MSW BIO-DRYING: AN ALTERNATIVE WAY FOR ENERGY RECOVERY OPTIMIZATION AND LANDFILLING MINIMIZATION

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În cadrul gestiunii deşeurilor solide urbane (DSU), în concordanţă cu noile directive Europene cu privire la recuperarea materialelor şi valorizarea lor energetică, o nouă opţiune bazată pe trateatea bio-mecanică (TBM) cu flux unic a deşeurilor solide urbane este în continuă devoltare.

Acest process de tratare poate fi utilizat atât ca un pretratament înaintea depozitării controlate sau /şi înaintea combustiei. In acestă lucrare se prezintă anumite aspecte ştiinţifice legate de introducerea acestui tratament bio-mecanic în România şi a utilizării Combustibilului Derivat din Deşeuri (CDD), în instalaţii industriale, cu minimizarea volumului necesar depozitării.

Rezultatele au fost obţinute în cadrul unei colaborări ştiinţifice dintre Universitatea din Trento, Italia şi Universitatea Politehnica Bucureşti, România.

In the management of Municipal Solid Waste (MSW), in agreement with the new European directives concerning the materials valorization and energy recovery, a recent approach is based on a one-stream Biological Mechanical Treatment (BMT).

The bio-mechanical treatment of MSW is an increasing option either as a pre-treatment before landfilling or/and before combustion. In the present paper some aspects related to the scientific introduction of the bio-drying process in Romania, and the use of Refused Derived Fuel (RDF) in industrial district, with a consequent minimization of landfilling volumes are presented.

The results have been obtained in the frame of an international collaboration between the University of Trento, Italy and Politehnica University, Bucharest, Romania.

Keywords: mechanical biological treatment, municipal solid waste, refuse derived fuel, landfilling

1. Introduction

On the 1st of January 2007 Romania became one of the European Union members. The European Association Agreement stipulates that Romanian

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development policies must be guided by the principle of sustainable development and take full account of environmental considerations. For this reason Romania began to implement the EU principles on waste management trying to put, in the first place, waste prevention, in the second one recycling and energy generation, and in the last one disposal of waste with no recovery of either materials and/or energy. Romania implemented in 2005 the final version of the landfill directive 1999/31/EC and completed in the same year the pathway for the adoption of the directive 2000/76/EU on the incineration and co-incineration of waste [1].

The technologies who are attracting a considerable interest are the Mechanical Biological Treatment (MBT) and Biological Mechanical Treatment (BMT), in particular aimed to energy generation. To this concern a one stream option of BMT could be preferred to a two stream option of MBT (Figure 1) as the first one could put to zero the need of landfill volumes. One of the biggest disadvantages of the two-stream system is related to the generation of Stabilized Organic Fractions (SOF) that have strong limitations for an utilization out of landfilling.

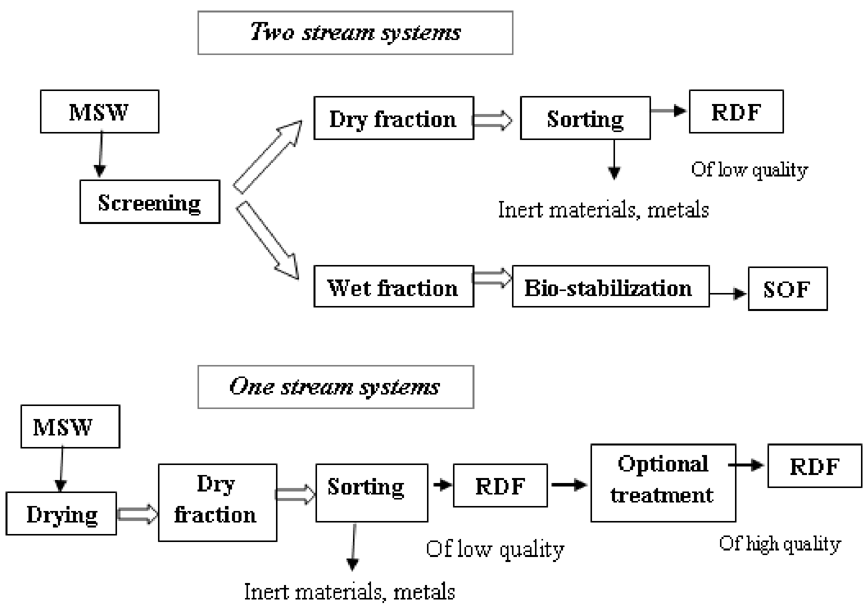

Fig. 1. One and two stream MBT.

A typical one stream option is based on the bio-drying process (the core of the system is a biological process followed by mechanical post-treatments without streams to be landfilled). A typical two stream option is based on the concept of sieving (originating two streams) and on the bio-stabilization of the undersieve (the oversieve is treated to be transformed in RDF but with a significant amount of refuse to be landfilled; also the role of the stabilized material is controversial in terms of disposal).

However, the MSW management represents one of the contemporary problems of the modern society. National, regional and municipal governments must face this problem frequently because all of the past low cost disposal practices are no longer acceptable in the EU context.

The Romanian waste has a high organic fraction content and a strong difference among the per-capita generation of MSW can be seen by comparing the main towns and the villages. In the first case, the daily per-capita generation of MSW can reach 0.9 kg inh^{-1} d^{-1}. In the rural areas, the daily per-capita production is around 0.4 kg inh^{-1} d^{-1}. In particular, the organic fraction content is generally high: in Bucharest only 5 years ago its content reached 50% [2].

The implementation of biological processes for MSW treatment [3] and their successful development [4,5,6] show an increasing interest in Romania. The final material, named generally Refuse Derived Fuel (RDF), after a refining stage can be sent to coal fired power stations or to cement kilns for partially substituting coal and pet-coke [7]. In Romania, at the moment, only 7 industrial plants have received the authorization for co-combustion also with pre-treated waste [8].

The present paper wants to point out the advantages of using this treatment for the Romanian waste and also to give original results regarding this treatment. With this configuration (bio-drying + RDF used in industrial plant) landfilling decreases, recycling increases and energy recovery increases compared with the present situation in Romania. The partial substitution of fossil fuels can give some advantages in terms of Kyoto Protocol. Anyway, it must be pointed out that RDF is only partially a biomass

2. Material and methods

Since 2003, a team formed by Italian and Romanian professors, researchers, PhD students and scholarship students worked in this field. The equipments used for the experimental runs was constructed at the Trento University and are presented in Fig. 2. The MSW used for the development of the runs was constructed artificially for having a composition almost equal with the Romanian one.

This pilot reactor is an adiabatic box placed on an electronic balance for monitoring the waste mass loss during the bio-drying process. The process air is sent into the reactor through a steel diffuser, placed at the bottom.

Fig. 2. Pilot plant, internal view and details regarding the probe temperature position

For monitoring the temperature during the bio-drying process, four temperature probes are placed inside the reactor, one at the air outlet/inlet and two at different levels. All this equipment is connected to a data acquisition system developed for a good management of the process.

A bio-chemical bio-drying model [9,10, 13] has been used in order to elaborate the generated data. The model is an interpretative tool for the dynamics of temperature, of mass losses and of air flow during the bio-drying process and also describes the dynamics of the calorific value both for the bio-dried material, and for the RDF obtainable after post-treatment.

3. Results and discussions

The results presented in this paper regards a run of Romanian MSW with a 50% of organic fraction content. This choice is in agreement with the typical composition pointed out in the recent literature [11]. The duration of the process was of almost 2 weeks. This is the optimal period for a good development of a bio-drying process. Indeed shorter periods do not allow a sufficient water evaporation giving a bio-dried material with a very low increase of its lower heating value (LHV). On the contrary a longer period do not allow an economical optimization of the process due to non optimized capital and operational costs.

In Fig. 3, the temperature dynamics during the bio-drying process are presented. Probe n.1 and n.4 show temperature values of air entering and exiting the biological reactor. Probe n.2 and n.3 show the temperature values in the core of waste. The temperature values resulted higher than 55°C for more than 3 days, confirming the correct management of the run. The fluctuations of the probe n.1 are caused by the daily cycle of the atmospheric conditions. Indeed, these fluctuations last exactly 24 hours.

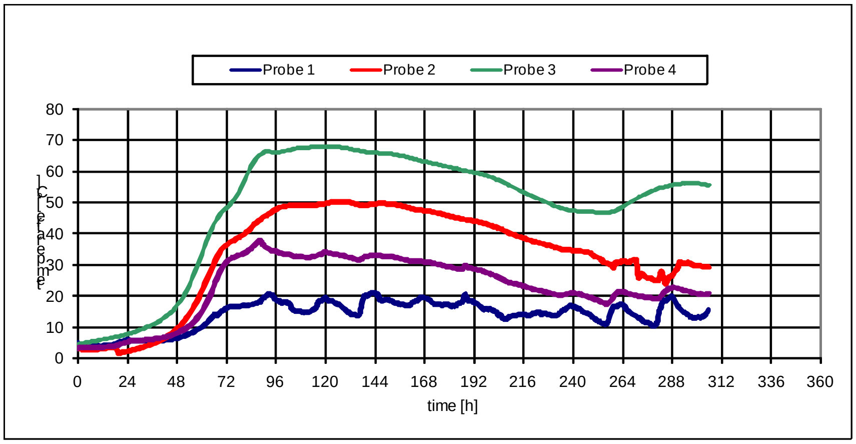

Fig. 3**.** Temperature dynamics during the bio-drying run

In Fig. 4, the dynamics of mass loss is presented. The application of the bio-chemical model allowed reconstructing the waste composition during the process of bio-drying, taking into account the volatile solids loss (C, H, O, N) and the water loss. The mass loss is significant: more than 25%. This result could be interesting in terms of reduction of transport cost.

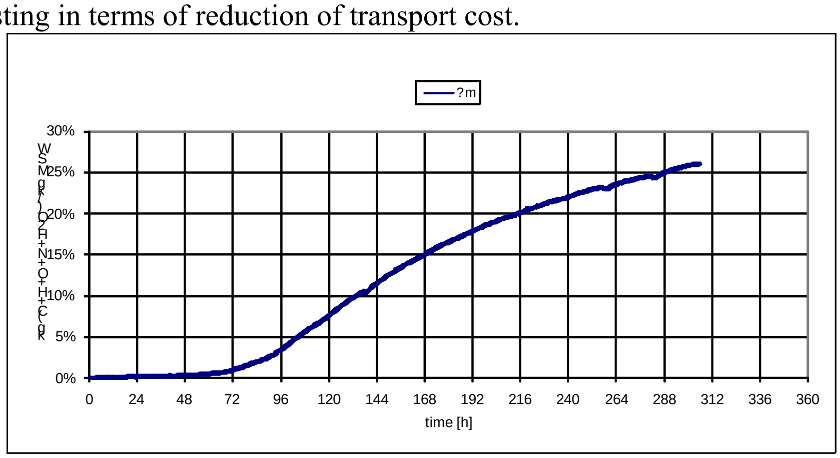

Fig. 4**.** Mass loss during the bio-drying run

In Fig. 5, the dynamics LHV for the initial MSW, for the bio-dried material (the waste obtained after the bio-drying process) and for the RDF (the waste obtained from de bio-dried material after the inert and metals separation) during the bio-drying run is presented. It can be seen that the LHV increase from initial MSW to bio-dried material is 33% and to RDF is 49%.

The initial value of LHV is relatively high compared to the expected value for a Romanian MSW, but this is due to a used composition with a low content of incombustible fractions.

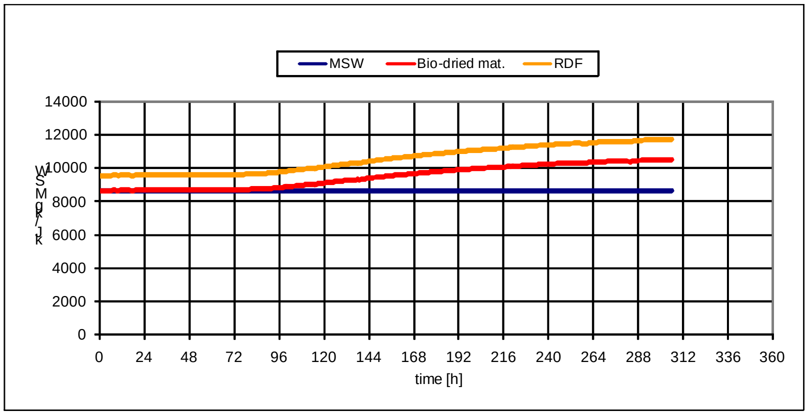

Fig. 5. LHV during the bio-drying

In case of variation of the composition of the waste, due to the implementation of selective collection for some fractions (PET, paper and cardboard, metals, glass, etc) the dynamics of the process could be the same but with a starting LHV for the residual waste in a range of ± 25%.

If the organic fraction is not selectively collected, a diversion at the source of other fractions could increase its percentage in the waste sent to bio-drying, with an advantage in terms of efficiency as this fraction is the core of the process.

It is important to understand that the final values of LHV for bio-dried material and RDF, higher than the initial LHV of MSW, are not related to energy generation but to its concentration in a lower mass.

In Table 1 the LHV for different fuels and for bio-dried material and RDF obtained from the Romanian waste are compared. This comparison is useful to understand the potential of RDF as a partial substitute of conventional fuels in industrial plants.

The use of RDF, resulted from the bio-drying process, in thermal power plants asks for very small grain size grinding. The maximum degree of substitution by RDF which is used directly in combustion chambers is 10% of thermal fixing capacity [12].

Table 1

LHV for different fuels

Fuels	**LHV** [MJ/kg]
Coke	29,5
Anthracite	25,0
Wood chips	12,0
Bio-dried material	10,4
RDF	11,7

As a consequence, the exploitation of RDF could be based also on the use in cement kilns, and, if viable, on its adoption as industrial fuel in particular burners. This last case concerns a scenario where due to the development of new industrial districts it is possible to plan the construction of RDF burners instead of fuel oil burners for local industrial uses. The sector of cement kilns could be activated even without modifications if the amount of RDF aimed to substitute the conventional fuel is small.

The adoption of RDF in cement kilns has a big advantage: the incombustible solids present in the RDF are included in the final product, thus zeroing the landfilling volume for this strategy. In more details, the volume for landfilling is zero only when the RDF generation is obtained without additional post treatment of refining for the separation of the finest fractions. If we look at the values in Table 1, it is clear that the RDF generable with the considered MSW has a low LHV compared to coke and anthracite. For this reason, there are two possibilities: the first one is the use of a small amount to substitute the other conventional fuels; the second one regards the re-processing of RDF, but in this case the volume for landfilling is not zero.

If the LHV of RDF are not acceptable for a fuel substitution because they are too low, a solution could be an additional post-treatment as pointed out in Fig.1. This additional post-treatment could be a screening stage aimed to separate the finer fractions generally wet and so with a low energy content. This solution should be avoided if the target of the strategy is also the minimization of landfilling volumes.

6. Conclusions

The presented scenario based on MSW bio-drying, followed by the use of RDF in different plants can be considered alternative to a direct combustion of MSW if viable. One advantage is related to the possibility of increasing the recycling efficiency as the post-treatment of bio-dried material allow separating more easily the fraction with a market avoiding their disposal in landfills. Another advantage is that the use of RDF in industrial process offers more flexibility than incineration, creating new ways and programs for recycling because it does not need to be fed with a steady amount of waste and it does not require to invest capital for other facilities.

From the environmental point of view, two aspects must be underlined: the first one regards the substitution of fossil fuels with RDF (that is partially a biomass); the other one regards the reduction of the impact from landfills (the putrescible fraction is exploited to support bio-drying and is not sent to disposal).

Finally, it can be pointed out that RDF from MSW could be used also in dedicated plants constructed to integrate the urban district heating that could suffer possible international crises in the distribution of natural gas.

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