SMART RECOVERY OF MATERIALS AND UPGRADE OF ORGANIC COMPOST & RDF IN EXISTING MECHANICAL BIOLOGICAL TREATMENT PLANTS BY USING NIR TECHNOLOGY

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ABSTRACT

The present study aims to present the objectives and the results of the project with title 'Smart Recovery of materials and upgrade of organic compost & RDF in existing mechanical biological treatment plants by using NIR technology'' which is funded by the Greek General Secretariat for Research and Technology. The main goals for the SmartWasteTech project are summarized to the smart recovery of the materials by using NIR technology in order to increase the quality of the produced compost and recovered materials (PET, PE/PP. LDPE film) and to optimize the process by using online monitoring software for the MBT plant operation. The paper presents the results of the recovery rate, the purity of the final products, the efficiency of the technology performance and the effective role of the NIR technology in existing MBT plants.

1. INTRODUCTION

The first near infra-red (NIR) sorting systems were used to process recyclable materials in the early 1990s. Until then, hand-sorting for the separation of the recyclables materials from the MSW had been used. Today, modern sorting systems, where e.g. paper, plastics or other recyclable materials can be sorted, cannot be run economically without near infra-red technology.

The NIR spectroscopy is often used for rapid analysis of samples and sample mixtures in process analysis. Here the infrared radiation generated by halogen lamps is directed on the sample surface. The radiation reflected by the sample is spectrally divided and detected as function of the wavelength. Depending on the sample material, specific wavelength ranges are particularly strongly absorbed. That occurs at wavelengths that correspond to the resonance frequency of the excited molecules. From the spectrum, characteristic for each material, by means of mathematical analysis and comparison with reference spectra the sample material may be determined reliably. To obtain sufficient information about the sample composition, it is necessary to measure the sample in the relevant wavelength band with a high spectral resolution (Habich 2007).

Automatic sorting systems have been used in waste processing for more than 10 years in sorting light packaging (e.g. Duales System Deutschland (DSD) - Dual System Germany Ltd.). These systems work with Near-Infrared (NIR-) sensors and can distinguish between different plastics. For the hitherto existing sorting of uncrushed packaging wastes a spatial resolution of several centimetres has mostly been sufficient. In the course of increasing production of refuse derived fuels from commercial or combined wastes more and more alternative sensor-systems which originally come from a field like metal recycling are used for impurity depollution. Furthermore, the crushing of the base material necessary for the material pulping increases the spatial resolution requirements, (Böhm, Smidt et al. 2010).

The aim of this paper is to present the scope of the project ‘’ Smart Recovery of materials and upgrade of organic compost & RDF in existing mechanical biological treatment plants by using NIR technology’’ funded by the GSRT

2. METHODOLOGY

2.1 Scope of the project

The scope of the project is to design, develop and integrate a Smart System for Recovery of materials and upgrade of the organic Compost & RDF quality in existing Mechanical Biological Treatment Plants by using NIR technology, state of the art technology systems for automation and measurement and algorithms for waste process and recycling optimization. The main goals for the SmartWasteTech project are:

- the development and integration of an online monitoring software for the MBT plant operation based on the continuous information obtained from the modern online sensor technology
- to increase the valuable plastic fraction (PET, PE/PP, LDPE film) sorted out from MSW, towards increasing recycling efficiency and overall environmental performance of the plant
- the process optimization based on the Greek MSW quality.
- to increase the compost quality through application of innovative technology for sorting out inert materials (glass, inert materials) and other unwanted materials such as heavy metals and the production of a high purity compost
- to perform continuous quality monitoring of the produced Refused Derived Fuel to investigate the economic, feasibility and environmental benefits of the proposed technology
- to disseminate the project results to all relevant stakeholders including among others manufacturers and operators of waste treatment facilities, local authorities, engineering and planning companies in the waste treatment sector, end users of recycled plastics and compost

2.2 Innovation activities

Through the latest development of online sensor technology (Near Infrared, laser, X-Ray etc.) different machines have been developed and are currently applied as complete solutions for sorting of mixed Municipal Solid Waste. Based on this development, modern waste treatment plants have the appropriate process technology installed to efficiently recover valuable materials from mixed Municipal Solid Waste (metals, specific plastic fractions like PET), while the remaining high calorific fraction of MSW is usually led to other energy recovery processes by producing high quality Solid Recovered Fuels (SRF) or Refused Derived Fuels (RDF), (Nasrullah, Vainikka et al. 2014; Cimpan, Maul et al. 2015). Nevertheless, recently developed waste sorting techniques cannot be applied in the existing Mechanical Biological Treatment Plants (MBTs), without additional research work and carefully planned modifications in the current waste treatment processes. Due to the difficulty of this task, no integrated concept solution for the enhancement of environmental performance in existing MBT plants has been developed and demonstrated up to now. This is exactly the first innovative aspect in the present project.

This conventional type of waste treatment plants usually includes a separation step for the finer organic fraction, which is usually followed by a biological drying and a composting step towards the production of a material with characteristics argued to be similar with these of organic “compost”. However, after a careful evaluation of the compost analysis it can be noticed that the compost material derived from mixed MSW has usually a high amount of inert materials and a high concentration in heavy metals. For this reason the utilization of this type of material is rather limited, thus it cannot be promoted as fertilizer. Therefore, the goal of the project is the upgrade of the compost quality up to a level that will be comparable with the organic fertilizer. This will be achieved by the development and optimization of a process for sorting out inert, heavy metals and other unwanted materials, which will be the second innovative point of the project. The particular process has been applied for other types of waste in the past (commercial waste) but it has never been tested for mixed MSW. Therefore, a further development of the process based on the particular characteristics of compost derived from mixed MSW is required and will be carried out. The remaining

stream with the bigger size particles, including packaging materials is then utilized for the production of a refused derived fuel (RDF). Nevertheless, the particular type of RDFs, produced at MBT plants operating with an aged technology, can hardly meet the high quality criteria required by today's incineration or co-incineration plants (cement, brick kilns) in terms of calorific value, chlorine content and heavy metals concentration. For this reason their marketability is limited and only a view of them are standardized according to the recently published European standards (EN 15357, EN 15358, EN 15359). Furthermore, the recovery of paper and plastic fractions is a target of the project. In specific, this type of recyclables is usually not recovered in mixed waste treatment plants. An ambitious goal of recovering about 85 % of the recyclables still present in the packaging material stream is set. This will be achieved through the customization of new sorting equipment and optimization based on the specific parameters of mixed MSW, which is the third innovative point of the project.

The concept under development was implemented in the Athens Mechanical and Biological Waste Treatment plant located in the main Athens land fill site of Ano Liosia and operated by Helector S.A and to the MBT plant in Larnaca, Cyprus which was designed, constructed and operated by Helector S.A. since 2010.

The daily input stream of the Athens MBT plant is about 1200 tn of mixed MSW. The production of RDF and compost rise to 450t/day and 180t/d respectively. The recyclable fraction of the input mixed MSW is about 1.5% PET, 1.5% PE/PP, 8% recyclable paper, 9% glass and 5% metals. The proposed work intends to provide a complete solution for the quality improvement of MBT plant‟s output streams and the increase of its recycling efficiency by the application of modern, innovative sensor and separation technology.

The technologies that were incorporated in the Integrated System SmartWasteTech are related with industrial research (IR) and aim at obtaining expertise by design and install:

- special electromechanical structures
- specific type and measurement sensors
- automation and control systems,
- optimization algorithms for measurement and process,
- quantitative and qualitative management system and evaluation assessment models (LCA, feasibility study for environmental, social and economic benefits) of the collected data

2.3 The technology

The Titech equipment uses an NIR sensor to detect the characteristic infrared spectrum of light reflected by an illuminated object. The NIR spectrum of each material is unique and can be used to identify specific materials and then separate them (Figure 1). The system has

- Modular design
- Modular build
- Maximize cost benefit process plant to product recovery

The basic characteristics of the system are:

- High tech sensors are utilized to identify objects on a conveyor belt
- High speed processing of information: material, shape, size, color, defect, damage and location objects
- Precise sorting by air jets

The system works by scanning the material as it travels along a conveyor belt. The PolySort UHR uses a fast near infrared analyzer along with a computer-controlled air jet ejection system. Material is identified across the entire width of the conveyor belt. The type of material, position and projected area of every single object on the belt is determined by the machine. A computer then rapidly processes the information and controls a series of air jets situated at the end of the conveyor belt. The air jets are activated

accordingly to remove the identified material from the main product stream. The projected area determines which air jets need to be activated and only those which the object will pass over are used. The duration for which the air jet is active corresponds to the overall projected length of the object.

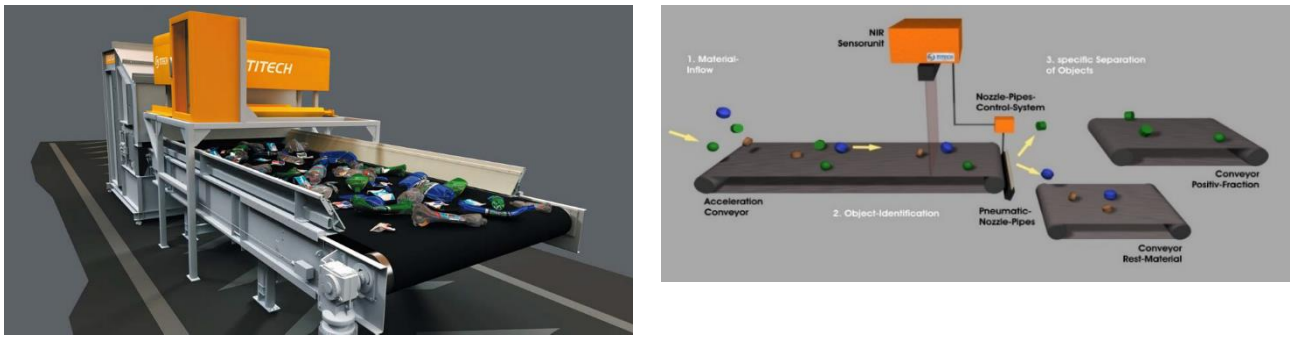

Fig. 1: NIR technology of TITECH (TOMRA)

3. RESULTS

NIR's municipal waste sorting systems identify and sort grain sizes from 10 to 500mm, separated according to preferred size ranges. These systems provide inert material elimination of up to 95% in municipal waste, producing material suitable for biomethanisation. Inert material, such as glass and stones, can cause significant problems during the treatment process and therefore has to be reduced to a minimum, while as little organic content as possible is removed. In addition, materials such as PET, PE/PP. LDPE film etc can be recovered successfully.

The NIR system is operated entirely by a computer with an LCD screen display from which the system can be controlled. Most settings and functions can be changed via the screen such as the belt speed, material selected for ejection. The SmartWasteTech system communicates directly to the NIR in order to monitor via a SCADA and MIS system the operating parameters. The integration of the SmartWasteTech system in the MBT plant leads to the following results:

- Process Analysis
    - Real time process and material information
    - Batch process and reporting
    - Real time analysis and process tuning
    - Input composition over a period
    - Material timetable which shows how much material was detected in a period
    - Distribution of the material which shows how much material was detected on different parts of the conveyor
    - Temperature and pressure
- Management
    - Database capture of process and material
    - Overall equipment effectiveness

The integration of the NIR technology in the MBT plant in Larnaca, operated by Helector SA have increased the recovery of the material and the efficiency of the technology performance. These results are presented in the following diagrams.

In specific, the purity of the materials are shown in the Fig. 2 and Fig. 3. As it is shown, the purity of the recovered materials are high. This means that the environmental benefit is high, as well as the selling price of the materials to the recycling industries. In Fig. 3, the purity of the materials in Larnaca is compared with

the green Dot system in Germany. The purity of materials is higher than the respective purity of the German Dot system, thanks to the NIR technology applied in the plant.

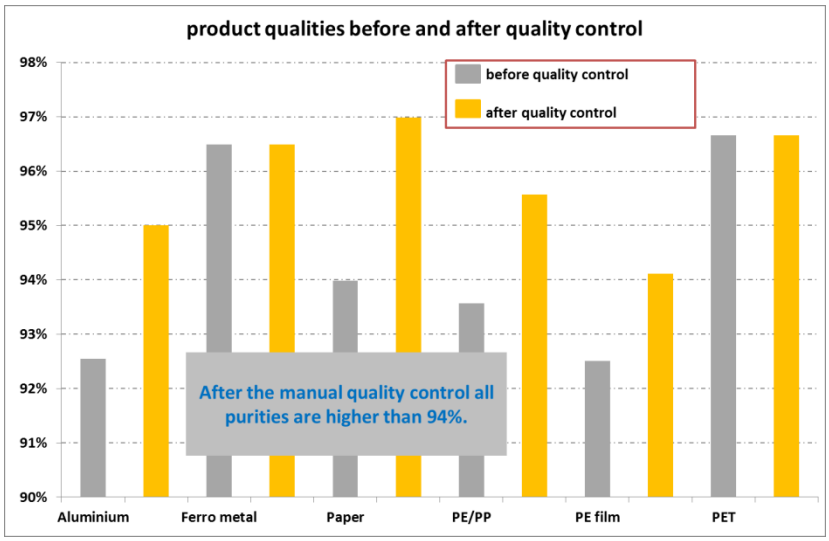

Fig. 2: Indicative purity results in MBT plant at Larnaca

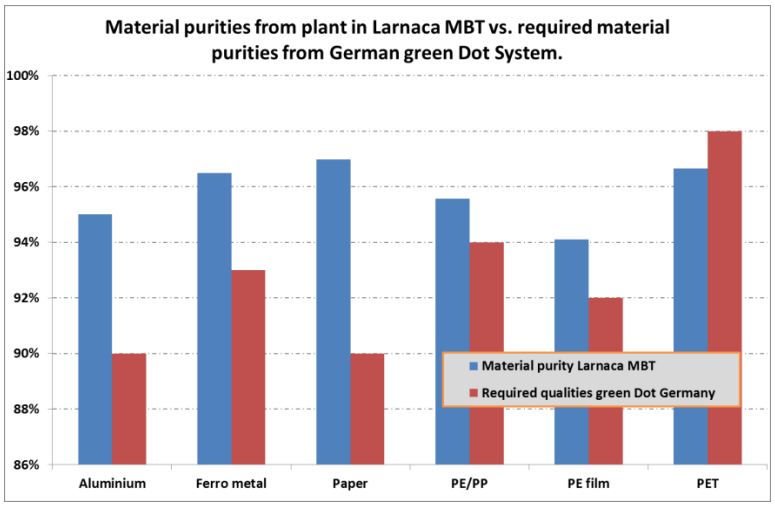

Fig. 3: Comparison between Larnaca's MBT plant with a typical plant in Germany

The NIR online analysis has been applied successfully for the identification of the input waste. The results are shown in Fig. 4. The results from NIR online analysis are very closed to the results from the experimental analysis (mass balancing). In summer months, there is a significant deviation of the results, since the waste composition is quite different due to the change of the consumer's behaviour e.g increase of tourism.

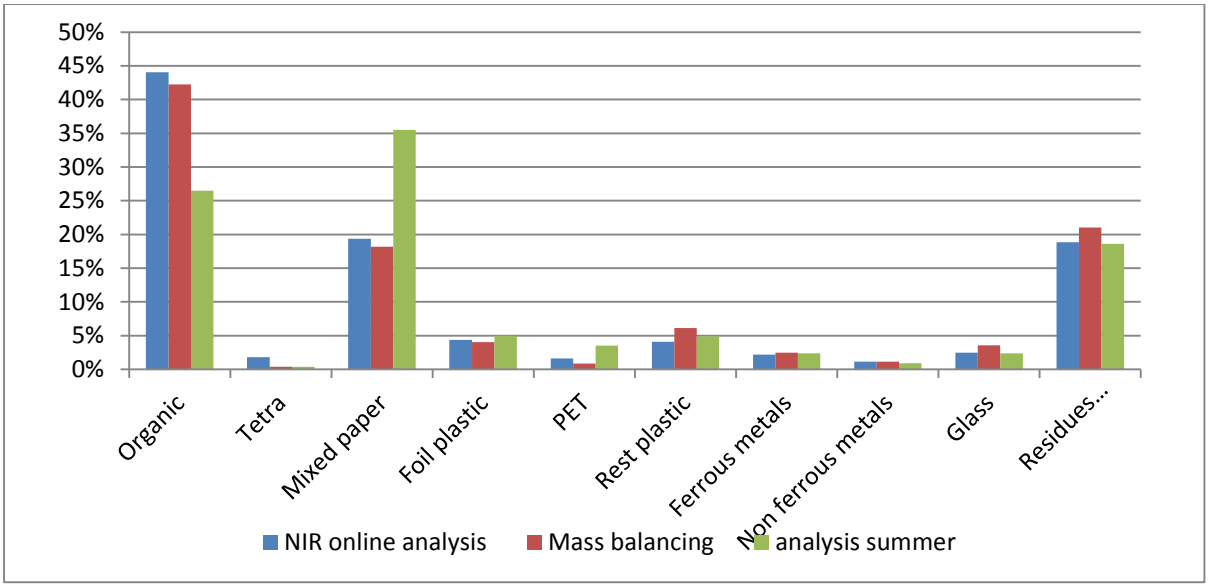

Fig. 4: Composition of input waste based on NIR online analysis and experimental analysis

4. CONCLUSIONS

The SmartWasteTech proposal, using NIR technology for recycling, improves the operation of the existing MBT plants and the SCADA system communicates directly to the NIR in order to monitor the process and the operating parameters. The SmartWasteTech system can be applied in existing MBT plant, giving a solution to the improvement of the final products (compost, RDF, PET, PP etc). In addition, despite the fact that the input waste corresponds to mixed municipal waste, the proposed system can recover materials in high purity. The overall environmental footprint of the plant is improved, as well as its economic feasibility. The identification of the input waste over a time period is also another outcome of the proposed system. Based on this identification, appropriate configurations of the NIR separators can be carried out, in order to maximize the recovery efficiency of the materials, as well as to improve the final quality of the produced materials (compost, RDF, PET,PP etc).

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