Recovery of Industrial Waste Heat for Faecal Sludge Drying

Use of waste heat from industries could enhance the faecal sludge drying process and minimise the treatment footprint.

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In Africa and Asia, 65–100 % of urban residents use on-site sanitation systems, such as septic tanks or latrines [1]. These systems are typically emptied with suction trucks or by manual labour. Faecal sludge (FS) is most commonly dumped directly into the environment or disposed of in a treatment plant if one is available. This practice has its origin in the common perception that FS is a waste product without any value. Yet, faecal sludge not only contains nutrients (N, P, K) for use as agricultural fertilisers, but it can also replace fossil fuel to produce heat in industrial processes.

Alternative fuel used in the cement industry

Use of alternative fuel in industrial kilns and boilers is a recent trend driven by increasing fossil fuel costs. Alternative fuels, such as tires, animal meal, sewage sludge, and waste oil have to meet certain criteria, not only as regards their energy potential, but also their physical characteristics. Solid fuels are, for example, most often fed into kilns by airflows and, therefore, require a minimum degree of dryness (≥90 % DM). FS passively dried on filter beds can achieve a dryness of 60–80 % [2] and would need to undergo an additional drying process. A possible option for an energy efficient approach to eliminate excess moisture is the use of waste heat from the clinker production process in cement factories. The SPLASH-funded FaME project (www.sandec.ch/fame) aims at evaluating the waste heat recovery potential from a cement factory in Dakar, Senegal.

Clinker production process

In a typical dry rotary kiln system (Fig. 1), raw material (e.g. crushed limestone, iron, silica) is preheated and precalcined (i.e. $CaCO_3$ decomposed to CaO and CO_2) before it is fed into the kiln. The rotary kiln itself is a lined tube of max. 6 m in diameter generating a temperature of ~1 500 °C. It is generally inclined at a 3–3.5° angle and rotates 1–2 times per minute.

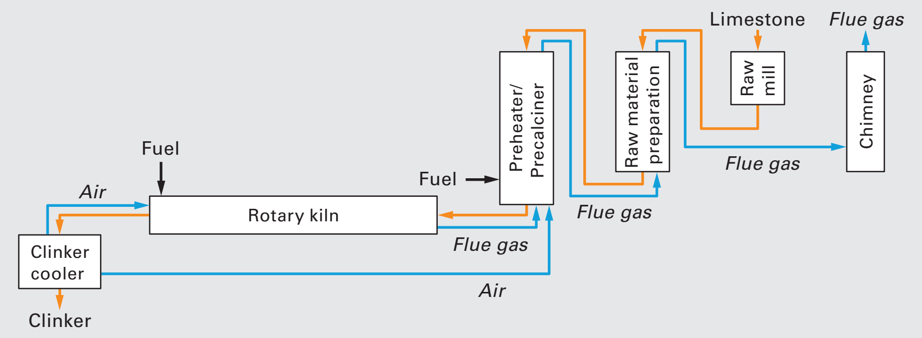

Figure 1: Overview of the clinker production process.

Waste heat recovery and reuse

Two sources of waste heat are generally available in a clinker production line: i) recovery of hot gases and ii) radiant heat loss from the kiln's surface. In this case, the flue gas from the kiln was already used directly in the preheater and for drying the raw material, leaving the flue gas from the chimney as the only hot gas stream available for recovery. The temperature of the flue gas amounts to 115–140 °C and the airflow stream to 450 000–500 000 Nm^3/h. Its heat transfer rate is 2.8 MW, which would be sufficient to evaporate 2.5–3.1 tons of water per hour. In Dakar, 6 000 m^3 of faecal sludge (DM 0.4 %) is collected daily. If the faecal sludge is dewatered on filter beds to 80 % solids content, the waste heat could be harnessed to achieve a 90 % dry solids content, resulting in 26.7 tons of dried faecal sludge. The flue gas heat recovery technology has already been successfully implemented in drying sewage sludge in Jiangyin, China [3], where some 100 tons of sewage sludge are dried daily to < 30 % moisture content. Use of the radiant heat loss from the rotary kiln has also been suggested recently as an energy recovery method. Up to 15 % of total energy input is lost through radiation and convection from the kiln surface [4]. High investment costs and limited access to the rotary shell for monitoring and maintenance of the heavy new equipment are major obstacles to the implementation of this technology.

Logistics considerations

Transport costs are a key factor in FS management, as the water weight involved is extremely costly to transport. Besides the energy potential of the waste heat, the economic feasibility of waste heat recovery for FS drying is therefore also determined by site specific and logistic FS transport factors.

A combination of the two waste sources – FS and waste heat – can create an alternative to industrial fossil fuel use. This valorisation process will enhance motivation of FS collection and alleviate the financial pressure on households.

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