Engineering

MODULAR AUTOMATED INSTALLATION FOR SEPARATE WASTE COLLECTING

Diana POPESCU[1]
Cicerone Laurentiu POPA[2]
Radu Constantin PARPALA[3]
Costel Emil COTET[4]

ABSTRACT:
IN THE CONTEXT OF A HIGHLY JUSTIFIED GLOBAL INTEREST TO COLLECT, RECYCLE AND REUSE WASTES FOR REDUCING NATURAL RESOURCES EXPLOITATION AND PROTECTING THE ENVIRONMENT, THIS STUDY PRESENTS THE INNOVATIVE CONCEPT OF A MODULAR FULLY AUTOMATED INSTALLATION FOR THE SEPARATE COLLECTING OF PLASTIC AND GLASS RECIPIENTS, ALUMINUM CANS, CARDBOARD, PAPER, LARGE AND SMALL ELECTRIC AND ELECTRONIC EQUIPMENT. AUTOMATIZING THIS COLLECTING ACTIVITY ALLOWS RAISING THE RECOVERED QUANTITY OF WASTES, DECREASING THE LOGISTICS COSTS, ELIMINATING POTENTIAL BOTTLENECKS IN CASE OF EQUIPMENT ERRORS, AND REDUCING AT MAXIMUM THE PRESENCE OF HUMAN OPERATORS. THE PROPOSED SOLUTION ENSURES A COLLECTING PROGRAM OF 24 HOURS A DAY, SEVEN DAYS PER WEEK. MODULARIZATION PROVIDES A FAST RECONFIGURATION OF THE INSTALLATION BASED ON THE RECYCLING STATISTICAL DATA SPECIFIC TO DIFFERENT GEOGRAPHIC ZONES REGARDING THE TYPE AND QUANTITY OF WASTES.

KEY WORDS: WASTE, SEPARATE COLLECTING, MODULAR, AUTOMATED, WEEE, CARDBOARD WASTE

INTRODUCTION

Collecting, recycling and reusing all type of wastes are mandatory aspects in the sustainable development of the actual society for reducing the exploitation of the natural resources and protecting the environment. Therefore, it is important to raise the efficiency of all these activities, to develop methods, systems, devices and installations with high productivity that allows recycling and then reusing a large quantity and variety of wastes.

The present study enrolls in this context of interest by proposing a modular and fully automated installation dedicated to the separate collecting of different type of wastes: plastic recipients, glass recipients, aluminum cans, small and large waste electrical and electronics equipment (WEEE), cardboard and paper, batteries etc. Automating this activity allows an

[1] Associate professor PhD, University POLITEHNICA of Bucharest, Romania, diana@mix.mmi.pub.ro
[2] Lecturer PhD, University POLITEHNICA of Bucharest, Romania, laur.popa79@gmail.com
[3] Lecturer PhD, University POLITEHNICA of Bucharest, Romania, radu.parpala@gmail.com
[4] Professor PhD, University POLITEHNICA of Bucharest, Romania, costelemilcotet@gmail.com

increase in the collected wastes quantity, a decrease of the logistics costs associated with the current installation operations, in the same time eliminating the bottlenecks determined by potential errors in the equipment functioning and reducing clients waiting time in rush hours in front of the station. Moreover, automation reduces at maximum the involvement of the operators' who currently perform difficult tasks such as verifying the wastes conformity, wastes' transport and transfer within the station for pressing/compaction and depositing. Thanks to automation, the solution proposed and described in this paper ensures a collecting program of 24 hours a day for seven day per week.

Modularity offers the advantage of a fast reconfiguration of the installation so that to better answer the collecting requirements specific to each geographic area. For instance, in some cities one possible configuration of the installation can include one module for plastics, glasses and aluminum cans, two modules for small WEEE and one module for cardboard and paper. While in another city, based on statistical data regarding wastes collecting quantity and types, the decision could be to implement an installation with one module for large WEEE, two modules for cardboard, one module for cans, plastics and glasses recipients and one module for small WEEE.

STATE OF ART IN THE FIELD

In Romania, the stations for separate waste collecting are manually operated, two employees being required for performing the tasks associated with large and small WEEE identification, weighing, transport and transfer etc.

There are several companies such as Tomra, Envipco, Wincor Nixdorf[2] that produce automate reverse vending machines. Currently, this equipment serves for selectively collecting plastic and glass recipients, aluminum cans, according to the type of waste and quantity the client receiving a voucher. Similar solutions can be found by studying patents in the field such as US5111927[3], US5988054[4], US20080027581A1[5], US8851265B2[6], EP1235191A1[7], US 7669740B2[8] or EP1173834A1[9]. All these patents implement different automation methods for selectively picking, sorting, weighing and compacting wastes such as plastic bottles, glass recipients or aluminum cans in dedicated containers. Some of these solutions also involve shredding the waste or breaking it into fractions. This is the case of the solution presented in US5447017A which collects, sorts, processes and compresses various types of waste such as cardboard, glass, paper, aluminum and plastic bottles.

Regarding cardboard recycling, there is the solution proposed in US 4240339 for collecting, compacting and baling cardboard. However, this patent is not containing any information on verifying cardboard humidity or paying the client in accordance to the quantity delivered to the recycling machine.

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[2] Tomra – Automated return systems for recycling, https://www.tomra.com/en/solutions-and-products/collection-solutions/reverse-vending/ accessed February 15th 2017; Envipco – Reverse Vending Machine, https://www.envipco.com/recovery-solutions/reverse-vending.php, accessed January 28th 2017; Wincor Nixdorf – Reverse Vending Systems, http://www.wincor-nixdorf.com/internet/site_PT/EN/Products/Hardware/Retail/ReverseVending/Node.html accessed February 4th 2017

[3] Automated Recycling Machine, US5111927 Patent, 1992

[4] Automated system for handling returned drink containers, Patent US5988054, 1999

[5] Means in a reverse vending machine (RVM) for receiving, handling, sorting and storing returnable items or objects, Patent US20080027581A1, 2007

[6] Reverse Vending Machine, Patent US8851265B2, 2011

[7] Reverse Vending Machine Patent EP1235191A1, 2002

[8] Beverage vending machine installation, Patent US7669740B2, 2004

[9] Rücknahmeautomat für verpackungen, Patent EP1173834A1, 2002

The only reference found regarding an automated recycling station is presented in EP2759988A1. This installation includes a depositing unit organized as matrix of shelves, a transport system of the recipes and a transfer system of the recipes from the deposit into containers or buffers. The installation uses sensors to make the distinction between different containers which hold different sorts of wastes. The patented solution automatizes only transport and transfer activities, but not the selective collecting task.

Hence, any solution currently implemented or patented is not offering an integrated, compact, fully automated and reconfigurable installation making possible a more efficient the separate collecting of various types of waste.

MODULAR AUTOMATED INSTALLATION FOR SELECTIVE WASTES COLLECTING

The installation proposed in this paper can be described by its two main characteristics: modular and fully automated.

Modularity means it can be configured differently upon recycling necessities in certain cities/geographical zones. An illustrative example is presented in figure 1, the installation containing:

- Module for plastics, glasses and aluminum recipients;
- Module for batteries;
- Two modules for cardboard wastes;
- Two modules for small WEEE;
- Three modules for large WEEE.

All modules include a system for communicating with the dispatcher for emptying the module, maintenance activities or repairs. Also, each module provides vouchers for clients according to the type and quantity of wastes.

The overall dimensions of the surface of the installation are 12m x 5m, that is 60m^2, each module having 1m width, 5 m length and 2.5m height.

At the back side of each module, there are access doors for the operators who empties the deposits/vertical carousels, conveyors, containers, etc. or who perform repairs or maintenance activities.

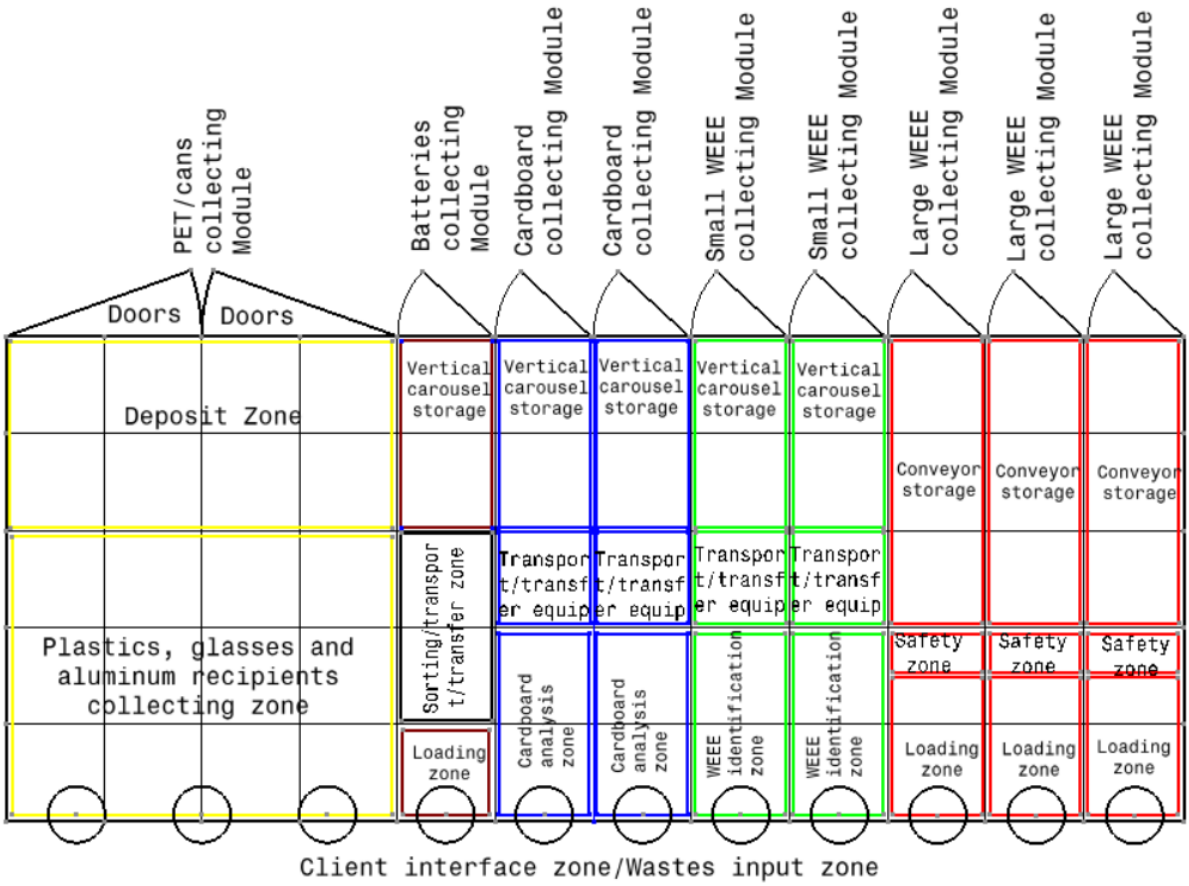

Figure 1. Illustrative example of a configuration for the proposed modular automated separate waste collecting installation

A typical workflow for the module collecting plastics, glasses and aluminum recipients contains the following steps:

– Recipients/cans are introduced in the dedicated slot placed in front of the module which has also an interface of communication with clients;

– Recipients/cans are collected, identified and weighed;

– Recipients/cans which do not correspond the established requirements are returned to the client using the same input slot;

– The client is paid with vouchers;

– Recipients/cans which correspond to the requirements are sorted by type of waste (plastic, glass, aluminum);

– Recipients/cans are placed in containers and afterwards are transported and transferred in the deposit area;

– When the warehouse/deposit is full, the module sends this information to the dispatcher for emptying the module.

The module for collecting cardboard and/or paper contains the following:

– System for interaction with the client for selecting the type of waste (cardboard or paper) and for proving a voucher;

– System for analyzing the waste conformity, especially its humidity level, using a specific sensor matrix;

– System for compacting and baling the cardboard/paper;

– Conveyor for transporting bale towards the transfer zone;

– Transfer system of the bale in a vertical carousel deposit.

The module for large WEEE includes the following components:

– System for interaction with the client for selecting the type of waste (washing machine, microwave oven, refrigerator, large TVs etc.) and for proving a voucher;
– System for identifying the type of waste and thus establishing the conformity with the client selection – it uses a video recognition module;
– System for weighing the waste;
– Safety system with doors which help avoiding unauthorized access inside the station (considering that the input for this type of wastes requires a large access area and not a slot as for the other modules);
– Conveyor for transporting the large WEEE towards the back of the installation, working in accumulation.

The module for selectively collecting small WEEE is composed of:

– System for interaction with the client for selecting the type of waste (mobile phone, laptops etc.) and for proving a voucher;
– System for identifying the type of waste and thus establishing the conformity with the client selection – it uses a video recognition module;
– System for weighing the waste;
– System for collecting small WEEE in larger containers;
– System for signaling the fill of the larger containers;
– Transport system of the container towards the vertical carousel storage deposit.
– The module for batteries collecting is composed of:
– System for interaction with the client and for proving a voucher;
– System for identifying the type of waste and thus establishing the conformity with the client selection using a video recognition module;
– System for collecting the wastes in larger containers;
– System for signaling container filling;
– Conveyor for transporting containers towards the deposit zone;
– Transport system of the container in the vertical carousel storage deposit.

Hence, each module has the zones presented in figure 2 which are placed in line so that to optimize the space:

– Zone A – zone for separate wastes input and interaction with the client;
– Zone B – zone for waste identification, verification of conformity and weigh;
– Zone C – pressing and compacting area needed for some type of wastes such as paper and cardboard, or for gathering small size wastes (small WEEE or batteries) in larger containers;
– Zone D – wastes transport and transfer area towards warehouse/deposit space;
– Zone E – warehouse/deposit space.

Depending on the type of waste the client wants to recycle, she/he goes to the reverse vending and collecting module which corresponds to the type of waste:

– If, for instance, the waste is a refrigerator, the client selects from the interface zone (A) the type of waste and places the object inside the loading zone which is positioned at the ground level. The loading area door is closed after the object is placed inside, then the waste type identification is performed and the conformity with the client's selection is established. In the same zone, the waste is weighed (zone B). The system displays the voucher value for that waste and the client chooses to accept the voucher or to cancel the process. In case of cancellation, the door is opened and the client can remove the refrigerator. If the client accepts the voucher, a second safety door is opened and the waste is transported from zone D towards the deposit area E. For large WEEEs, the transport and storage are made on the conveyor. The conveyor is working in accumulation which means that each object is pushed forward by a new object until the deposit area/conveyor is filled. When the conveyor is full

with objects, the system is sending this information to the dispatcher and blocks the input zone. The module is manually emptied using the door placed at the back of the station.

– If the waste is cardboard type, for instance, the client inputs one by one the wastes using the input slot from zone A. The cardboard is tested for humidity in zone B and if it is in conformity with the specification, a voucher is issued for the client. If the cardboard is too humid, it is sent to a different container in order not to contaminate the other cardboard or paper wastes. The accepted cardboard reaches then zone C for pressing, compacting and baling. The bale is transported by a conveyor in zone D and transferred towards the deposit zone E.

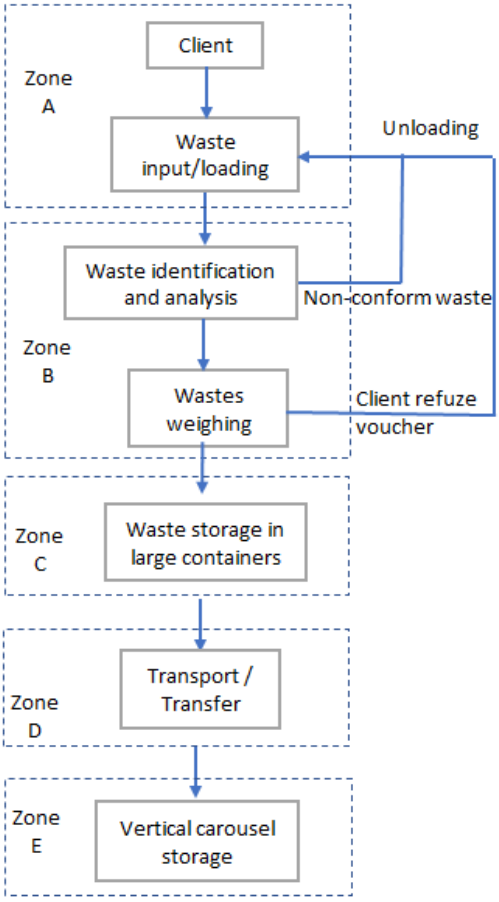

Figure 2. Example of a collecting flow for small WEEE

DISCUSSIONS AND FURTHER WORK

The installation presented in this paper provides the following advantages:

– Allows reconfiguration by integrating and interconnecting different reverse vending modules, thus allowing adaptation to the particularities of the geographical area or city where the respective wastes collecting station is located;

– Allows the installation to operate even if one of the module is blocked, needs repairs or maintenance due to the fact that modules function independently;

– Allows the installation to operate autonomously 24 hours a day, seven days a week;

– Automates wastes collecting, identification, verification and weighing, compacting, transport and transfer according to their type, thus eliminating the need for a human operator;

– Provides storage on waste categories so that they can be removed from the installation/station at different times for transportation for further processing/recycling;

– The modular configuration ensures a high degree of storage compared to the existing solution (manually operated installation) relative to the same surface;
– Communicates with the dispatcher the amount and type of wastes in each module allowing optimal programming the discharging of the various modules, as well as maintenance and repairs activities;
– Includes standard conveyor equipment, vertical carousel storage systems, compactor and cardboard baling press, plastic container compressing press, thus reducing the cost of implementing the installation.

Further work will be focused on developing each module and then integrating them into the prototype installation for performing tests.

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