ODOUR GENERATION AND DUST IN BELT DRYING OF SEWAGE SLUDGE

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Abstract

Belt drying of sewage sludge results in odour generation in the exhaust air. Odourous components and the factors influencing their concentration in exhaust air are discussed. Different components contribute on different levels to the smell produced. Typical odour treatment units for belt dryers consisting of scrubbers and bio-filters are briefly presented. A sludge drying test unit that simulates belt drying of sludge and measures components in exhaust air is also presented.

Dust is also an issue in belt drying of sewage sludge. Extruding and back mixing of sludge before drying are briefly described and their advantages and disadvantages stipulated. With regard to safety, dust development has to be limited and deposits have to be removed to follow ATEX regulations and to avoid zoning inside the dryer. Good access of the belt dryer and heat exchangers for cleaning as well as extruding of sludge before and low mechanic stress during drying are key issues.

Key Words

accessibility of dryer and heat exchangers for cleaning, ATEX and safety, belt drying of sewage sludge, extrusion and back mixing, factors influencing dust development, odour components, simulation of belt drying and measurements of exhaust air components

Odour generation

This part will deal with the odour components which might be present in the exhaust air of belt dryers and the influencing factors affecting them. Figure 1 shows a typical arrangement of a two belt dryer with extruding of sewage sludge before entering dryer and a condensing line with integrated heat recovery. The exhaust air treatment is normally done by a two stage scrubber and a downstream bio-filter (HUBER SE 2012). Even if air temperatures are as low as 50°C, an exhaust air treatment will be necessary.

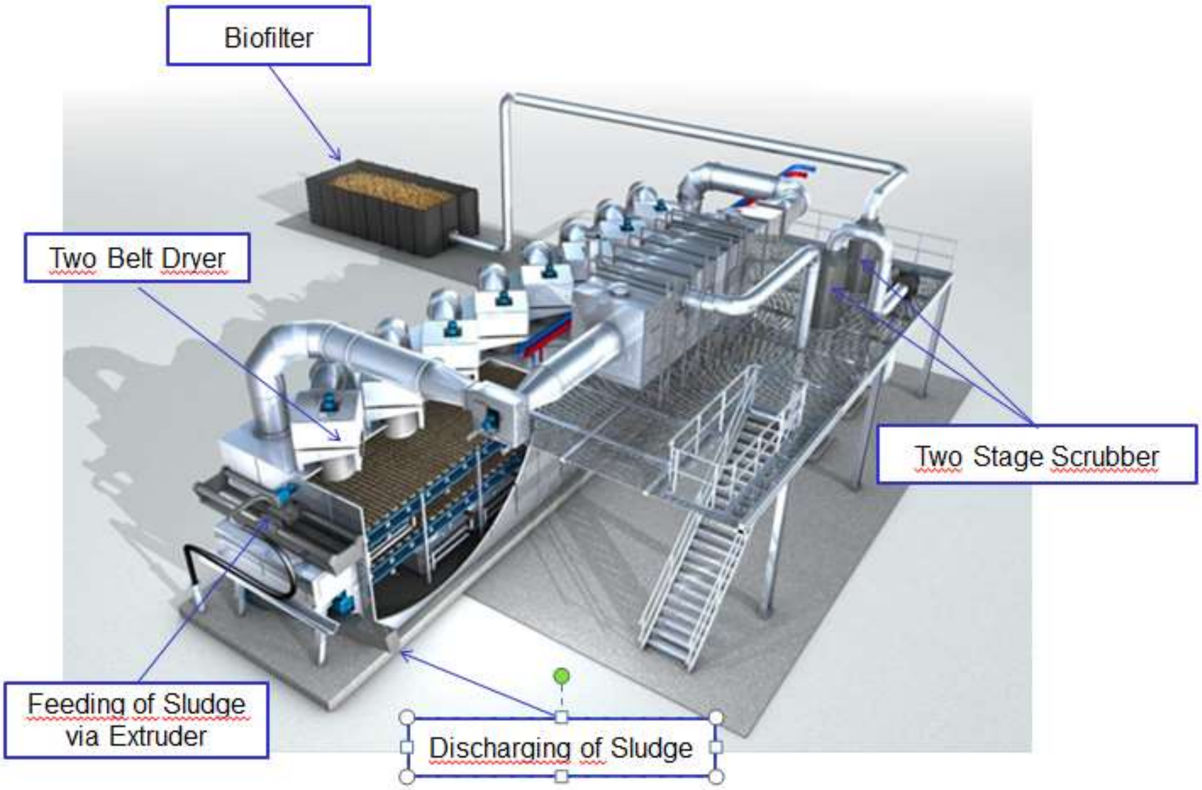

Figure 1: Two-belt dryer for sewage sludge with sludge extruder, condensing line and exhaust air treatment with a two-stage scrubber and a bio-filter (HUBER SE 2012).

The small exhaust air pipe starts at the condensing line and connects the scrubbers with the bio-filter.

The following odour generating components can be found in the dryer´s exhaust air, depending on kind of sludge and sources of waste water:

- Ammonia NH_3, stripped out of N-NH4-solutions in sludge
- Dimethylamine (DMA), Trimethylamine (TMA) $C_6H_{15}N$
- Hydrogen sulphide H_2S
- Methylmercaptan CH_3SH
- Dimethyldisulphide (DMDS) $(CH_3)_2S_2$, developing from H_2S and CH_3SH – reactions & Dimethyltrisulphide $(CH_3)_2S_3$

Further components like other acids and alcohols or volatile carbon components - in case of ventilated bunker for dewatered sludge and treated exhaust air of bunker – are encoutered. The maximum values of components and odor units in the exhaust air of a sewage sludge dryer is limited by local regulations. In Germany, the TA Luft specifies the limits for different components for sewage sludge dryers, which are shown in table 1 (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2002) together with typical loads of untreated exhaust air.

Table 1: limits of German TA Luft for odour units (ou) and gas components as well as typical loads

Odor units & Gas component	Limits	Typical load
Odor units	500 ou/Nm³	20.000 – 30.000 ou
Ammonia NH_3	20 mg/Nm³and 0,1kg/h	100-400 m³/h

Table 2: shows the types of smell certain components can produce and the detection thresholds (Fritz 1990), (Schön 1996), (Flury 1969)

gas component	Odor like	Odor threshold mg/m³ at 20°C	Rough Concentration equivalent to odor units as single odor carrying component (practical experience)
Ammonia NH_3	pigsty	3.55	30 mg/m³ = approx. 500 ou/m³
Hydrogen Sulphide H_2S	rotten egg	0,025	1 mg/m³ = approx. 500 ou/m³
Mercaptans	garlic and rotten cabbage	0,00004-0,0006	
Trimetyhamine	fish	0,005	
Dimetyhldisulphide	stinckhorn, skunkiness of milk	0,05	
Dimethyltrisulphide	rotten cabbage, sea	0,01	ou: odour unit

Table 3 indicates an example on how different components of exhaust air contribute to odour in dependence of their mass-concentration of odour developing components (Bouchy 2009).

Table 3: influence of different components of exhaust air on odour contribution (Bouchy 2009)

Gas component	Mass-%	Mean contribution to odor counts
Ammonia NH_3	89	Medium, f.ex. 13%
Hydrogen Sulphide H_2S	1	Low, f.ex. 3%
Methylmercaptan CH_3SH	3	High, f.ex. 50%
Trimethyamine TMA	< 4	Medium, f.ex. 18%

Factors influencing the development of odour components

Odour increasing in sludge drying with elevated

- Temperature of sludge - due to increase of Nitrogen and Sulfur- components in exhaust air with elevation of steam pressure
- pH-Value - due to increase of Nitrogen- components with elevation of pH
- Sludge composition – e.g. higher portion of industrial waste water with high protein (ammonia development) and fat contents (sulfur components development)
- Sludge history – e.g. method of transport or dewatering due to destruction of cell walls caused by high pressure or shear forces and increase of organic acids at high Dry Solids (DS) contents
- Sludge storage time - due to increase of Nitrogen- and Sulfur- components with prolonged storage time

Critical odourous sludges with regard to ingredients and history of processing are:

- non-digested, unsufficiently stabilized sludge => higher loads of NH_3
- Unsufficiently digested sludge and pH < 6,5 => higher odor loads caused by acids
- high pH-Value of sludge > 7,5 => higher loads of NH_3
- High portion of waste water from leather, paper, food industries (protein and fat), starch industry (protein), oilseed rape and soya industry (sulfur) or slaughterhouses (protein, sulfur, fat) => higher loads of NH_3, H_2S, CH_3SH
- Hydrolyzed sludge => higher loads of H_2S and CH_3SH
- Sludge with long anaerobic storage conditions => higher loads of H_2S

Test unit measurements of exhaust air components

Exhaust air measurements have been undertaken on a small experimental dryer simulating the conditions of belt drying of sewage sludge. Analysis of exhaust air components was executed with FID-detector. GC-determination of some components was done from bagged samples (figure 2).

Figure 2: Testing of exhaust air from a small experimental dryer (HUBER SE 2012)

The dewatered sludge originated from a digester with high content of co-substrate from a chicken processing plant. The DS content of dewatered sludge 29.7%. The dewatered sludge stored for 3 weeks. The DS content of dried sludge was 92.7%. The drying temperature of air was 125°C. The loss on ignition was 54.1% (ODS), whereas the fat content was 6.4 g / 100 g DS. The protein content was 31.6 g / 100 g DS and the sulfur content was 1.27 g/ 100 g DS. The following transfer to air related to one kg Organic Dry Substance could be observed:

- Ammonia: approx. 113.2 g / kg ODS or averaged 424 mg/Nm³ air
- Mercaptans total: approx. 2.7 g / kg ODS
- Dimethyldisulfide: approx. 78 mg / kg ODS
- Dimethyltrisulfide: approx. 38 mg/ kg ODS

Simulated drying of sludge with a high portion of Co-Substrate from Chicken processing – having high protein and fat contents - resulted in a higher transfer of ammonia and mercaptans into the exhaust air. This is only one observation valid for a specific sludge under the indicated conditions. Further research has to be done to be able to predict the relationship between sludge analysis and air borne pollutants in dependence of drying parameters in future.

Typical arrangement of exhaust air treatment of belt drying

Figure 3 shows a belt drying line of sewage sludge with all peripheral machines for sludge conveying, energy supply and exhaust air treatment (HUBER SE 2012).

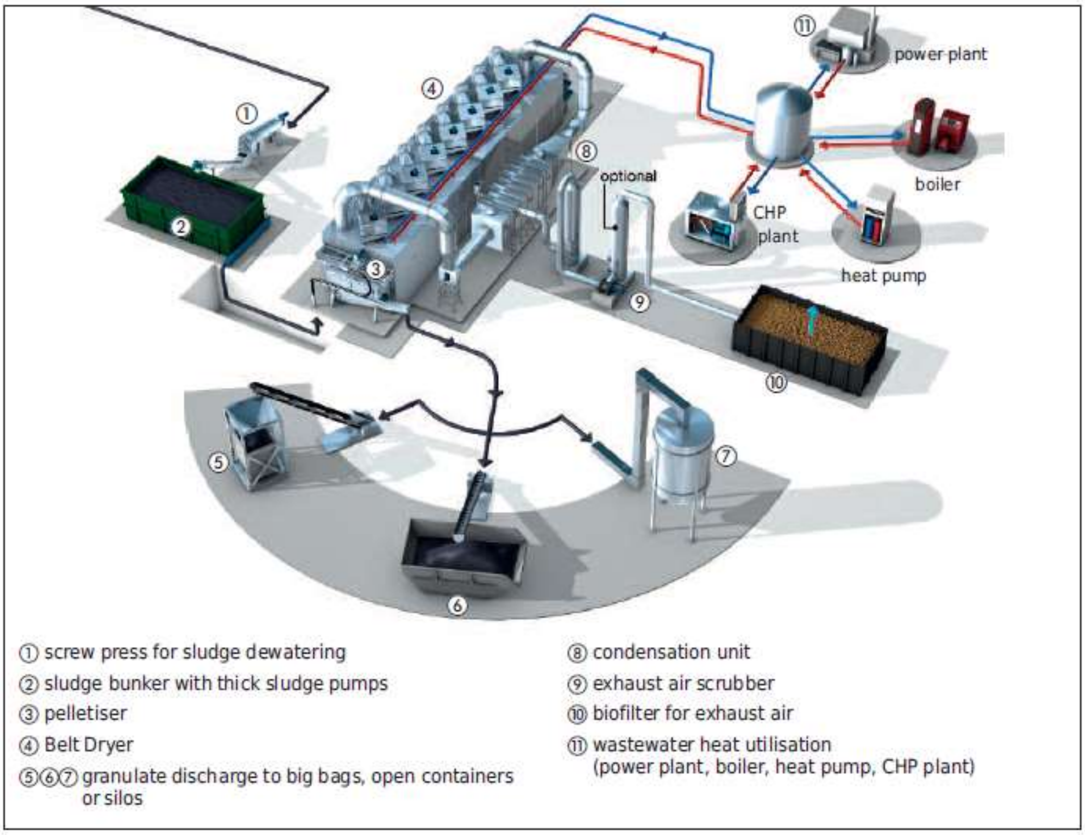

Figure 3: **complete belt drying line sewage sludge with peripheral machines (HUBER SE 2012)**

Figures 4 and 5 show an indoor two – stage scrubber and an outdoor bio-filter for belt dryers.

Figure 4: Indoor two stage scrubber

Figure 5: Outdoor bio-filter with wood – chips in open plastic tank

Dust in Belt Drying of Sludge

Methods for preparing sludge for belt drying

There are two systems in preparing sludge for belt drying: extruding and back – mixing. Extrusion is where pellets or compressed "noodles" of 8 to 13 mm diameter are produced, which are evenly spread across the width of the belt. This system gives for the following advantages:

- low dust formation due to compressed form,
- even drying of "noodle" surfaces,
- Lower air resistance.

Its main disadvantage is that the sludge has to be suitable for pellet forming. Usually 9 of 10 sludge varieties can be pelletized. Figure 6 shows an extruder or pelletizer forming sludge "noodles".

Figure 6: **Extruder forming pellet strains**

Back – mixing of a portion of dried sludge to dewatered sludge is done to get a feeding DS content of approx. 60%. Figure 7 shows a principal back – mixing system arrangement together with a two belt dryer for sludge. Thus, problems with the sticky phase of the sludge can be avoided. Its main advantage is:

- high flexibility with regard to sludge characteristics (e.g. thixotropic behavior or initial DS)

However also some disadvantages have to be considered:

- Higher investment,
- Higher electric energy demand,
- higher wear in mixing line,
- more dust development in dryer and higher demand for cleaning.

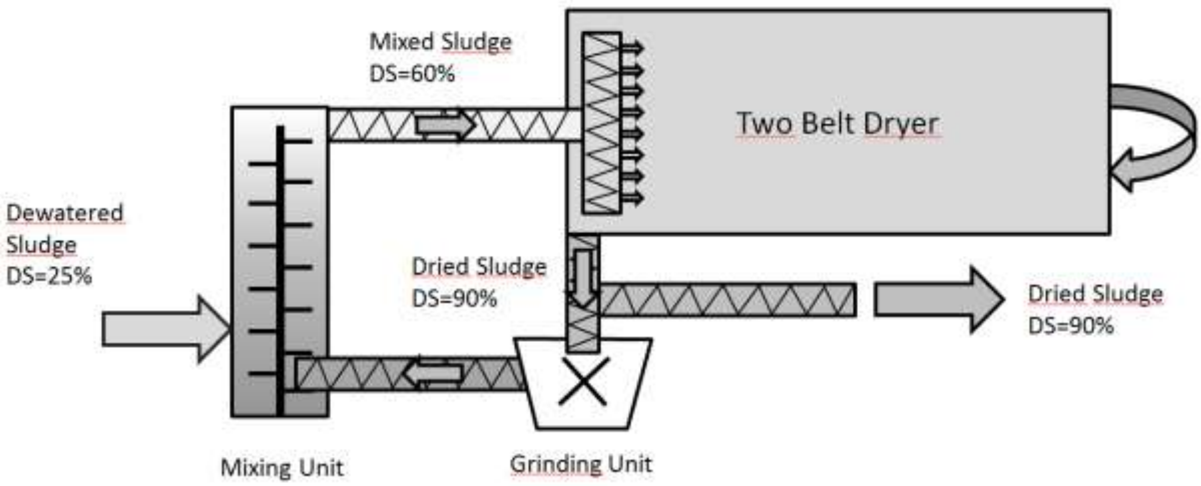

Figure 7: **Back-mixing arrangement for the drying sewage sludge**

Dust and ATEX

A Dust explosion requires an ignition source plus a minimum dust concentration and oxygen. There will be no explosion, if one of these conditions is missing.

The minimum dust concentration for sewage sludge is approx. 60 g/m³ air - you can hardly see a 40 W light bulb in a 2 m distance if such a dust concentration is present in the air. Dust concentrations in belt dryers are far below these values, typically far below 20 mg/m³ in the case of sludge extrusion before drying. Therefore, there is a high safety of more than 3,000 with regard to dust concentration.

ATEX regulations specify maximum allowable temperatures: the maximum temperature has to be smaller than

- 2/3 of the MIT (minimum ignition temperature of a dust cloud), which is 360 to 510°C for most sewage sludge dusts

and

- 75 K below the LIT (layer ignition temperature of a 5 mm dust layer), which is 220 to 260°C for most sewage sludge dusts (BGIA 2012).

The lowest resulting temperature has to be chosen. Assuming that the maximum surface temperature is 145°C, there is sufficient safety with regard to ignition source. As ignition source and dust concentration miss, there will be no danger of explosion and as a consequence no zoning inside the dryer.

However, the monitoring and removal of dust layers in dryer is essential!

Therefore:

- Good access to the dryer via big doors and openings is essential for cleaning.
- Fin space distance of heat exchangers has to be large enough for quick and easy cleaning with high pressure water.
- The depths of heat exchangers have to be limited and enough space between heat exchangers has to be provided for cleaning actions.
- Direct spray washing can be used alternatively in condensing lines.

Dust deposits have to be avoided and removed. Therefore:

- Pellet forming of sludge is recommended to limit dust development in dryer,
- Regular removal of dust deposits is a must,
- high pressure water spraying device for belt cleaning is recommended for sludge varieties with a high portion of silt (grain size < 63 µm)
- Good access to the dryer and heat exchangers is necessary with regard to dryer cleaning,
- Only low levels of mechanical stress on the sludge in the dryer should be applied (e.g. two belt dryer with one transfer station).

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