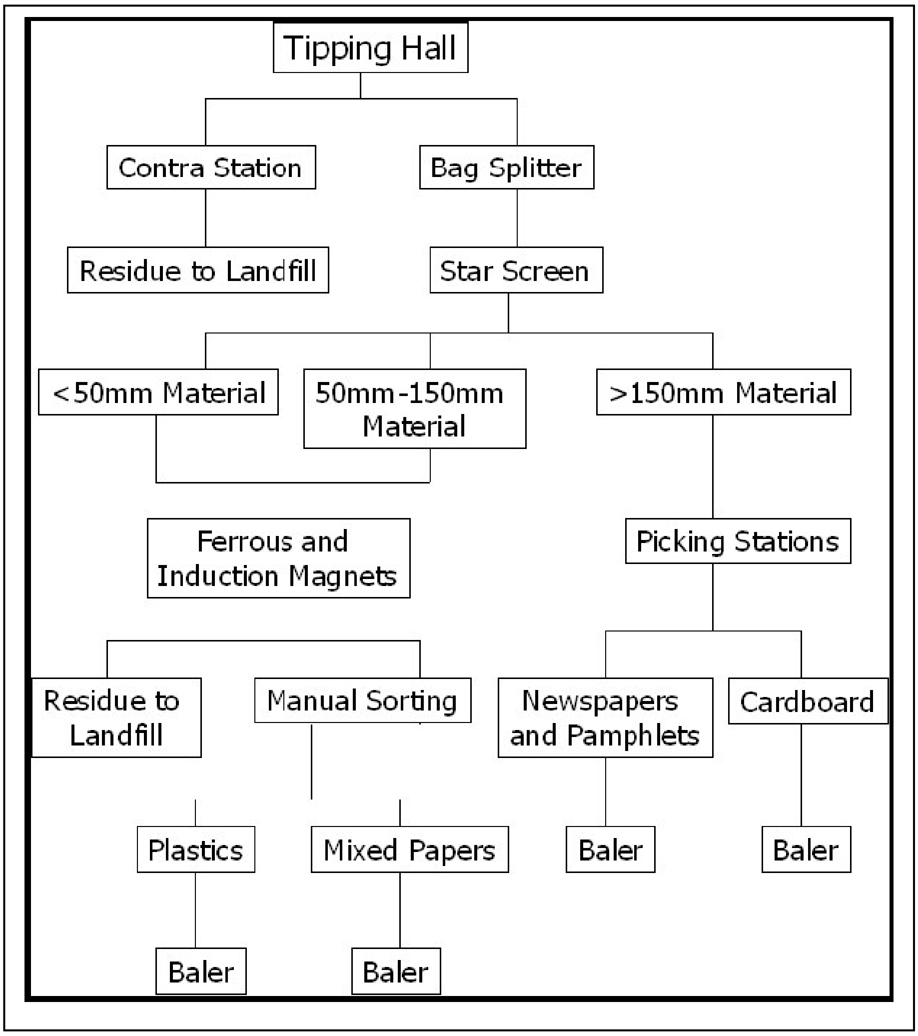

Figure 3.1 An example of dirty MRF processing system

(Source: ETSU 1999)

As it is seen, there is a dirty MRF processing system at Figure 3.1. In this example, mixed waste is taken from a tipping floor where solid waste is waited to dry. Next collected waste is sent to a bag splitter that tears plastics bags. After this machine, mixed waste goes into a star screen which separates solid waste into 3 different sizes. Bigger size materials are sent to the picking station where people take newspapers and cardboards from the waste stream and smaller size materials are sent to magnet sorting. After ferrous materials are removed, the waste stream arrives at a manual sorting place where plastics and papers are removed by people. After all usable materials are removed, unusable solid waste is sent to a landfill. As it is seen, in this facility people remove usable materials from waste and also only metals, papers and plastics can be taken from the waste stream. Other usable materials are sent to the landfill. This is a very big loss.

Another example is given Figure 3.2. According to this figure, first metals are sorted from mixed municipal solid waste by magnetic and eddy current separation. After this stage, waste is separated into 2 parts by pulverization and air classification; one part is light, the other is heavy. Plastics and paper are taken from the light part of the waste by automatic and manual sorting. Other recyclables are separated from the heavy part of the solid waste. Rejects are sent to a landfill or thermal treatment. Again humans are used for sorting in this facility.

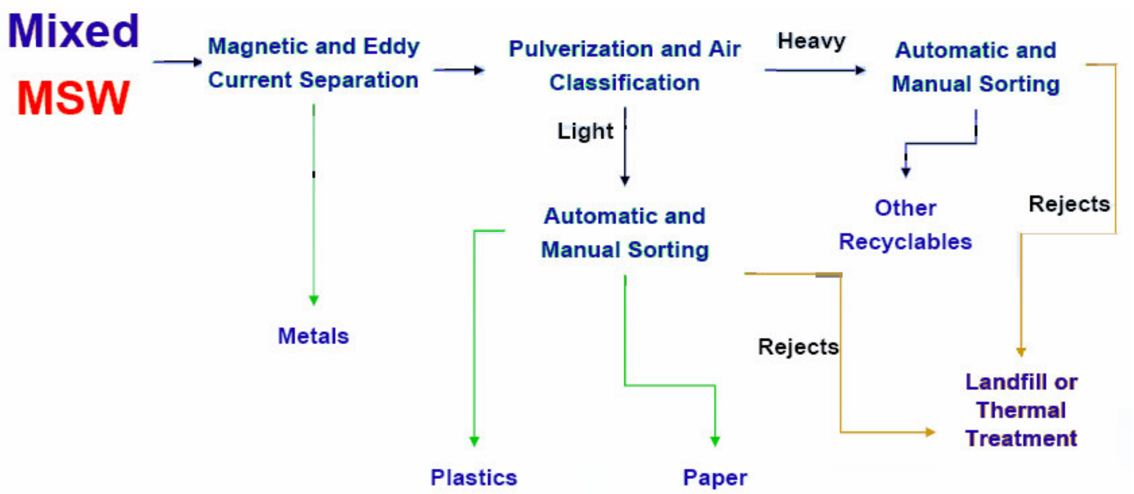

Figure 3.2 A dirty MRF flow chart

(Source: Poon, C.S.)

In Figure 3.3, another facility using humans for sorting is explained. To start with, large items and films are sorted by humans. Then ferrous metals are taken by an overhead magnet belt. After, a man separates plastic films and then the waste moves into an air classifier where heavies and lights are separated from each other. Heavies like glass and ceramics are separated by manual sorting, lights like plastics and aluminum are separated by manual sorting and eddy current.

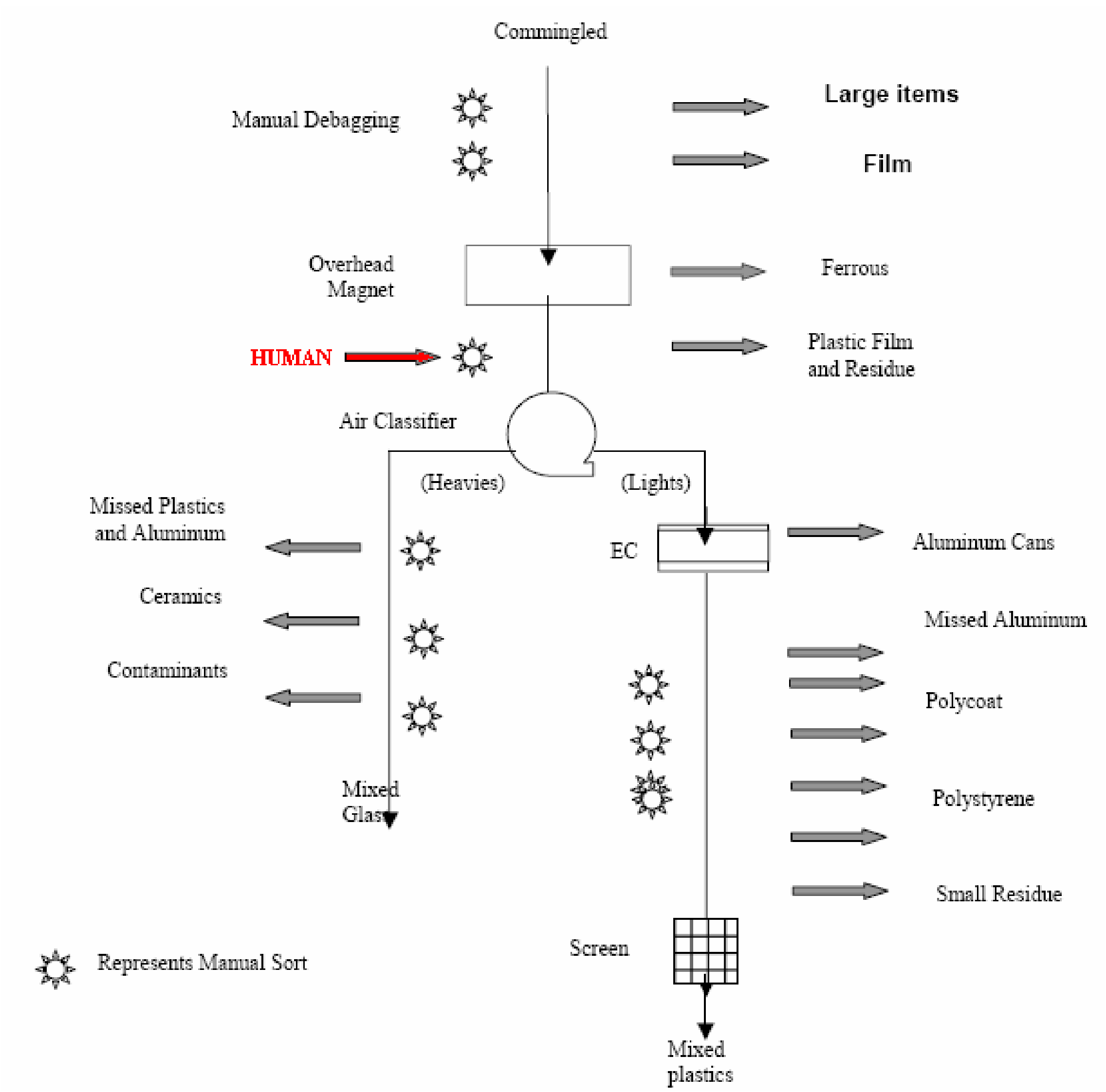

Figure 3.3 Ottowa (HRR) commingled sort sequence

(Source: Enviros RIS 2001)

An example of a facility using sensors is given in Figure 3.4. In this facility, first plastic bags are opened by a bag opener. Then a trommel separates some materials. Non-separated materials are sent to magnetic separation. After, ferrous metals are sorted and then the waste stream moves through an optical sorter that sorts cartons. Next, an eddy current separator takes aluminum metals. After this stage, the waste stream goes to another optical sorter which separates aluminum composites. Later, an air classifier blows away mixed plastics. Finally, the third optical sorter separates plastics from each other.

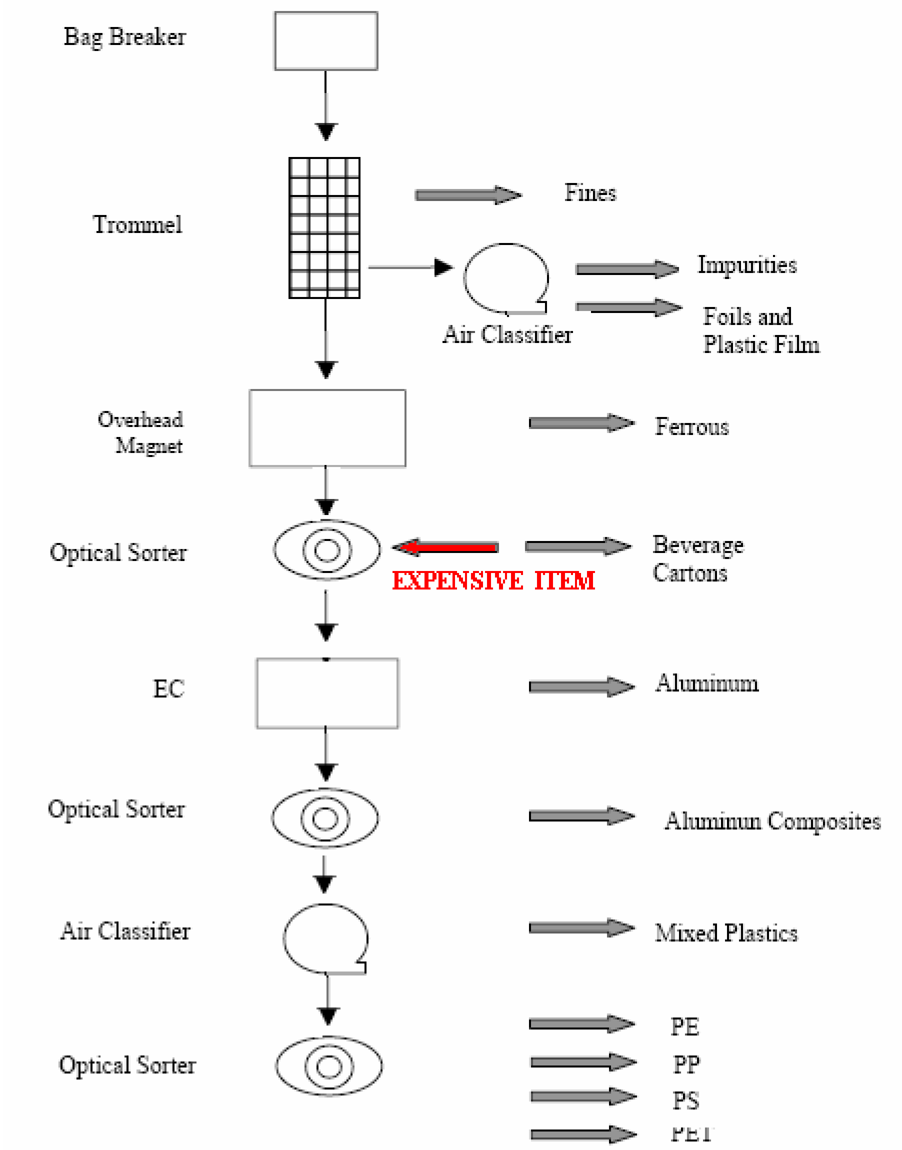

Figure 3.4 Duales System Deutschland AG (DSD) A.R.T. Sortieranlage – sort equipment

(Source: Enviros RIS 2001)

Figure 3.5 shows us a dirty MRF flow chart. Firstly, a man takes large items and then magnetic separators sort ferrous metals. Next, a trommel separates contaminants from the stream. After this process, the solid waste stream goes into an air classifier where heavies go through a manual sorting line and lights go to another manual sorting line. Glass is removed from the heavy parts sorting line and plastics and aluminum are removed from the light parts sorting line.

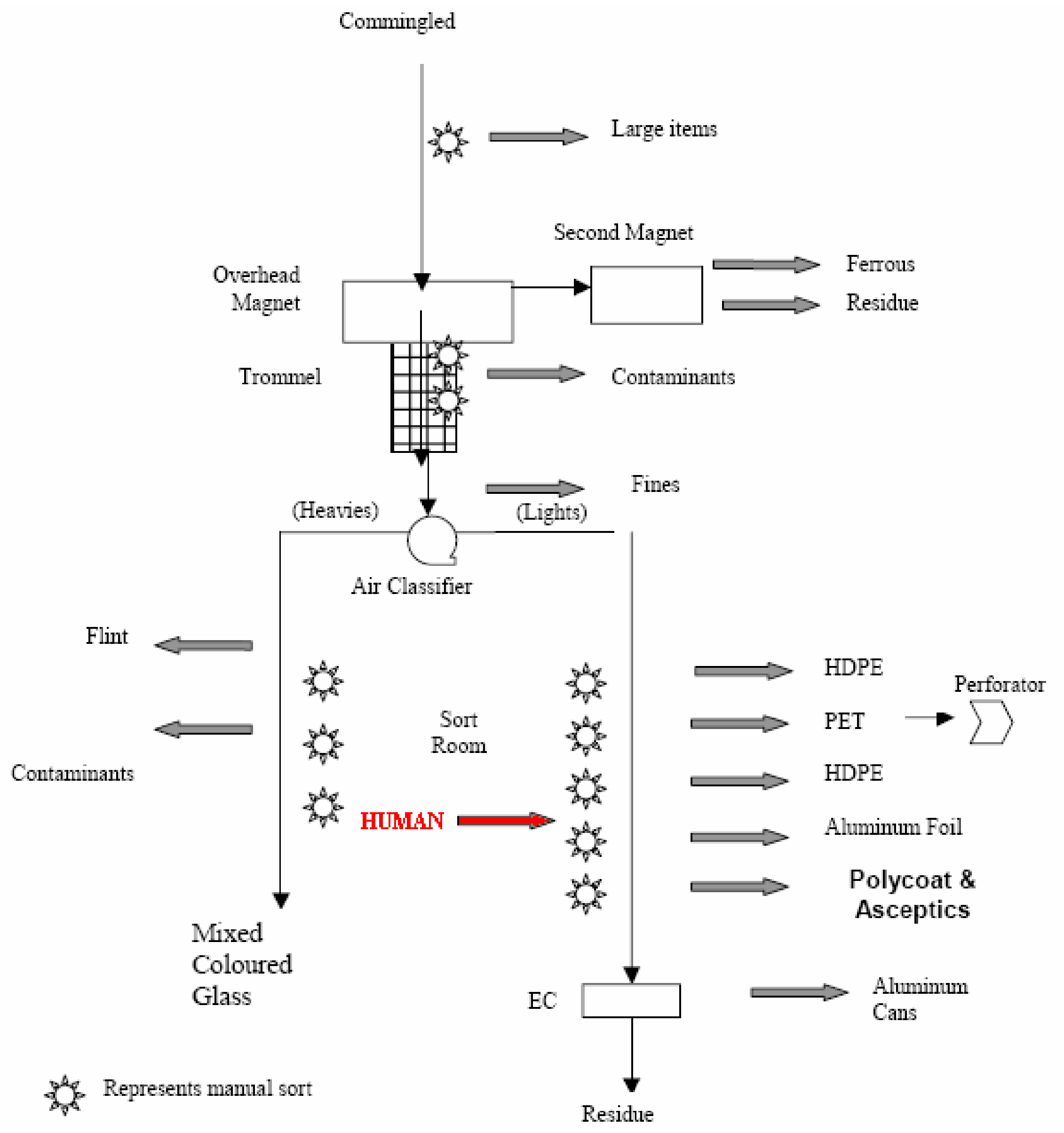

Figure 3.5 Toronto's Dufferin MRF commingled sort sequence

(Source: Enviros RIS 2001)

Figure 3.6 shows another MRF example. First, large items are removed by humans and ferrous metals are removed by magnetic sorter. Later, the waste stream goes through a trommel. In this machine, fines like labels or caps are separated. Then a air classifier separate solid waste into two parts. Finally, recyclables are taken from these parts by manual sorting.

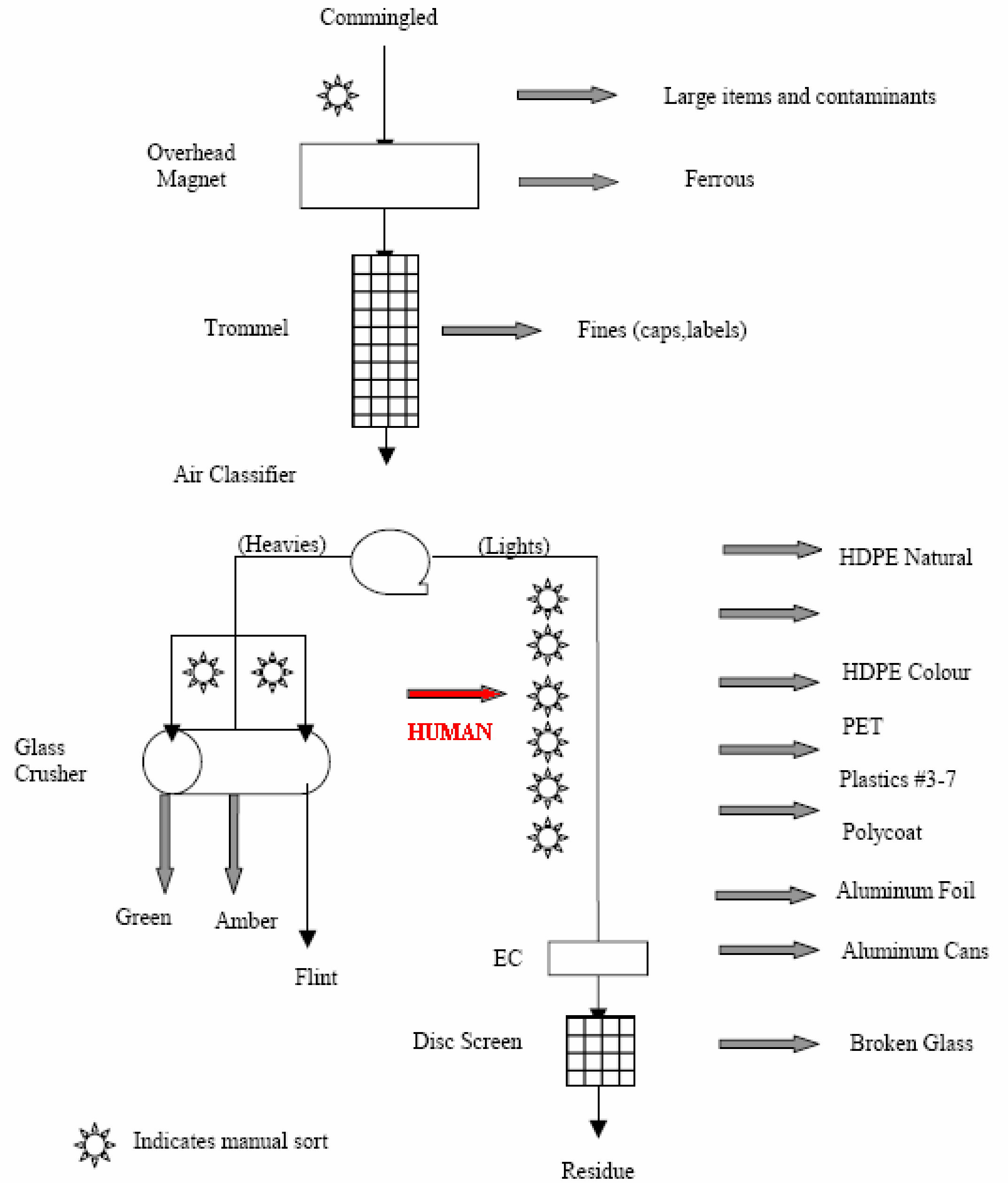

Figure 3.6 RRT suggested commingled process at Springfield
(Source: Enviros RIS 2001)

According to Figure 3.7, there is an automatic material recovery facility which uses sensors to separate recyclables from solid waste. Organic materials are sent to composting facility. A magnetic separator is used for removing ferrous metals, an eddy current separator is used to sort aluminum and air classifiers are used to separate heavy materials from light materials. At this facility glass and plastic are separated by machines with sensors. These machines are a glass color separator and a plastic separator.

Figure 3.8 shows a sorting plant. Working principles of this plant are given below:

Trough tipping vehicles transport the material consisting of building rubble, demolition waste, construction waste and commercial waste to delivery zone, where it is stored.

With the help of a mobile hydraulic crane (pos.25), the material is gradually fed to the pit conveyor (pos.1). At this place the hydraulic crane also provides a rough presorting by taking out bulky, troubling materials. The pit conveyor loads the material onto the bucket screen (pos.2). The throughput capacity of the plant as well as the dosed charging of the material onto the bucket screen (pos.2) is determined by infinitely variable conveying speed of the pit conveyor (pos.1).

The bucket screen (pos.2) divides the material mixture into 2 fractions, fines smaller than 400 mm and coarse material larger than 400 mm. The coarse material (overflow) is transported through the outlet of the bucket screen onto the intermediate conveyor (pos.8) and from there to the sorting belt (pos.9).

In the sorting cabin (pos.23) the sorting personnel take the recyclable material from the sorting belt and throw them into the provided chutes. The material mixture remaining on the belt is conveyed as residual fraction to the disposal area. The fine material of the bucket screen is transported by intermediate conveyors (pos.10, 12 and 13) to the screening machine (pos.3).

The first screening stage separates the fine material smaller than 10 mm and discharges it via conveyor (pos.14). The second screening stage separates the material of the size 10 – 35 mm. The overflow is charged via outlet directly onto the screening machine (pos.4). Here the two screening stages 35 – 60 mm and 60 – 80 mm take place.

The screened fractions 10 - 35 mm, 35 – 60 mm and 60 – 80 mm are fed to building rubble purification plant (pos.7) the material mixture is now freed from contamination (light material and ferrous parts).The cleaned mineral fraction is discharged as final product via an intermediate conveyor (pos.22) and a discharge conveyor (pos.17). The light material is discharged by intermediate conveyors (pos.18 and 21). The discharge conveyor (pos.15) transports the separated ferrous parts into the collecting container. The overflow of the screening machine (pos.4) of the material size 60 – 400 mm is directly brought to the inclined sorting machine (pos.5). The inclined sorting machine separates the flat light material from the rolling and heavy components supported by air. The rolling heavy fraction, which is now freed from ferrous parts due to the magnetic separator (pos.6) is transported via intermediate conveyors (pos.20 and 19) to the impact crusher (pos.24), where the material is crushed.

The intermediate conveyor (pos.16) transports the crushed material to the screening machine (pos.3). Thus this material flow again passes each different treatment step. The flat light material is transported by the intermediate conveyor (pos.21) from the inclined sorting machine (pos.5) and is discharged as residual fraction by a discharge belt (pos.11).

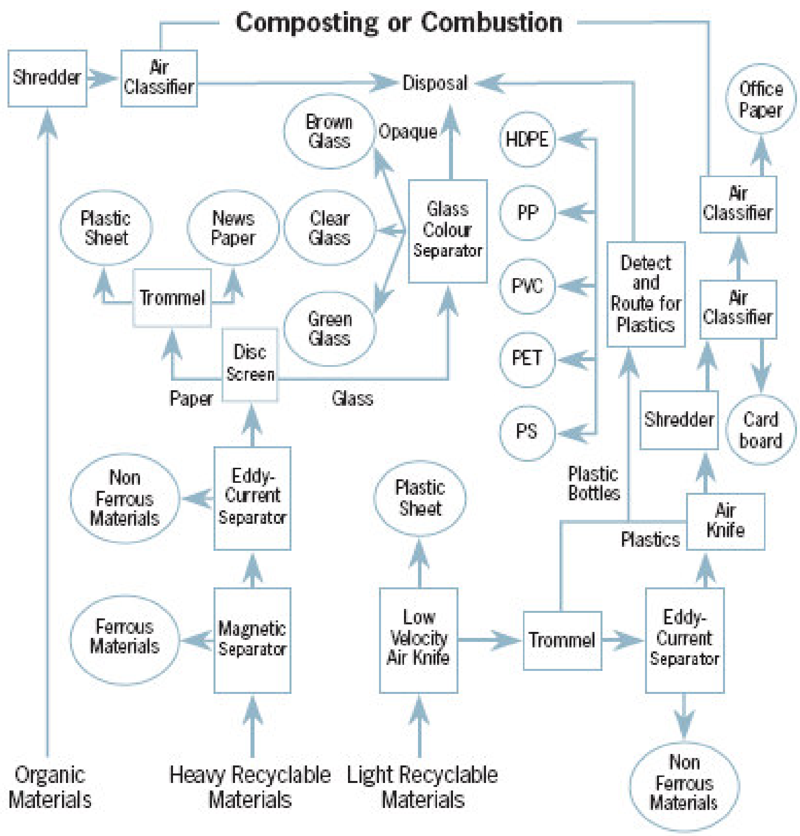

Figure 3.7 an automatic MRF flow chart example

(Source: WEB_2, 2005)

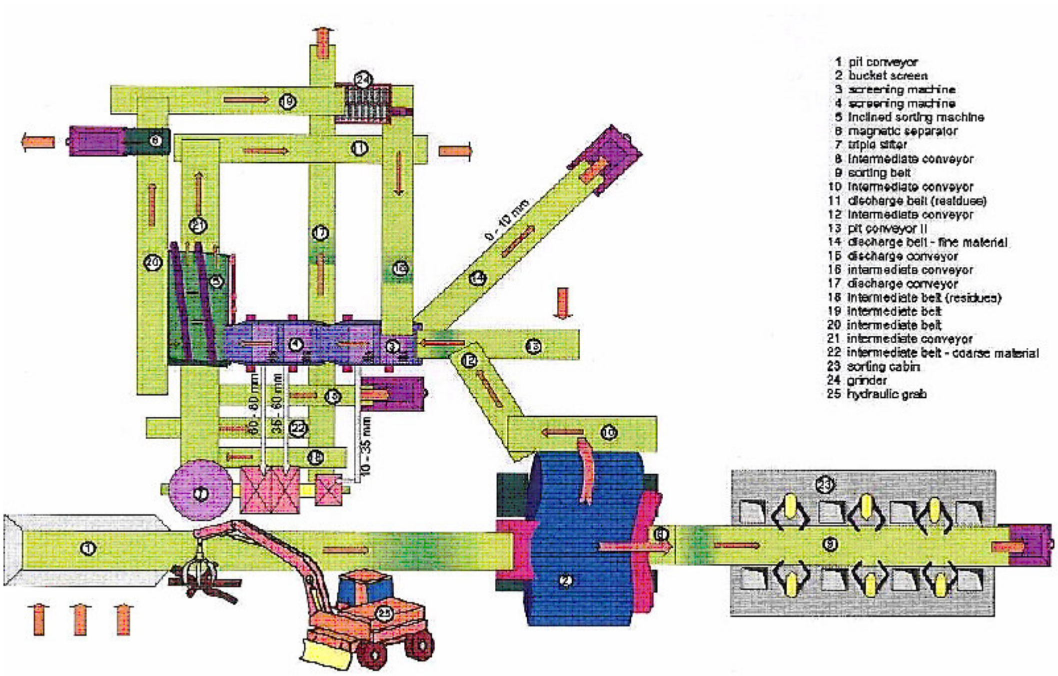

Figure 3.8 Sorting plant - Fa. Meyer / Birr

(Source: WEB_3, 2006)

3.2 Separation Facilities in Izmir

Izmir has three municipal solid waste separation facilities. These facilities are Uzundere, Harmandalı and Menemen but the Menemen facility is not working now because of insufficient municipal solid waste. Enough solid waste is not taken to this facility to let it work. Also Harmandalı has a repair so it is also not working. The Uzundere facility has two parts: one part is composting and the other one is a clear waste separation part.

The Uzundere composting plant has 500 tones per day capacity but it is working with 300 – 400 tones per day capacity (Figure 3.8). A flow chart diagram is given in Figure 3.12. This facility is working for 16 hours in a day. The compost product is usually used for parks by the municipality and some part is sold to farmers for agriculture.

First, trucks dump their loads on a tipping floor. Solid waste is then carried to a trommel that has 45 mm holes on its conveyor (Figure 3.9). Upper size materials are sent to picking area and under size materials are sent to another trommel containing 15 mm holes. At the picking area, recyclables like paper, glass, plastics are separated by human but metals are sorted by a magnetic sorter (Figure 3.10). At second trommel, materials smaller than 15 mm, especially inorganic materials like soil and sand, are removed. Materials from the second trommel and hand separated materials are conveyed to a fermentation area. There are six stages in the fermentation area.

Figure 3.9 Inside of the trommel that has 45 mm diameters of holes

Compost materials are waiting for 10 days at every stage so this composting period takes 60 days. Then, the compost is conveyed to a temporary storage area where it matures. Mature compost is sorted for marketing by sorting units. Finally, fine compost is kept in storage area.

Figure 3.10 Picking area

Figure 3.11 Uzundere compost facility

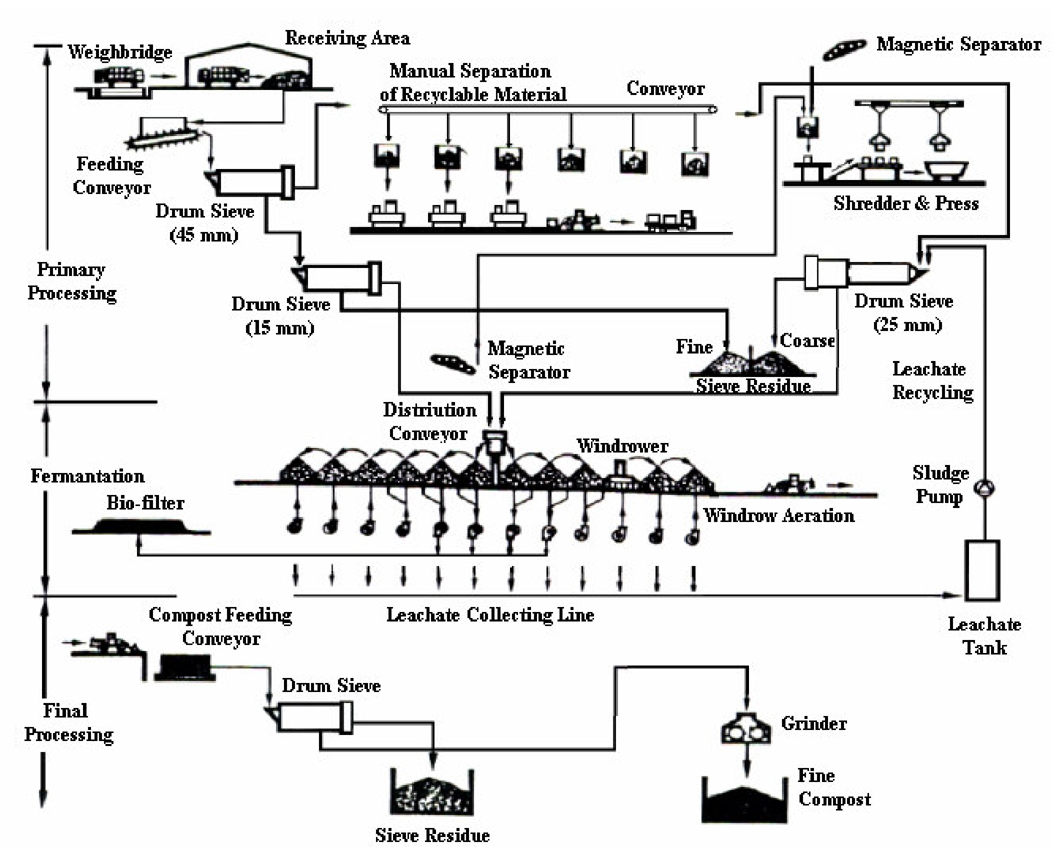

Figure 3.12 Flow chart of Uzundere compost facility
(Source: Ulgen and Erdin 2005)

The clear waste separation part sorts only recyclables from collected at source. There is only manual separation at this part of the facility (Figure 3.13). Then these recyclables like paper and plastics are pressed for easy transportation. There are 8 trucks that collect source separate municipal solid waste from houses.

Figure 3.13 Manual sorting at Uzundere municipal solid waste separation facility

The Uzundere facility consumes about 150.000 YTL for electricity, salaries, transportation … etc. and it only gains about 150.000 – 160.000 YTL from compost and recyclables because this facility is an old facility and uses old technology.

Harmandalı is another municipal solid waste separation facility in Izmir (Figure 3.15). This facility separates recyclables only using manual sorting. This facility has 1000 tones per day capacity.

Figure 3.14 Three number manual sorting lines of Harmandalı sorting facility

There are three manual sorting lines in this facility (Figure 3.14). Trucks dump mixed waste on the tipping floor then waste is taken by three bunkers and sent to manual sorting lines. There are 18 people for every line. These people take recyclables like plastics, paper, metals and glass from the waste stream and throw recyclables on conveyors that convey materials to recyclables boxes. A conveyor that is at the end of the sorting lines takes materials which are not sorted to a landfill. Also there are two balers; one for papers and one for metals in this facility. In addition to these, there is one plastic break unit.

Figure 3.15 Harmandalı municipal solid waste separation facility

If one of three sorting lines is broken down, the facility is not shut down because other sorting lines can go on working but if the conveyor that is at the end of the sorting lines is broken down, the facility must be shut down until it is repaired.

Every day about 2000 tones of municipal solid waste comes to the Harmandalı waste area. Only about 1000 tones waste is sent to a separation facility and about 1000 tones of solid waste is dumped at the Harmandalı landfill. When a landfill area is filled, the place is closed with soil. Pictures of the Harmandalı landfill are given in Figure 3.16 and Figure 3.17.

As it is seen, there are a lot of gulls on the landfill. These birds can be dangerous for humans because they go around in solid waste and then go to other places where people live. In order to prevent this danger, the number of landfills should be decreased.

Figure 3.16 Harmandalı landfill

Figure 3.17 A waste vehicle

CHAPTER 4

DIFFERENTS OF THE NEW DESIGN

In this thesis, we will not use humans nor sensors for sorting mixed municipal solid waste. To separate solid waste into its components, material properties will be used. Only physical separation processes for doing this job will be employed. As a result, it will be more efficient than the other designs. People will not be affected by hazardous waste because people will not be used for separating waste in this facility. Many recent facilities have needed to stop working when a machine is broken down but our design will have two sorting lines and some connecting conveyors that will be used to send solid waste from one sorting line to another sorting line.

In this facility, physical separation technologies will be used. These technologies are given at Table 4.1.

Table 4.1 Physical separation technologies
(Source: Richard 1993)

Technology	Materials Targeted
Screening	**Large:** film plastics, large paper, cardboard, misc.
	Mid-size: recyclables, organics, misc.
	Fines: organics, metal fragments, misc.
Magnetic Separation	Ferrous plus contaminant associated with ferrous metal
Eddy Current Separation	Non-ferrous metal
Air Classification	**Lights:** paper, plastic
	Heavy: metals, glass, organics
Wet Separation	**Floats:** organics, misc.
	Sinks: metals, glass, gravel, misc.

CHAPTER 5

THE NEW DESIGN

Flow chart of the mixed waste separation facility that is designed in this thesis is given Figure 5.1.

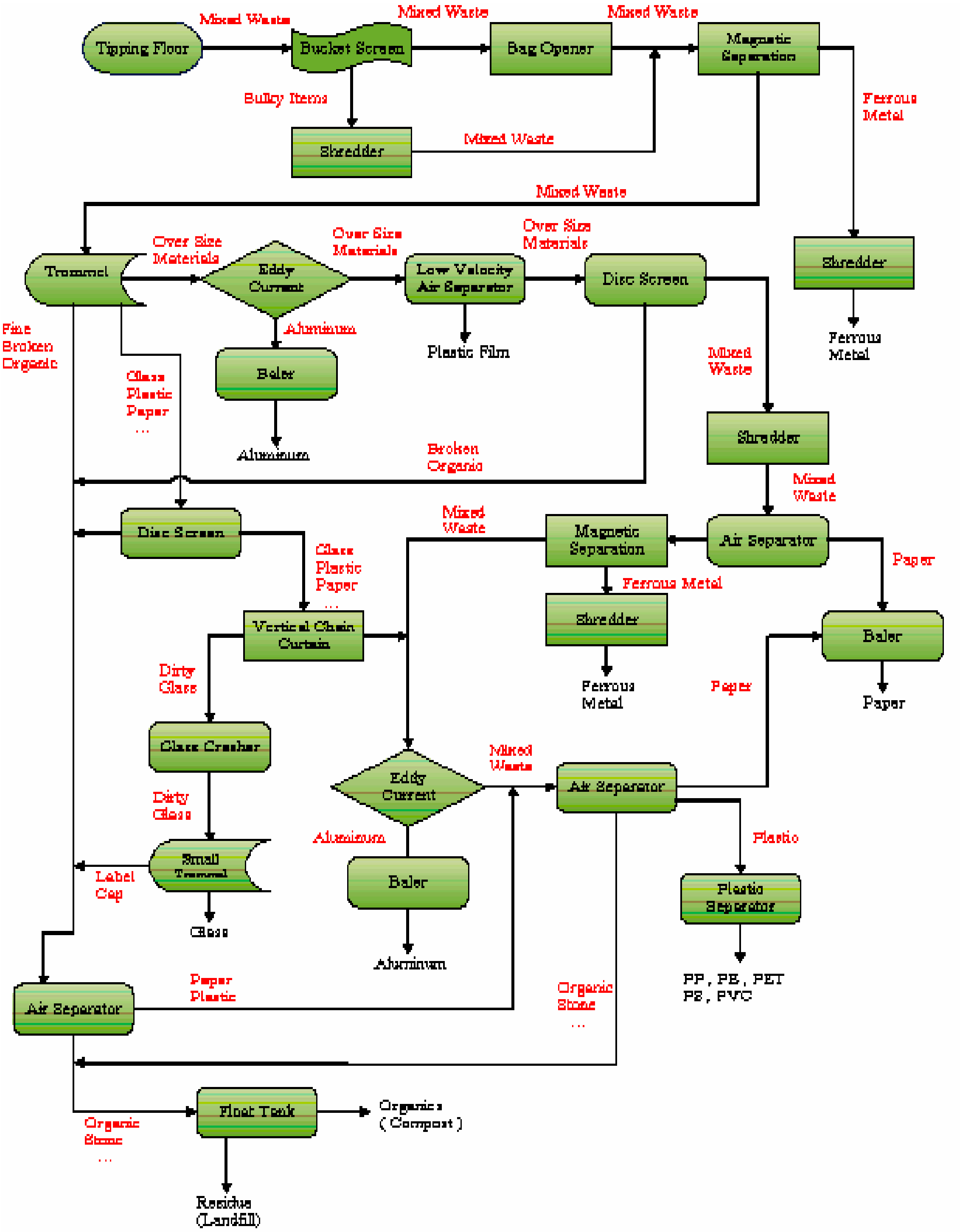

Figure 5.1 Flow chart of new designed facility

In our design, mixed municipal solid waste is brought by trucks to the tipping floor and there is a drainage system that takes waste water. Waste waits at a tipping floor for one or two days to dry because of having too much water in it. Then, mixed waste is conveyed to a bucket screen to sort bulky items. Bulky items are sent to a shredder to cut into pieces so that these items can not damage machines in the facility. Mixed waste, which has no bulky item, is conveyed to a bag opener machine that resembles trommels containing knives, not holes, inside it. It tears plastic bags so in side materials can be sorted. After these stages mixed wastes that come from the shredder and bag opener go to magnetic separation. Ferrous metals are separated and sent to another shredder to cut into pieces for easy transportation. Later, mixed waste having no ferrous metals is conveyed to a drum. This drum is a two stage trommel, in other words it has two size holes. The first half of the trommel has 20 mm diameter holes that separate broken glass, fines and organics and the second half of the drum has 120 mm diameter holes that separate recyclables like glass, paper and plastic. Small size materials are sent to an air classifier, where as middle size materials are sent to a disc screen and over size materials sent to an eddy current separator. Non-ferrous metals are sorted from oversize materials and conveyed to a baler to decrease their size. Then, oversize materials are fed to a low velocity air separator which takes plastic films and middle size materials are conveyed to a disc screen. At this screen, recyclables like glass, plastic and paper are separated from broken glass, contaminant, organic and miscellaneous materials. Recyclables are sent to a vertical chain curtain but others are sent to the same air separator that sorts small size materials. At the vertical chain curtain, glass is sorted and conveyed to a glass crusher. Other recyclables are fed to another eddy current separator. After the glass crusher, broken glass goes through a small trommel that separates labels and caps from broken glass. Labels and caps are conveyed to an air separator. Oversize materials come from a low velocity air separator and are transported to another disc screen that separates broken materials, organics and misc. from oversize mixed waste. Broken materials and organics are sent to an air classifier but other materials are conveyed into a shredder. Mixed waste that comes out from the shredder goes to a second air separator that separates paper from heavy materials. Paper goes to a baler. Another magnetic separator takes ferrous metals from heavy materials. Other heavy materials are sent to an eddy current separator with materials coming from a vertical chain curtain. After removing aluminum, heavy materials go into a different air separator that separates materials into three parts: one is paper, one is plastic and the other one is heavy materials. Paper is sent to a baler. Plastic is sent to a plastic separator that sorts its components. Heavy materials come from air separators are conveyed to a float tank that separates organics from residue. Organic materials are sent to a compost facility and residue is sent to a landfill.

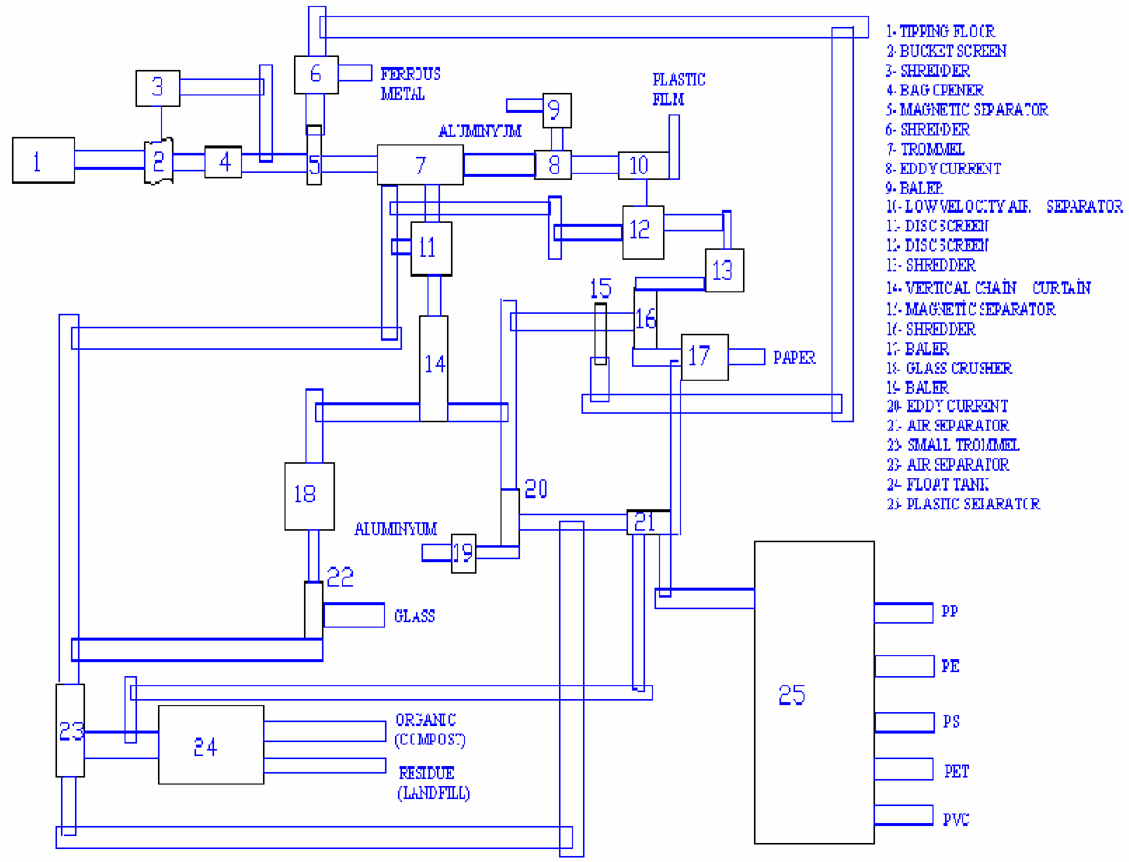

Figure 5.2 Plan of separation facility that is designed

5.1 Machines are used in design

Details of the processes and machines that are seen in the flow chart are given below:

5.1.1 Tipping Floor

When materials are brought to the facility, they are deposited in a large area called a tipping floor. Solid waste waits there one or two days so that it looses its water. Waste waster is taken by a drainage system. Unloading the materials from trucks onto the tipping floor must be efficient yet not harmful to the materials. Figure 5.3 and Figure 5.4 show a waste truck. There must be minimum glass breakage so as not to damage the recyclables materials. Conveyors take materials from the tipping floor into a separation facility (Dubanowitz 2000).

Figure 5.3 A waste truck

Figure 5.4 Back side of a waste truck

5.1.2 Bag Opener

The bag opener resembles a trommel but it has knives inside to tear bags but it has no holes to let small items fall on a conveyor. Recyclable materials in side of plastic bags can be accessed with the help of a bag opener.

5.1.3 Trommel

The trommel is a rotary cylindrical screen whose screening surface consists of wire mesh or perforated plate (Figure 5.5). This item is used to separate small pieces from big pieces. The tumbling action of the trommel efficiently brings about a separation of individual items or pieces of material that may be attached to each other, or even of one material contained within another.

Figure 5.5 a trommel prior to installation

(Source: Barlaz 2005)

It has two stages; the first stage separates the broken glass and other small contaminants and the second stage separates glass, aluminum and plastic containers. The trommel allows large items to pass. In side of a trommel is shown in Figure 5.6.

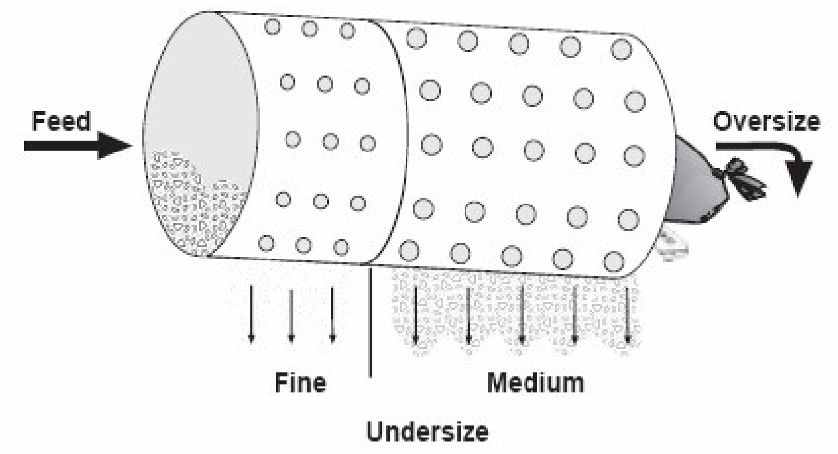

Figure 5.6 Inside of a two stage trommel

(Source: Richard 1999)

5.1.4 Magnetic Separator

Magnetic separation is a relatively simple unit process and is used to recover ferrous metal from the commingled waste stream. Magnets may be either of the permanent or the electromagnetic type. They are available in three configurations, namely; the drum (Figure 5.7), the magnetic head pulley (Figure 5.8), and the magnetic belt (Figure 5.9).

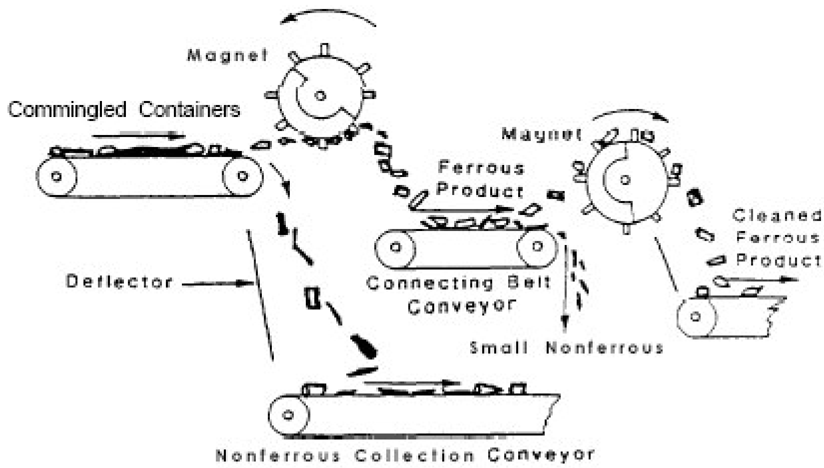

Figure 5.7 Multiple magnetic drum

(Source: Consultants 1991)

They may be assembled and suspended in line, cross belt, or mounted as conveyor head pulleys. The magnetic head pulley conveyor is arranged so that in its operation, the material to be sorted is passed over the pulley in such a manner that the nonferrous material will fall along a different trajectory than will the ferrous material. The drum magnet assembly can be installed for either overfeed or underfeed and directs the ferrous along a trajectory other than that taken by the nonferrous material. The magnetic belt, in its simplest form, consists of single magnets mounted between two pulleys that support a cleated conveyor belt mechanism.

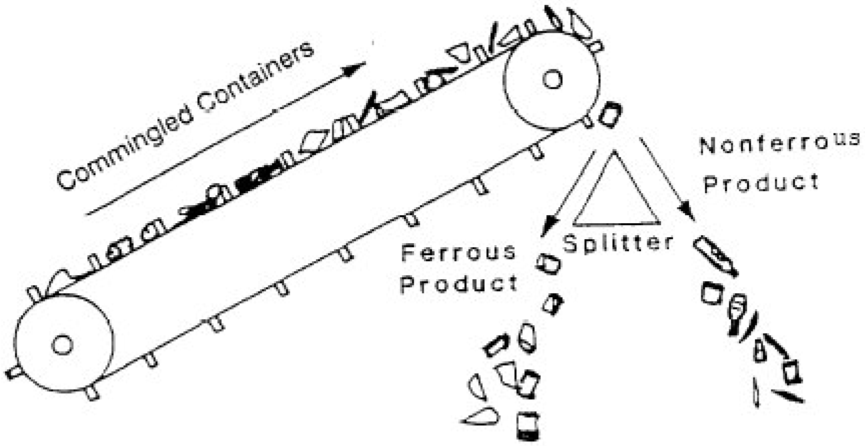

Figure 5.8 Magnetic head pulley
(Source: Consultants 1991)

The efficiency of magnetic separation is affected by the bed depth of the waste stream. For more complete removal of ferrous, a secondary magnetic separator may be considered. Conveyor and hopper components in the vicinity of the magnetic field should be constructed of nonmagnetic materials.

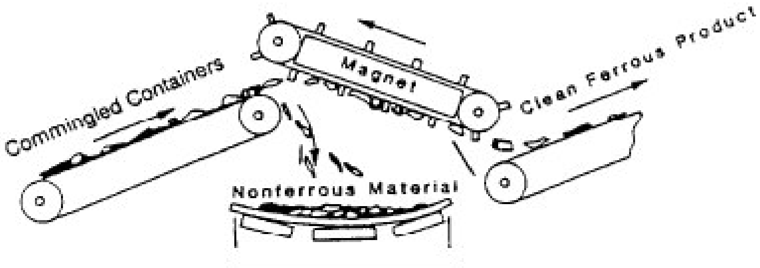

Figure 5.9 Magnetic belt
(Source: Consultants 1991)

5.1.5 Vertical Chain Curtain

A vertical chain curtain consists of one or more rows of common chain each suspended from a continuously revolving link type conveyor chain which provides a barrier to less dense (aluminum , plastic) containers while permitting denser material (glass) to pass through on a downwardly sloping surface (Figure 5.10). The efficiency of the traveling chain curtain can be greatly influenced by the feed rate into the unit.

Excessive quantities of incoming material may cause lighter materials to push through the curtain rather than to be directed to one side.

Figure 5.10 Vertical chain curtain
(Source: WEB_3, 2006)

5.1.6 Bucket Screen

A bucket Screen handles waste mixtures, which may contain large, bulky and heavy parts, long wooden beams, large cardboards, long foils, carpets etc (Figure 5.11). These materials, which could cause clogging in conventional screening devices, can be sorted with the help of the Bucket Screen without any problems.

Figure 5.11 Bucket screen
(Source: WEB_3, 2006)

5.1.7 Float Tank

In a float tank, separating materials from each other is done with water (Figure 5.12). In this process, like the air separation, density differences are used. Materials like metal, sand and stone sink to the bottom of the tank. These materials are taken from the bottom of the tank by conveyor. Materials like plastic, paper and organics float on the water. These materials are taken by rotating parts of the tank and these parts send light materials on to another conveyor. Rotating parts of the float tank are shown in Figure 5.13. In the float tank different liquids in stead of water can also be used so that lighter or heavier materials can also be separated from each other.

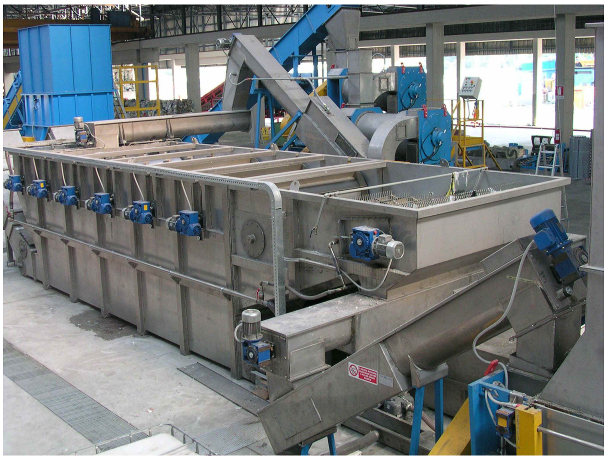

Figure 5.12 Float tank

(Source: WEB_8, 2006)

Figure 5.13 Rotating part of the float tank

(Source: WEB_8, 2006)

5.1.8 Disc Screen

A disc screen consists of parallel multiple shafts all rotating in the same direction (Figure 5.14). Discs are mounted on each of these shafts, and spaced in such a fashion so that the discs on one shaft are located midway between the discs on an opposing shaft. The shafts and discs are so positioned relative to each other as to establish fixed interstices through which the undersize material (e.g., broken glass or grit) will pass and the oversize material is conveyed by both the discs and the series of rotating shafts (Consultant 1991).

Disc screen causes less glass breakage compared to other screens. The disc screen also offers adjustability in opening size and can be self-cleaning. Disc screens are most effective when breakage could be a problem and when fine material to be removed is denser than the larger materials; the larger materials are relatively rounded and will not prevent passage of the fine materials to the screen (Dubanowitz 2000).

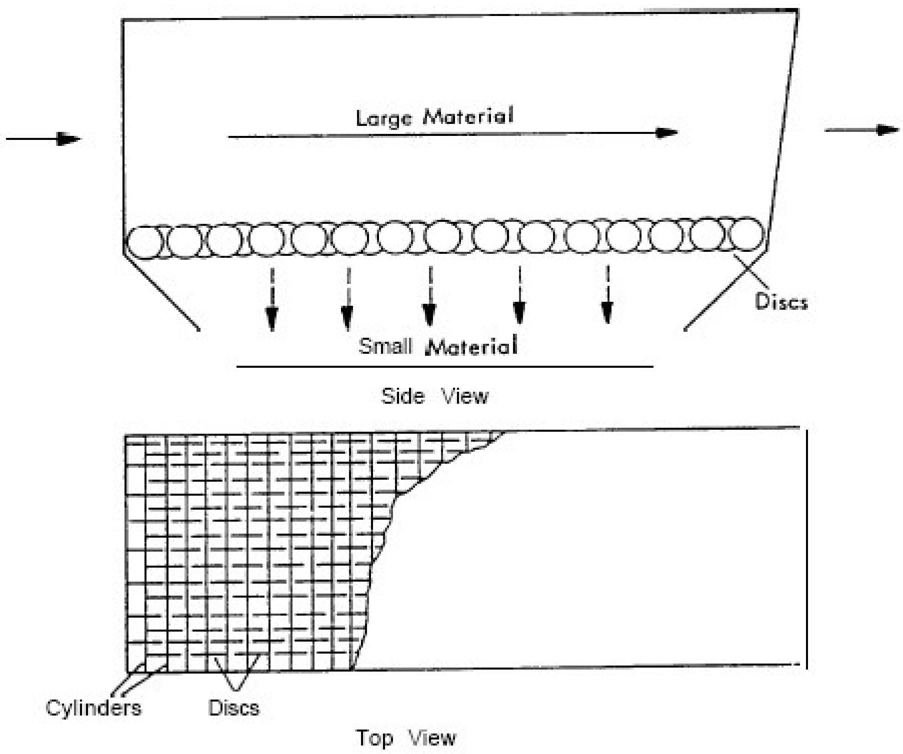

Figure 5.14 Disc screen

(Source: Consultants 1991)

5.1.9 Air Classifier

Air classification employs an air stream to separate a light fraction (e.g., paper and plastic) from a heavy fraction (e.g., metals and glass) in a waste stream (Figure 5.15). Variables other than density, such as particle size, surface area and drag, also affect the process of material separation through air classification. Consequently, aluminum cans, by virtue of a high drag-to-weight ratio, may appear in the light fraction, and wet and matted paper may appear in the heavy fraction. Air classifiers may be provided in one of a number of designs. The vertical, straight type is one of the most common units. Air classifiers require provisions for appurtenant dust collection, blower, separation, and conveying.

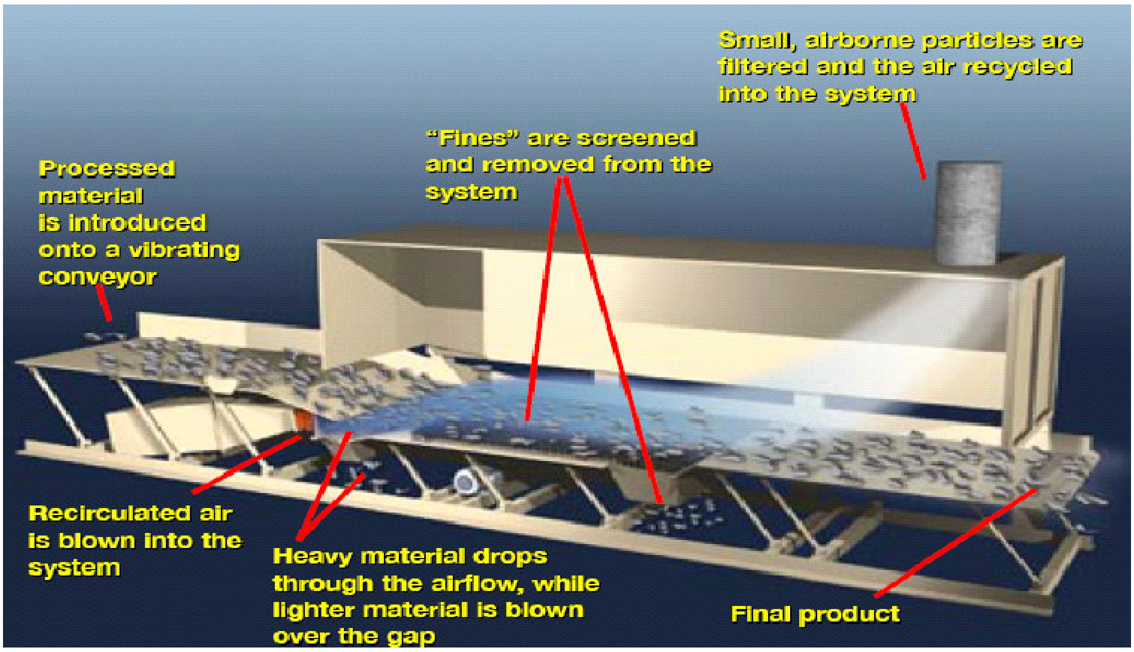

Figure 5.15 An air classifier

(Source: WEB_4, 2006)

5.1.10 Eddy Current Separator

Eddy current separation removes non-ferrous metals based on conductivity, and is a well proven and established technology for resource recovery. Although there are a number of different configurations, a design type known as the Rotating Disk Separator will be used in the proposed facility. The Rotating Disk Separator involves the materials "free falling" between parallel rotating magnetic disks, which are composed of permanent magnetic plates. The opposing magnetic fields create high magnetic fluxes that generate electrical currents within the non-ferrous metals. The electrical (eddy) currents in the non-ferrous materials cause them to be deflected when faced by an opposing magnetic field. The conductivity of the metal determines the strength of the eddy current that can be produced. Since aluminum has a low density relative to its conductivity, it is easily extracted using eddy current separation (Veasey 1997). Figure 5.16 and Figure 5.17 show eddy current separator.

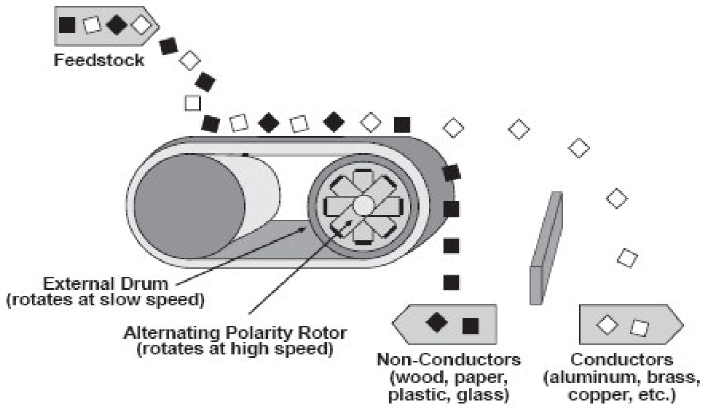

Figure 5.16 Eddy current separator

(Source: Richard 1993)

This technology can potentially be used to separate a wide range of additional metals that have value such as lead, copper, silver, gold and titanium.

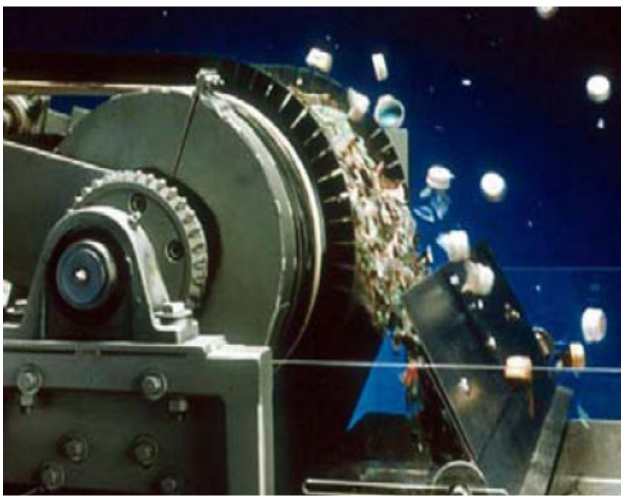

Figure 5.17 Eddy current separator

(Source: Richard 1993)

However, the only non-ferrous metal that is targeted is aluminum. Aluminum is the most common non-ferrous metal in municipal solid waste, accounting for about 90 percent of all nonferrous metals. If other non-ferrous metals are targeted in the future, the system could be adjusted with additional separation processes such as flotation to further separate among these metals. The removal of lead for example would be environmentally beneficial before disposal. (Dubanowitz 2000)

5.1.11 Baler

A baler is a compressed packing system that is used to compressed materials like paper, metal cans and plastic bottles for transportation.

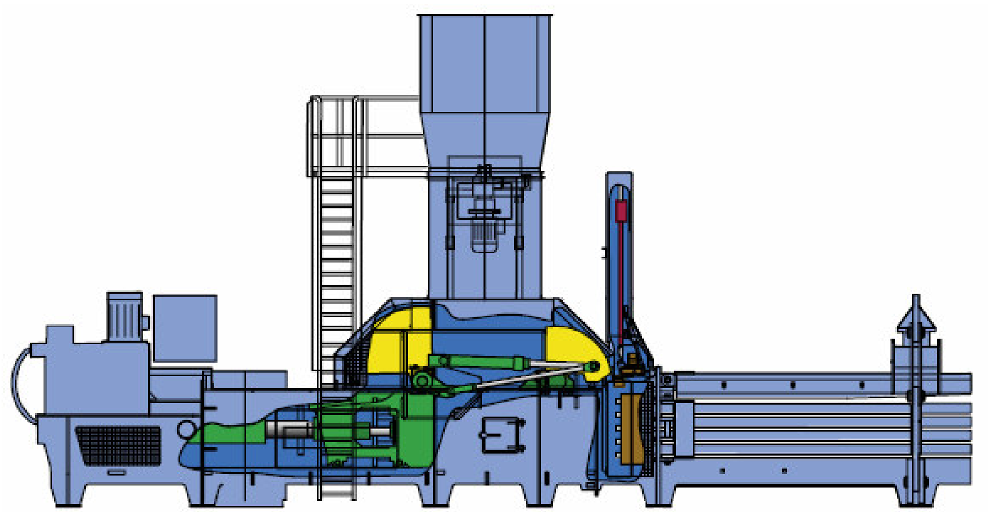

Figure 5.18 Baler
(Source: WEB_5, 2005)

Some balers are equipped for fully automatic operation while others demand a considerable amount of operator attention. If the design calls for the use of the same baler to bale more than one material, it is extremely important that the baler selected be specifically designed for that purpose. The market specifications which must be met should be determined before a baler is selected. Not all automatic tie devices are alike. The number and size of baling wires, as well as the available wire tension, must be adequate for the particular materials to be baled. Figure 5.19 shows a baler and its package which are in Uzundere municipal solid waste separation facility.

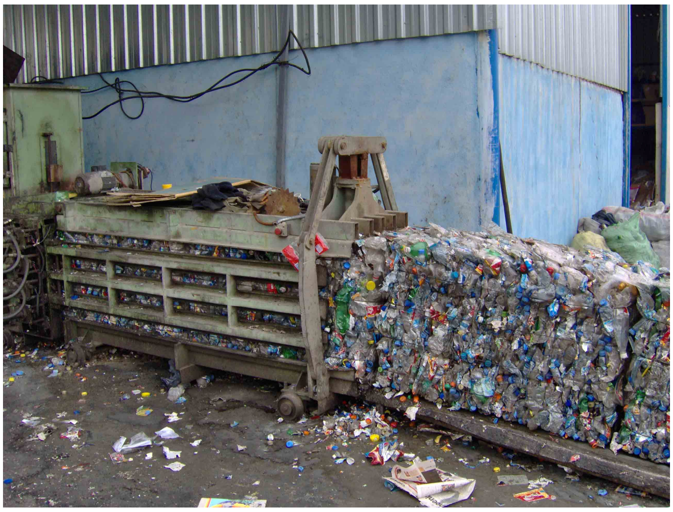

Figure 5.19 A baler and its package

5.1.12 Shredder

A shredder is a machine which is used for cutting materials like metal into small pieces. The shredders will be used for large items that are initially removed from the waste stream and for organic material that are brought to the facility. A shredder is seen in Figure 5.20.

Figure 5.20 A single shaft rotary shredder
(Source: WEB_6, 2006)

The size-reduced product is reasonably uniform and has greater surface area to volume ratios, which increases decomposition. The increased surface area also increases air exposure, reduces odors and promotes drying. The choice of shredder will depend on the material to be shredded, the amount of energy required, the size changes needed and the benefits of those size changes.

5.1.13 Glass Crusher

It is used to reduce the volume of glass for transportation in bins or large boxes. There are small hammers inside of the glass crusher. These hammers are on a rotating mill. While the mill is rotating, glass bottles are being crushed inside of the glass crusher by hammers. Broken glass is removed from under the machine by a conveyor. Inside of a glass crusher is shown in Figure 5.21.

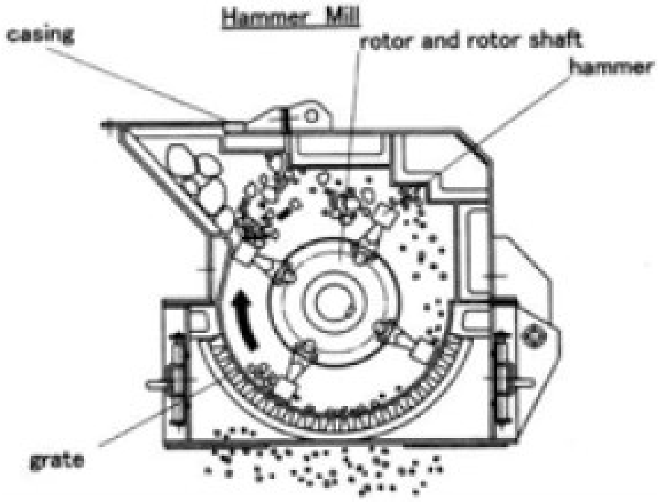

Figure 5.21 Glass crusher
(Source: WEB_6, 2006)

5.1.14 Conveyors

Conveyors are used to transport solid waste from one separation system to another. They can transfer waste not only on a horizontal plane but also on a vertical plane. A vertical conveyor is shown in Figure 5.22. However, vertical conveyors must have smaller than a 40 degree angle to avoid accumulation of heavies. Waste drops onto conveyors from other conveyors or machines. This facility is designed with duplicate trains so that if one conveyor fails, the operation is not shut down. They also require maintenance due to dusty environment. Their working speed can be increased or decreased to change working capacity of the facility (Swartbaugh, Diaz, Duvall, Savage 1993).

Figure 5.22 Vertical conveyor

(Source: Morton)

5.1.15 Plastic Separation

Mixed waste first comes to the mixing device where waste mixes it with water. Then the waste water mixture goes to a separating device. In this device, PE and PP are separated from mixed waste by centrifuge (Figure 5.23).

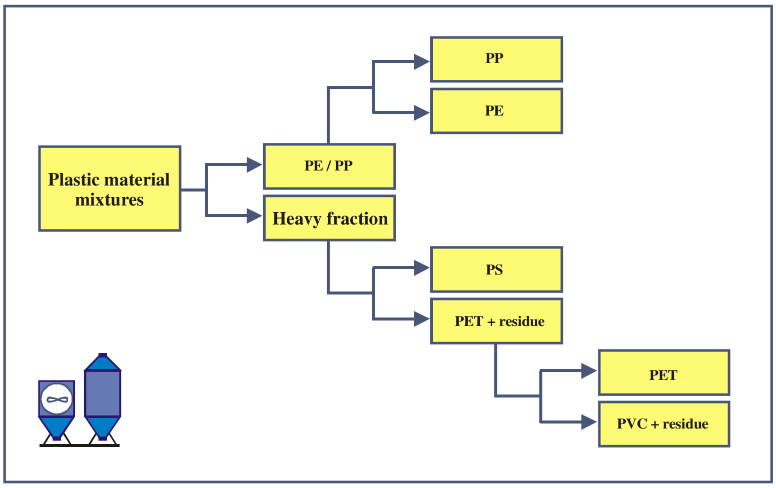

Figure 5.23 Separation of solid plastic

(Source: WEB_7, 2005)

Later, PE and PP are separated from each other by the same process. Mixed waste goes to another mixing device. After, it goes to a separating device where PS is sorted from PET and residue. Finally, PET and PVC are separated from each other by the same process. In plastic separation, the same process is done five times to separate PP, PE, PS, PET and PVC from each other. These stages are shown in Figure 5.24.

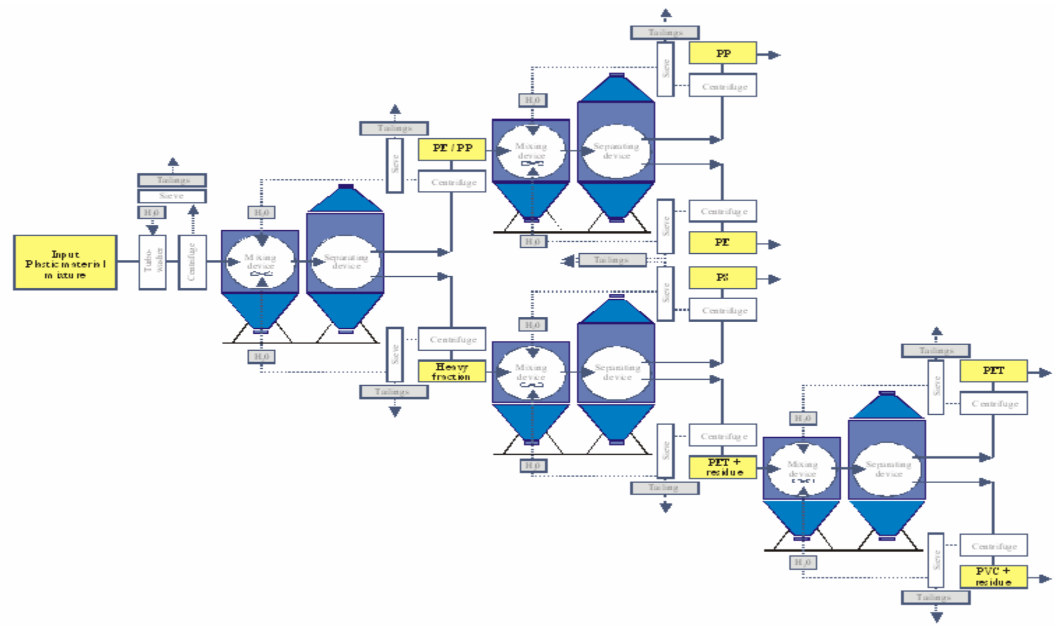

Figure 5.24 Plastic separation
(Source: WEB_7, 2005)

CHAPTER 6

IMPROVEMENT OF THE DESING

The first design was changed for a new design that is seen at Figure 6.1. The first design was changed because of possible repair problems the facility might face. These problems were seen during a visit to an İzmir compost facility and municipal solid waste separation facilities. If any machine is broken down, the entire facility is shut down and remains closed until the machine is repaired. Some times the closing time of the facilities can last a month or even longer. Reasons for this are one sorting line and only one example of each machine. Repair time can be too long because broken parts must be made again. Conveyors and bearings are the most commonly broken parts in separation facilities. For these reasons, there are two sorting lines in our new design and numbers of some machines are more than one so if one sorting machine is broken down, the facility will not be shut down but only will decrease its capacity.

In addition to this, plastic sorting was changed. Separation is done by mix of a float tanks and plastic separation (EuRec plastic separator) that was told in the new system. The new system has more efficiency than the original plastic separation system. Moreover, two new separation machines are designed, these machines can be used at the facility instead of other machines. These machines are the bucket screen and the plastic separation system.

6.1 Final Design

There are two sorting lines in this facility and this is shown in Figure 6.1 by use of different colors. First sorting line is showed with black arrows and second sorting line is showed with blue arrows. Every arrow has a number.

Municipal solid waste is dumped onto tipping floor by trucks. Waste waits there for one or two days to dry. Then, waste is conveyed to two bucket screens (1-43). Bucket screens separate bulky items and send to a shredder (5-44). Bulky items are cut into pieces in shredder and conveyed to one of two sorting lines after bag opener (6). Bag openers tear plastic bags in waste stream come from bucket screens (2-45). Later, magnetic separators take ferrous metals and send to another shredder (41-46). Other waste goes into trommels (4-48). After trommels, there are some differences in the two sorting lines. In the first sorting line, there is a two stage trommel. At first stage, there are 20 mm diameter holes that separate fines, organics and broken glass and send them to an eddy current separator (9). The second stage has 120 mm diameter holes that separate recyclables and send them to a disc screen (8). Over size materials like newspaper, plastic films and other big materials go to a low velocity air separator (7). This separator sorts plastic films (10). Over size materials are conveyed to a disc screen after the low velocity air separator (11). The disc screen takes broken materials, organics and contaminants from the over size materials and sends them to an eddy current separator (12). Other waste goes into a shredder (13). Then aluminum is taken from the solid waste and is cut into pieces by the shredder (15). After the eddy current separator, waste goes to an air separator (16) which separates papers and sends them to a baler (17). A magnetic separator sorts ferrous metals from solid waste that has no paper (21). After the magnet, another eddy current separator takes aluminums again (22). After another shredder, an air separator sorts waste into two parts: plastics and heavies (24). Plastics are conveyed to plastic sorting but heavies are conveyed to a float tank (36). Recyclables that are separated at the second stage of the trommel are conveyed to a vertical chain curtain (26) after passing the disc screen. This machine sorts glass from other recyclables that are sent to a magnetic separator where over size materials come (27) and sends them to a glass crusher (28). Broken glass passes into a small trommel that separates caps and labels and sends them to an air separator where fines and small materials come (30). Then this separator sorts materials into two parts which are light materials that are sent to a shredder (32) and heavy materials that are sent to float tank (35) which takes organics from residue. Finally, at the plastic sorting place, plastics are separated according to their types: PP, PE, PS, PET and PVC (40).

The same process is done at a second sorting line but this line has less sorting machines than the other sorting line. The first sorting line has one bucket screen, one bag opener, four shredders, two magnetic separators, one trommel, one low velocity air separator, two disc screens, three eddy current separators, three air separators, one vertical chain curtain, one glass crusher, one small trommel, one baler, one plastic sorting and one float tank. Second sorting line has one bucket screen, one bag opener, two magnetic separators, one trommel, one low velocity air separator, two disc screens, two shredders, two eddy current separators, one baler, two air separators and one vertical chain curtain.

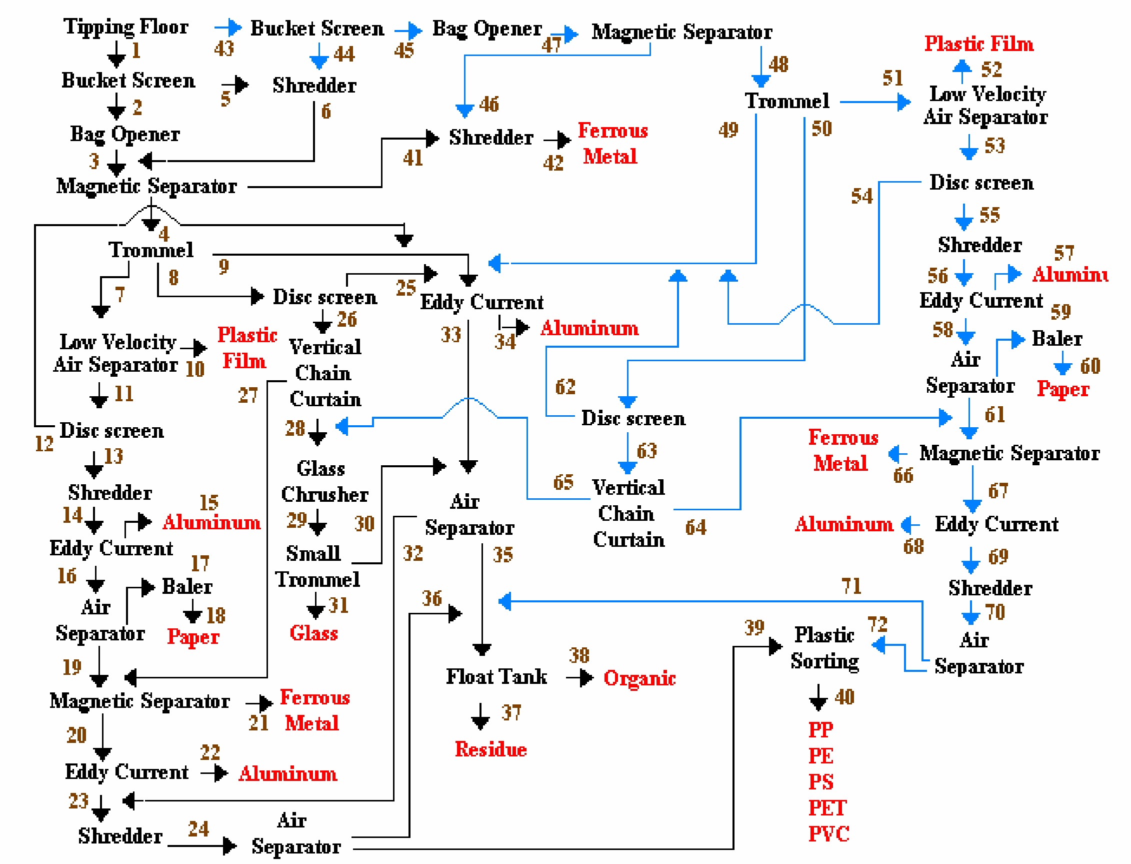

Figure 6.1 Flow chart of final solid waste separation facility

Two sorting lines can be the same to each other but this increases the cost of the facility so some sorting processes are used by two sorting lines. Also this results in less expenditure also and a smaller area needed by the facility.

6.2 New Sorting Machines

Two new sorting machines were designed in this project instead of the sorting machines that were originally designed for this project. New machines are better than old machines because their separation efficiencies are higher than the others and new machines are more suitable for this thesis than the old machines because new items use physical properties better than others to separate materials. The two new machines are a bucket screen and plastic separation system.

6.2.1 New Bucket Screen

The new bucket screen is bigger than the old one because the old machine has one conveyor but the new design has five conveyors. This design has a superior feature than the old one which is to separate bulky items that have low height but are long and can cause damage for separation machines inside of the facility like branches and carpets. The bucket screen that is used today is shown in Figure 5.5. The new design is shown in Figure 6.2.

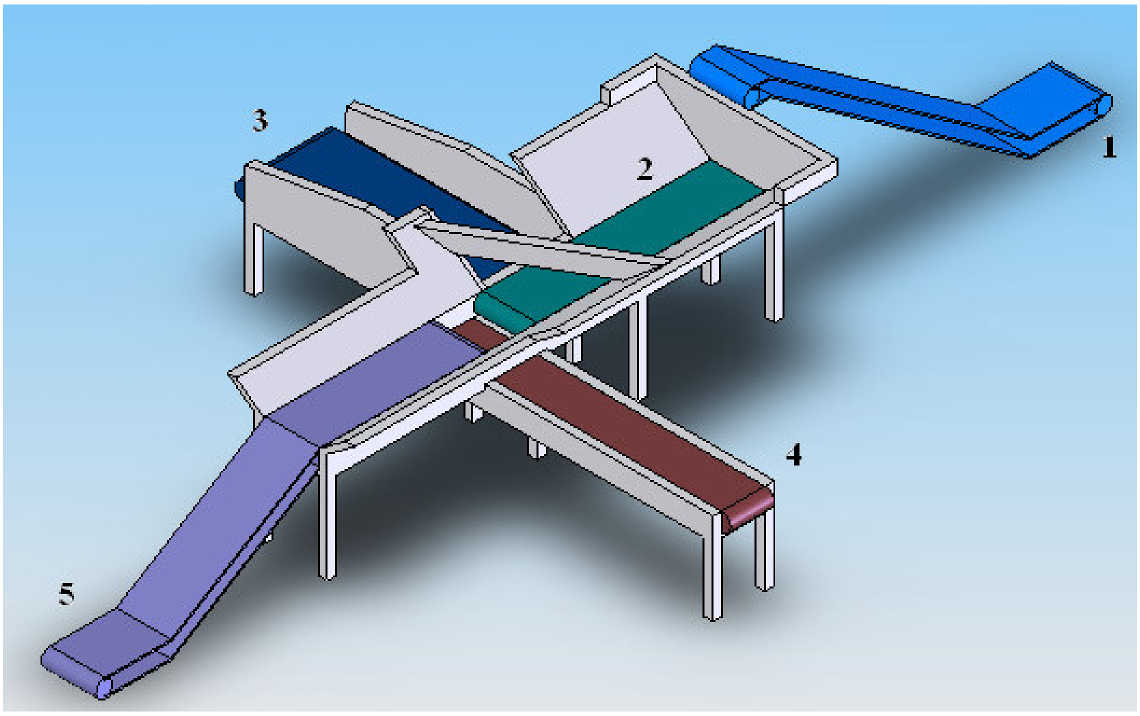

Figure 6.2 New bucket screen

In the new design mixed municipal solid waste is conveyed to the machine by conveyor number 1. Conveyor number 2 conveys solid waste that drops from number 1 in a forward direction. There is one height changeable bar on number 2. This bar permits small items to pass under it. Big items are sent to conveyor number 3 that conveys bulky items to a shredder. Materials that can pass under the bar come to a big hole. Long and big wastes which can not fall down into the hole are conveyed to the shredder by conveyor number 5. Small materials that can not pass above of the hole are fed to a bag opener in side of the facility by conveyor number 4.

6.2.2 New Plastic Separator

The new plastic separator uses densities to sort plastics according to their types. Five different types of plastics are separated to recycle. These types are PP (Polypropylene), PE (Polyethylene), PS (Polystyrene), PET (Polyethylene Terephthalate) and PVC (Polyvinnyl Chloride). Densities of these plastics are given at table 6.1.

Table 6.1 Densities of recyclable plastics

Material	**Density (g/cm^3)**
PP	0,90 – 0,92
PE	0,95 – 0,97
PS	1,05 – 1,07
PET	1,33 – 1,39
PVC	1,32 – 1,42

Although there are five recyclables, four float tanks are used in this separator because PET and PVC can not be separated from each other due to their densities. Therefore, they will be sorted at the end of EuRec plastic separator system.

This separator is cheaper and more simple than other plastic separators. It is more efficient in removing plastics from the waste stream because it uses densities.

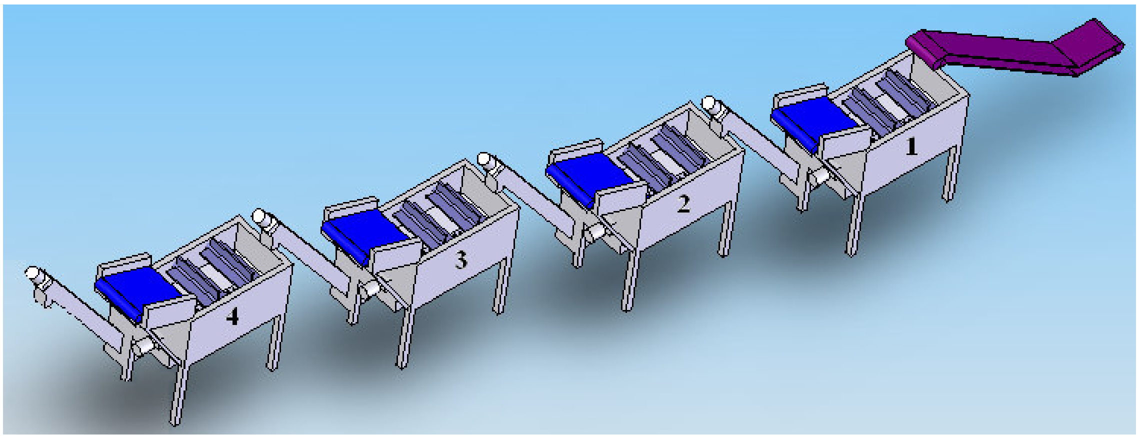

Figure 6.3 Float tanks of new plastic separator

Float tanks in the plastic separator are nearly the same as other float tanks. In this float tank materials drop into the float tank at back side. Then light material floats and heavy materials sink. Light material is pushed forward to a conveyor by rolling parts of the float tank. Heavy materials are taken from the bottom of the tank by three conveyor screws. Mixed plastics are conveyed to the first float tank. At this tank, PP is removed and the heaviest materials are thrown into a second float tank. PE is removed in this tank. The same process is repeated in each of the float tanks. The third tank sorts PS. The fourth tank separates PET and PVC from residue and sends PET and PVC to the EuRec plastic separator part. This part separates them using centrifuge. The Eurec plastic separator can be seen in Figure 5.13.

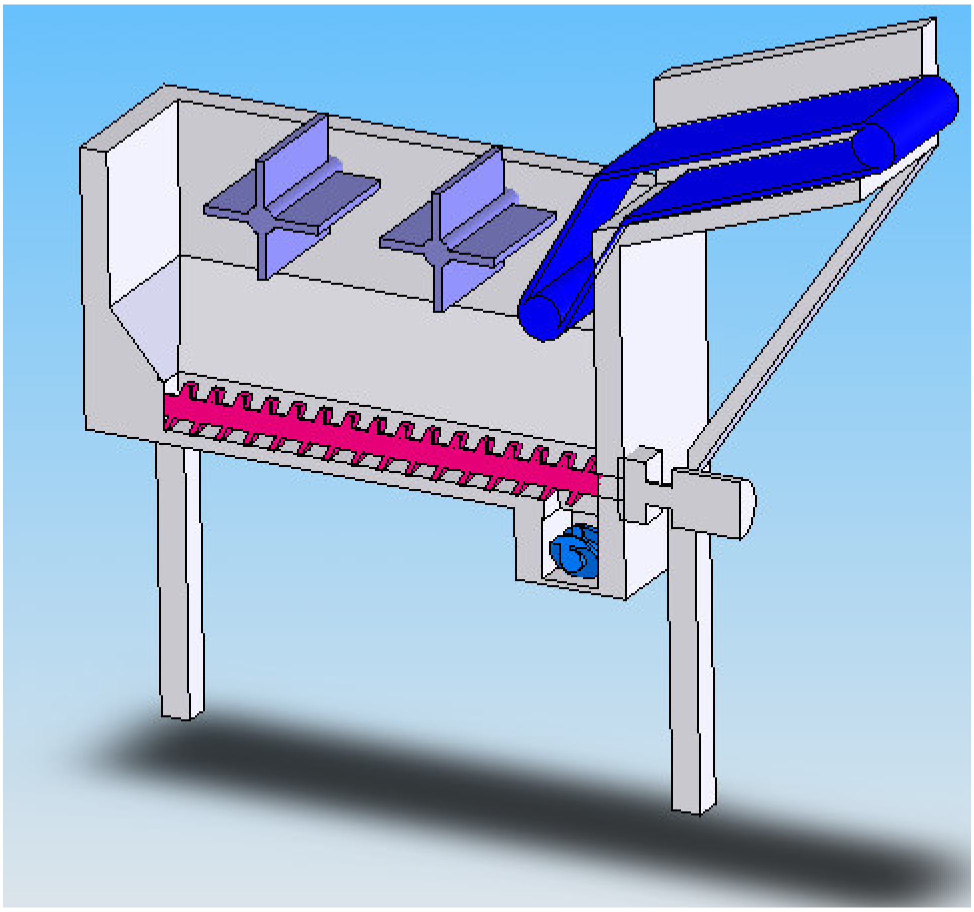

Figure 6.4 Section view of a float tank of plastic separator

CHAPTER 7

CAPACITY OF THE NEW SEPARATION FACILITY

Mixed municipal solid waste separation facility at this thesis is designed to be established in İzmir so capacities of the machines that are used were chosen for Izmir waste composition. Amount of municipal solid waste of İzmir was 846.194 tons for the year of 2005 (İzmir Metropolitan Municipality). Waste composition of Izmir is glass 4%, metal 3%, plastic 12%, paper 12%, organic 46% and other 23% (Metin, E., Eröztürk, A., Neyim, C., 2003). While the facility was designed, data that how much of solid waste will be glass or paper was taken from these information.

Designed facility has 60 tons per hour mixed waste separation capacity so if facility works 16 hours in a day, it can separate about 1000 tons per day mixed municipal solid waste. Capacities of the machines that should be used in this facility are given in Table 7.1.

Table 7.1 Capacities of the machines that are used at separation facility

Machine	**Capacity in the facility (tons / h)**
Bucket screen	30
Bag opener	30
Shredder	18
Trommel	30
Eddy current separator	20
Disc screen	20
Baler	10
Glass crusher	5
Conveyor	30
Float tank	10
Vertical chain curtain	20
Plastic separator	10

This capacity can be increased with adding new machines but this is not economical because of the transportation cost. To take the solid waste to separation facility is difficult and need more transportation cost. To solve this problem, number of the facilities can be established around the city.

About 2500 tons/day municipal solid waste is collected at İzmir so that there should be two or three mixed solid waste separation facilities are designed in this project.

Another problem of the increased capacity is establishing cost of the facility because sorting machines are too expensive and in addition to this they are not made in Turkey.

To get profit from solid waste separation facility, it should work more than 2/3 capacity because if it works less then this capacity, it can only pay its expense that electricity, salaries, taxes, transportation, repair and maintenance.

CHAPTER 8

CONCLUSIONS

This new municipal solid waste separation facility is cheaper than existing facilities and more efficiency. Only using physical properties to separate materials makes this facility more efficient. The recovery rate for marketable secondry materials from dirty MRFs is normally around 20-30 per cent but in our design this ratio would be more than 60 per cent. Much more recyclable materials can be sorted, such as aluminum and plastics.

Human is not used to remove materials from waste stream. For this reason, this facility is not hazardous for people. The hazardousness of the existing separation facilities that use human for sorting materials can be seen in Figure 8.1. Moreover, the facility is much faster than the existing facilities.

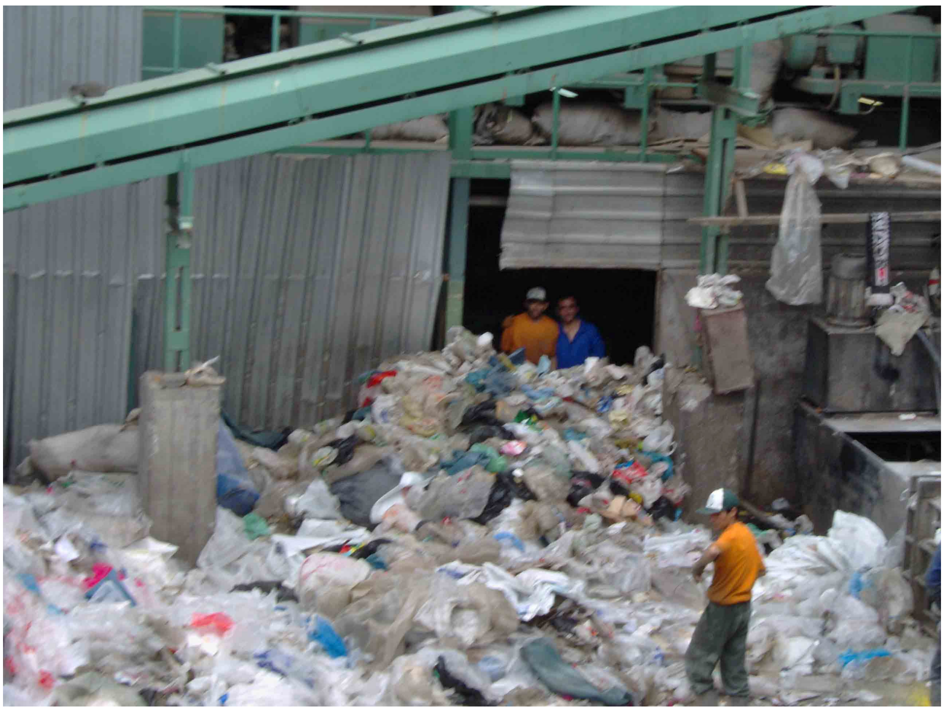

Figure 8.1 A solid waste separation facility that uses human to sort materials

Due to not using sensor, this facility is cheaper than other facilities. Repair and maintenance expense are less than other facilities because of not using electronic sorting machines that have sensors.

25.373.100 tons municipal solid waste is collected in Turkey (SIS, 2004). For this reason, Turkey needs about 70 waste separation facilities to sort all of this solid waste that is produced in one year. Unfortunately, to establish separation facility like new design is not possible for every city in Turkey with the current conditions like economy and not having awareness of the environment but in the future the number of separation facilities will increase because of developing awareness of the environment and quality of life. It is not enough to only build separation facilities, it is also necessary to establish other solid waste disposal facilities which are more efficient and less hazardous.

REFERENCES

Pehlivan E., 1995. "Examine of the Recyclable Materials",Yıldız Technical University, Institute of Science and Technology, Master Thesis, İstanbul

Cascadia Consulting Group, Inc., 2004. Statewide Waste Characterization Study, pp. 90-105.

Dubanowitz, A.J., 2000. "Design of a Materials Recovery Facility (MRF) for Processing the Recyclable Materials of New York City's Municipal Solid Waste", Department of Earth and Environmental Engineering, Columbia University, pp. 10-27.

State Istitute of Statistics of Turkey (SIS), 1993. Environmental Statistics, Household Solid Waste Composition Survey

State Istitute of Statistics of Turkey (SIS), 1994. Municipal Environmental Inventory, Fundamental Environment Indicator

State Istitute of Statistics of Turkey (SIS), 2001. Environmental Statistics, Household Solid Waste Composition Survey

State Istitute of Statistics of Turkey (SIS), 2004. Municipal Environmental Inventory, Fundamental Environment Indicator

Metin, E. and Eröztürk, A. and Neyim, C., 2003. "Solid Management Practices and Review of Recovery and Recycling Operations in Turkey", Waste Management 23 (2003) 425-432.

İzmir Metropolitan Municipality, 2006. Municipal Waste Statistics of 2005

Küçükgül, O., 2000. Appropriate Environmental & Solid Waste Management & Technologies for Developing Countries

Ürüt, A., 2003. "İzmir Büyükşehrinde Üretilen ve İşlenen Katı Atık Miktarları Hakkındaki İstatistiki Bilgiler", 2. Ulusal Katı Atık Kongresi Bildiriler Kitabı.

Barlaz, M.A. and Ranjithan, R and Weitz, K.A. and Nishtala, S.R., 1995. "Life – Cycle Study of Municipal Solid Waste Management" p. 3.

Planning for Resource Sustainable Communities, Vol.1: "Waste Infrastructure & Management" pp. 1-21.

Stenstrom, M.K., 1981. "Anaerobic Digestion of Classifield Municipal Solid Waste" pp. 5-24.

The Environmental and Plastics Industry Council (EPIC) and Corporations Supporting Recycling (CSR), 2005. A Review of Automated Technology to Sort Plastics & Other Containers

EnvirosRIS, 2001. “Material Recycling Facility Technology Review” pp. 4-33.

Consultats, P., 1991. “Material Recovery Facilities for Municipal Solid Waste” pp. 2-47.

Richard, L., 1993. “Municipal Solid Waste Composting: Physical Processing”, Department of Agricultural and Biological Engineering, Cornell University, pp. 1-6.

Ulgen, A.Ü. and Erdin, E., 2005. “Mechanical / Biological Pre-treatment of Municipal Solid Waste in İzmir”, Environmental Engineering Department, Dokuz Eylul University, pp. 6-7.

Veasey, T.J., 1997. “An Over View of Metals Recycling by Physical Separation Methods”, Department of Chemical Engineering, National University of Science and Technology, Bulawayo, Zimbabwe, pp. 62-63.

Swartzbaugh, J.T. and Diaz, L.F. and Duvall, D.S. and Savage, G.M., 1993. Recycling Equipment and Technology for Municipal Solid Waste: Material Recovery Facilities, (William Andrew Inc., New York), pp. 27-54.

WEB_1, 2005. RRT Design & Construction’s web site, 05/11/05. http://www.rrtenviro.com

WEB_2, 2005. Waste Guide’s web site, 09/11/05. http://www.wasteguide.org.uk

WEB_3, 2006. Bezner Company’s web site, 11/03/06. http://www.bezner.dk

WEB_4, 2006. Vecoplan Company’ web site, 11/03/06. http://www.vecoplanLLC.com

WEB_5, 2005. Synmet Company’s web site, 17/01/06. http://www.synment.nl

WEB_6, 2006. Eurohansa Company’s web site, 21/01/06. http://www.eurohansa.com

WEB_7, 2005. EuRec Company’s web site, 18/10/05. http://www.eurec.de

WEB_8, 2006. Navarini web site, 15/04/06. http://www.navarini.com