LOW TEMPERATURE DRYING AS KEY TECHNOLOGY FOR WASTE RECYCLING

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SUMMARY: Recycling and energy recovery from waste and biomass are more and more important in waste management as well as global energy supply. Recycling materials from waste are recovered increasingly by automatic sorting technologies for example by near infrared technology (NIR). The efficiency of these technologies increases significantly with better pre-treatment of the waste. The paper presents a new process for low temperature drying of waste, using a waste adapted belt dryer with recirculating air. The dryer can process material with a particle size up to 400 mm, which makes it ideal as pre-treatment for automatic sorting systems. The dryer is heated with low temperature industrial waste heat at only 95 °C.

1. INTRODUCTION

Recycling and energy recovery from waste and biomass are more and more important in waste management as well as global energy supply. Recycling materials from waste are recovered increasingly by automatic sorting technologies for example by near infrared technology. The efficiency of these technologies increases significantly with better pre-treatment of the waste. The most effective pre-treatment for NIR is drying. Dry material is easier to sieve and wind shift and can be better separated by NIR. The collected recyclables are further cleaner, sanitized and with low odor emissions.

Dry stabilate technology has already shown that effective waste separation depends largely from the degree of drying i.e. the dry matter content. Biological drying is achieved by use of the intrinsic heat of the waste mixture in combination with forced ventilation and energy recirculation by means of a heat exchanger. The energy for drying is generated primarily by oxidation of organic substances contained in the waste based on micro-bacterial processes. Disadvantages of this method are a high volume of extracted airflow and a long retention period of 7 to 10 days for the waste to dry.

However, fractions with high calorific value from municipal solid waste and industrial waste contain not enough biogenous material for using this drying method. For these waste materials, high temperature industrial dryers with short retention time and high drying temperature are already in use.

High temperature dryers require mechanical treatment before drying. The material has to be shredded to a particle size of < 60 mm. The relatively small particle size makes recycling of the material extremely difficult. Furthermore, there is an increased fire hazard due to the high drying temperature. The exhaust air is cleaned by scrubber, bag filter and regenerative thermal oxidation (RTO). These dryers are often operated with natural gas for waste drying. Operating costs of drying already consist of about 50 % fuel costs alone - and increasing. Therefore, industrial waste heat instead of fossil fuel energy should be used for waste drying.

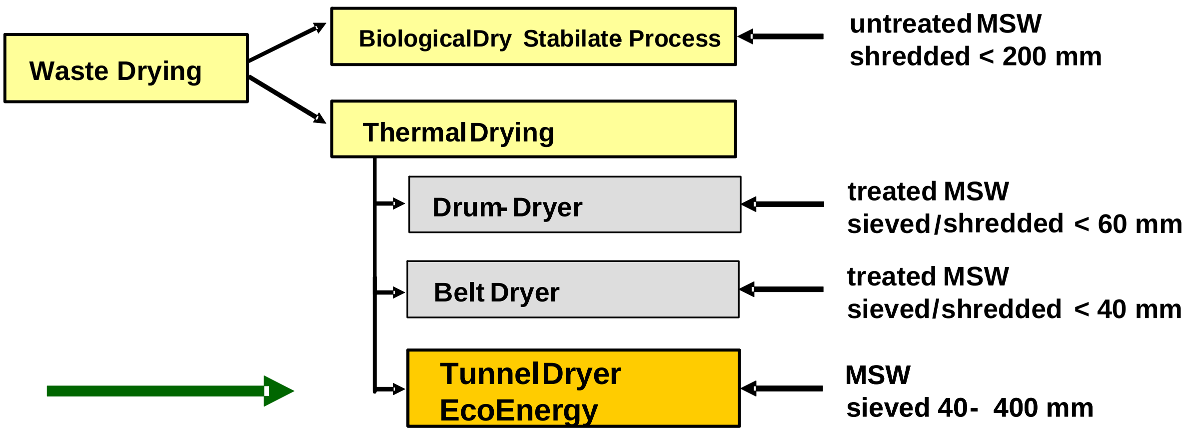

Figure 1. Waste drying technologies for different material

2. LOW TEMPERATURE TUNNEL DRYER

We propose a new process for low temperature drying of waste, using a waste adapted belt dryer with recirculating air. The dryer, heated with low temperature industrial waste heat, can process material with a particle size up to 400 mm.

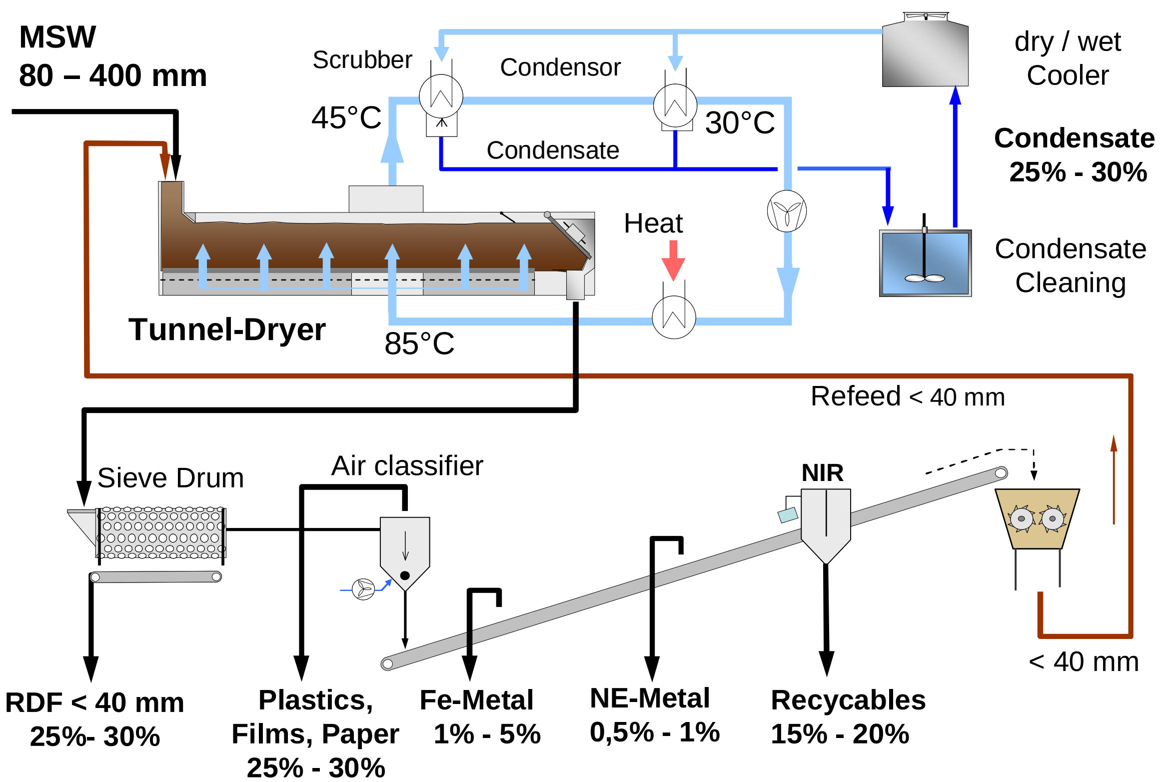

Figure 2. Process Flow of Low Temperature Tunnel Dryer

The drying air is recirculated, cooled down for condensation and reheated. The air is stripped of dust, pollutants and odors in the scrubber. The condensate/washing water is cleaned in a waste water treatment unit before use in the cooling tower. The recirculated air is reheated to a temperature of 85 °C , low enough to avoid fire hazard. The relatively low temperature level can easily be reached by using cheap industrial waste heat e.g. from CHP-units or other power plants.

Drying, charging and discharging are carried out automatically. After drying, the material is treated mechanically by sieving, air classification, metal separator and optical sorting. Consequently a recycled material of high quality and with high recovery rates is obtained.

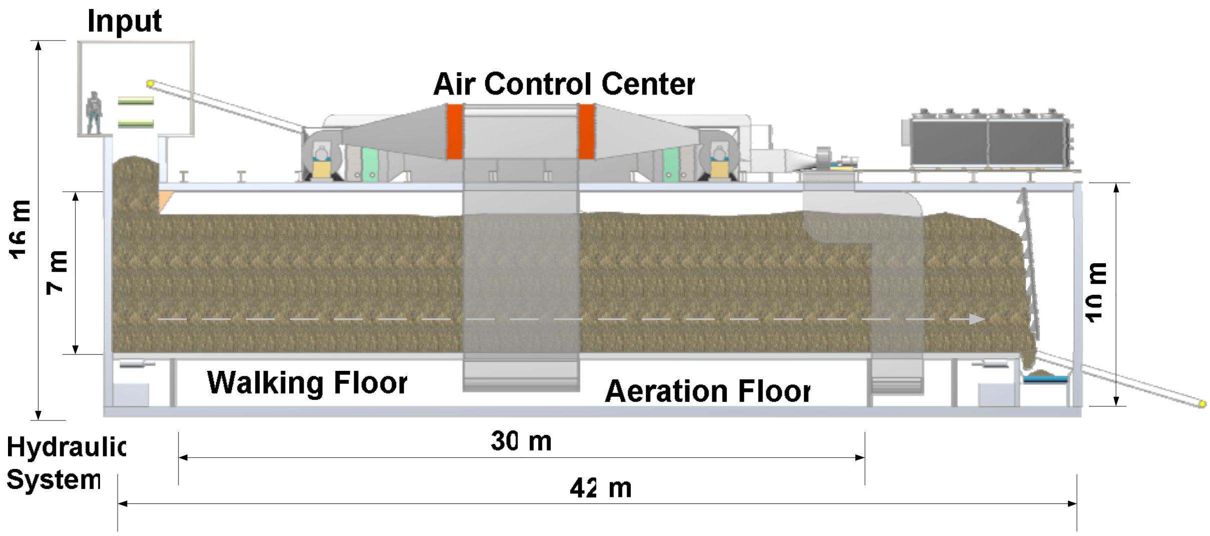

Figure 3. Cross sectional drawing of Low Temperature Tunnel Dryer

The material discharged from the dryer is sieved at 40 mm in a drum sieve. Material with particle size < 40 mm is discharged as refuse derived fuel (RDF). From the sieve overflow recyclables are collected by subsequent wind sifting, metal separation and optical sorting. The residual fraction is shredded to a particle size of < 40 mm, and recirculated into the tunnel dryer. Thus we improve separation by wind sifting and automatic sorting. Furthermore the recyclables as well as the RDF fraction have better storage properties because of dry stabilisation.

Further advantageous side effects to be named are a raising of the calorific value in the RDF fraction as well as adjusting a residual moisture content of around 8 % to 12%, which is beneficial for a subsequent pellet generation.

The circulating air for the drying process is preheated to temperatures of around 85° C. The use of lower temperature waste heat (< 100° C) reduces drying costs, which today already account for around 50% of the energy costs. At the same time, the safety requirements regarding fire and explosion risks in the possible presence of solvents can be met by remaining under the maximum surface temperatures.

The circulating air for drying has to be dehumidified and cooled down for reuse. The exhaust air is cooled by a two-level cooling system. The first level of the cooling takes place over air cooling and the second level over hybrid cooling.

The exhaust air is washed wet in the first stage of cooling in a spray condenser or spray washer and is cooled down to 40 °C to 45 °C (cooling limit temperature), depending on entry temperature. Thus the dust as well as pollutants and odorous substances, e.g. ammoniac and hydrogen sulphide, are washed out. The condensate/washing water of the first stage contains pollutants and must be treated according to effluent treatment requirements before discharge.

In the second stage of cooling, the circulating air gets into the condenser, which is constructed as a hybrid cooling tower. Here, the circulating air is cooled to less than 30 °C to 35 °C. The condensate is only slightly polluted and can be used as cooling water after wastewater treatment.

The cooled and dehumidified circulating air is once again heated up to a temperature of > 80 °C, so that waste heat at a temperature level of around 90 °C to 100 °C can be used. Should sufficient waste heat not be available, optional introduction of a heat pump is possible.

Because of circulating air cleaning, the dryer can also be operated largely without exhaust air, through which the exhaust emissions are considerably reduced in comparison to other drying techniques. Only a certain amount of leakage accounts for exhaust air quantities. In addition, the drying as well as charging and discharging of the tunnel dryer is carried out fully automatically so that dust and odour emissions are minimized and operation is possible with a minimum of personnel.

The tunnel dryer is charged over a funnel with moveable and reversible conveyor belts. While being fed in by the funnel feed system, the input material seals off the feed system. For discharge, the tunnel dryer features a discharge system with conveyor belt or scraper conveyance system and a swinging flap which is additionally provided with a winch system for regulated discharge. Simultaneously the flap serves as an airtight seal opposite the discharge system. This way, the incursion of leak air is minimised and the quantity of exhaust air considerably reduced accordingly.

The introduction of metering units for measuring out the discharged material allows further for an effective and extensive disruption-free operation of the further processing units.

The material is moved through the tunnel dryer with a walking floor system, which allows for mass flow of the material to be dried being pulled through the dryer. The height of the pile in the tunnel dryer comes to between 3 m and 6 m, depending on density. For adjustment of the height of the pile, a scraper can be installed arranged on the top side. Retention time for drying is about 8 hours.

2. DRYING AS KEY TECHNOLOGY FOR WASTE RECYCLING

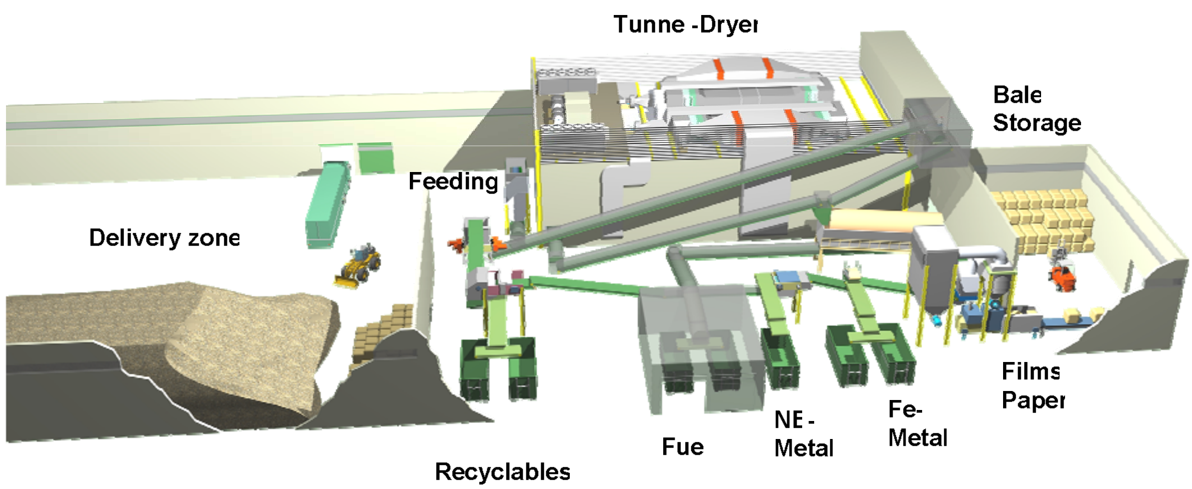

Figure 4. Low Temperature Tunnel Dryer as Key Technology for recycling

Low temperature drying is a precondition for high-value material recycling of the coarse fraction. A maximised material utilisation rate is possible through the further development of positive sorting with fully automated optical detection systems.

The sankey diagram below shows the mass- and energy-distribution for household waste sieve overflow > 80 mm (input). Recyclables represent only a mass percentage of only about 15 %, but the energy content of this fraction makes for one third of the whole input. The fraction paper/plastic film can be sorted by NIR into material recyclable paper and plastic fractions.

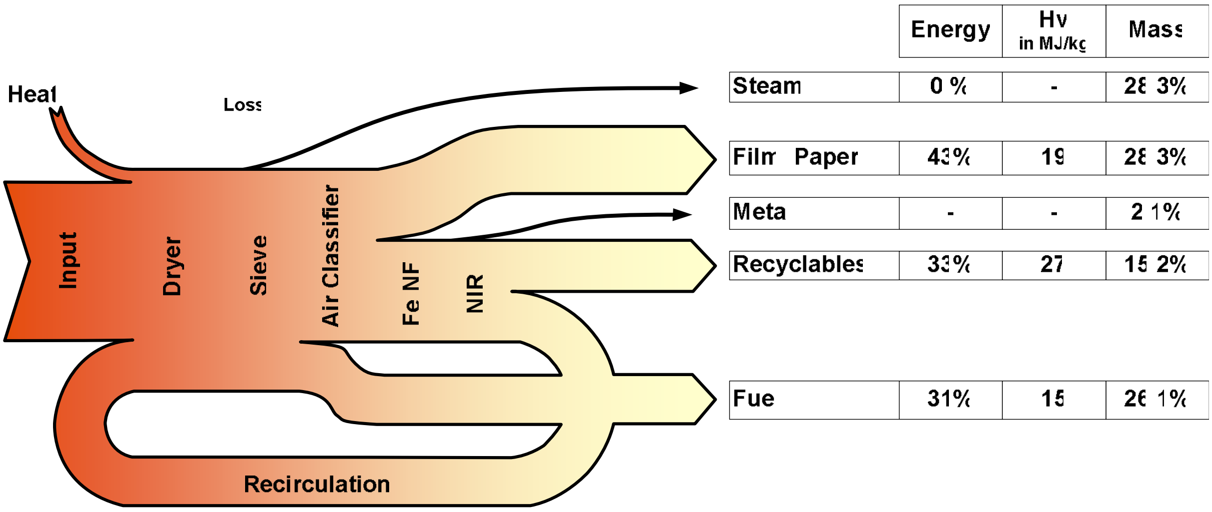

Figure 5. Sankey Diagram Low Temperature Tunnel Dryer

Energy recovery of material recycling is much higher than energy recovery by thermal waste treatment.

Production of 1 kg plastics consumes 1.8 l up to 2.3 l raw oil for raw material as well as for production energy. The heating value of raw oil is about 41 MJ/kg.

The following table shows the production energy consumption for a range of recyclable materials.

Table 1: Energy consumption for different packaging materials

Material	Total energy consumption (MJ/kg product)	Material	Total energy consumption (MJ/kg product)
LDPE Foil	91,81	Tin foil	35,79
HDPE Foil	99,80	Aluminum	193,27
PP Spraycast	118,84	White glass	12,74
PVC Foil	66,25	Corrugated board	19,82
PS (high impact)	91,81	Paper, cardboard	44,79
PET Bottle	101,44	Composites, paper based	55,80
PET Folie	109,19	Wood	17,67

In material recycling of plastics there is a further difference between chemical recycling as opposed to mechanical recycling. Most of the energy consumption for production of plastics is used for polymerisation and ploycondensation of monomers. Mechancal recycling preserves this structural energy.

In contrast, with chemical recycling of plastics 70 % to 90 % of procution energy is lost. Energetically it is therefore much more efficient, to try for mechanical recycling whenever possible.

However, material recycling requires a rather selective sorting technology to yield a contaminant free material. Automatic sorting by NIR can not detect recyclables with moist surface and adherent dirt. Pretreatment by washing and/or drying and adapted mechanical treatment is therefore crucial for a better detection rate and unmixed recycling products.

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