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NEWSLETTER

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Wastes as alternative fuels in the cement industry

Co-processing of alternative fuels as a solution which is technically sound and environmentally friendly

The plastic industry today produces 322 million tonnes of plastic (2015) worldwide on an annual basis. Plastic production in Europe is approximately 60 million tonnes. A good part of this volume is used in the packaging industry, and for various reasons approximately 3 million tonnes per year ends up in the sea and an unknown amount in the soil. It is estimated that this number will increase to approximately an estimated 40 million tonnes per year by 2025.

For several reasons only a limited percentage of the plastic waste can be recycled. Although recycling is without doubt the preferred solution, considerable development will still be necessary in order to make the recycling of larger quantities of plastic possible. The need for technical recycling options, but also the lack of collecting methods drive huge quantities of plastic to landfill deposits. Some European states force incineration by limiting the calorific value for deposited materials.

Of the 60 million tonnes of plastic produced in Europe in 2016, 27.1 million tonnes of plastic waste was collected. 10.6 million tonnes (39 %) went to power generation, 8.1 million tonnes (30 %) to recycling, and 8.4 million tonnes (31 %) to landfill.

The total production volume on one hand, and the materials used and the waste streams on the other hand are not balanced. The problem is that too much material finds its way uncontrolled into the natural environment. This "leakage" is currently poorly documented and studied, but will require much more attention in the future. A higher degree of collection and recycling of this material is definitely needed to reduce the consumption of fossil fuels and to protect our oceans and open land. But since the degree of recycling is limited for quality reasons, the co-processing of plastic wastes as alternative fuel in the cement industry remains the preferred answer.

Cement industry as a solution

Of particular relevance today against the background of movements such as "Turn the Tide on Plastic", the cement and power sectors are two of the few industries which consume used plastic, and this utilisation process can certainly be used as a solution until the overall amount of plastic waste is reduced and/or better recycling methods have been developed.

Many of the alternative fuels and raw materials being used in cement kilns provide synergies between the cement industry and other industries and communities. Primary fuels are saved on the side of the cement industry and the waste streams to the landfills are reduced, which in turn helps communities.

Cement kilns are ideal for utilising plastic and other waste streams since the ashes or the impurities of the waste materials in general are mineral components which are then used in the mineralogy of the cement clinker. In addition, the cement kilns have many control devices which ensure that the waste fuels are burned without creating an increase in environmentally-relevant emissions.

Within the EU, only Austria and Germany have maximum calorific limits for materials which go to waste landfill. Both countries have relatively high rates of substituting fossil fuels by alternative ones in their cement industries: with 70 % for Austria and 65 % for Germany. If all EU plants could be raised to the 70 %-level, an additional 10–12 million tonnes of waste – including plastic waste – could substitute regular fuels (mainly coal and petcoke) in the cement industry. This would significantly lower the amount of plastic materials going to landfill.

Modern equipment for adding fuel to the kiln is necessary, but also a continuous supply of waste materials, as the raw meal has to be adjusted to the chemistry of the ash of the alternative fuels. Alternative fuels – often called refuse-derived fuels (RDF) – are "designer" fuels which are prepared in recycling plants and have designed heat values and a chemistry which is required by the cement plants.

The waste material arrives at the cement plant in covered trucks and is usually stored in covered storage halls or silos. In order to feed the RDF to the kiln, high-quality feeding and dosing equipment is required, and in some cases even a drying process is beneficial to stabilise the thermal input and increase the burnability of the waste fuels. The dried fuels are advantageous for reducing the fuel consumption of the kiln system, but also for reducing kiln exit gas volumes which influence the power consumption of the kiln system.

Burning RDF and other waste fuels in the calciner is easier with modern equipment, like for example the Pyrostep (TKIS, Polysius), Hot Disk (FLS), and Fire Bed Combustor (IKN). With this equipment higher investment is needed but lower and coarser fuel qualities can be fed, which helps create savings on the costly size reduction process of waste streams.

Co-processing alternative fuels in the main burner is however more chal-

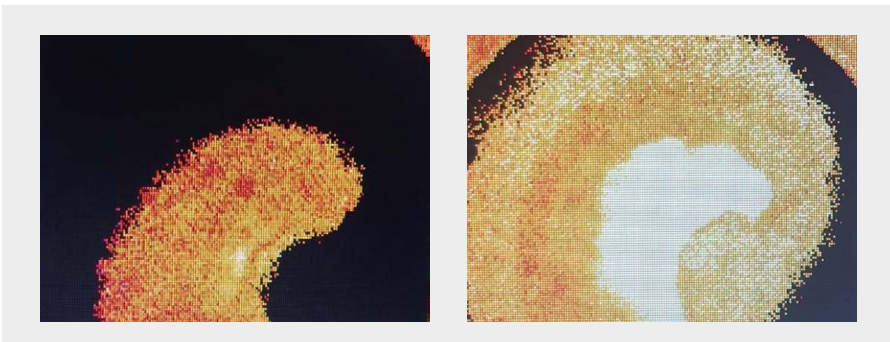

Figure 1: The flame of a main burner which was optimized to allow a high degree of alternative fuels utilisation. The digitised pictures show the flame before and after optimisation.

lenging, and normally fuels with higher heat values are required in order to stabilise the flame. Even with modern high-momentum burners which are used to burn alternative fuels, it is not unusual that only very small amounts of alternative fuels can be used at the main burner. In this case the burners must be trimmed so that fuels can ignite in a way which allows the heat to be released in a short time at one point. Optical thermo cameras can be used for a thermo scan of the flame. With this method the flame can be adjusted in order to optimise the combustion process and create a single peak flame temperature. **Fig. 1** shows the digitised image of a flame that has been optimised in order to allow high substitution rates for alternative fuels.

Conclusion

Co-processing waste fuels in cement kilns is a very challenging task, and major investments are needed to ensure that it is environmentally safe and that at the same time product quality remains unchanged. There are ongoing challenges which need to be mastered. The cement industry cannot help reduce waste streams, but it can at least utilise the waste in an environmentally friendly manner until better solutions are found to reduce their generation.

New emission abatement techniques to comply with ambitious limit values

Secondary measures for the reduction of NO_x and organic compounds gain in importance

The European Industrial Emissions Directive (IED) is the most important legal regulation for industrial plants in the field of air pollution control and applies also to cement plants co-processing waste. The stipulated emission limit values should be consistent with the achievable emission levels which are specified in the BREF Document (Best Available Techniques Reference Document) for the cement industry. However, several European countries have set stricter emission limit values which require the installation of high-effective abatement techniques for certain air pollutants. This applies especially to the components NO_x and NH_3, but in the meantime also TOC and CO are being looked at more critically. This has led to the installation of the first multi-component abatement technologies in the European cement industry.

The clinker burning process requires very high temperatures in the rotary kiln which leads to significant emissions of nitrogen oxides (NO_x). Therefore, most rotary cement kilns have to apply NO_x reduction measures to meet the individual emission limit values for NO_x. The BREF Document for the cement industry gives an overview of the Best Available Techniques for NO_x reduction and has specified a range from 450 to < 200 mg/m^3 as a so-called achievable emission level (AEL) which can be met if the associated abatement techniques are applied. In line with this, the European IED has set a NO_x emission limit value of 500 mg/m^3 (daily average, 10 % O_2) for cement kilns.

Secondary measures for NO_x reduction

The most powerful secondary measures for NO_x reduction are the SNCR (selective non-catalytic reduction) and SCR (selective catalytic reduction) processes. Since the end of the 1980s, the SNCR process has been installed at many cement kilns worldwide and is state-of the-art in the cement industry. The associated specific costs for the SNCR process are moderate. Depending on the initial NO_x concentration, it is possible to achieve a NO_x level below 500 mg/m^3 and to meet the European emission limit value.

In contrast to this, the SCR process was not state-of-the-art in the cement industry when the current version of the BREF Document was developed. Nevertheless, stricter NO_x emission limit values have been stipulated in certain European countries, and certain local circumstances have led to the requirement of improved NO_x reduction. To gain more operational experience, demonstration projects with the SCR process have been carried out and first full-scale SCR plants have been installed in Germany, Italy and Austria. Both the high-dust and the tail-end version of the SCR process have been tested within the framework of these projects and also the so-called semi-dust process in an additional specific case. The available results show that NO_x emission levels below 200 mg/m^3 can be met with the SCR process (lower end of the BAT-AEL).

Relevance of NH_3 emissions

For the selection of a NO_x reduction process, the permissible level of ammonia emissions plays a significant role. When the SNCR process is applied, emissions of unreacted ammonia (NH_3 slip) can occur when the reducing agent is injected in overstochiometric amounts and when the raw mill is off (direct operation). In contrast to this, catalytic reduction (SCR) allows an almost stoichiometric reaction between NO and NH_3 which results in only a very low NH_3 slip.

Although the European IED does not include an emission limit value for NH_3, there are certain European countries which have specified an emission limit value of 30 mg/m^3 which is also valid for cement plants. Furthermore, the European Directive on National Emission Ceilings (NEC) plays a significant role as several countries are exceeding their individual national emission limitation for NH_3. This requires measures for the reduction of NH_3 in all relevant sectors and leads inevitably to the installation of SCR or other similar processes.

The special German requirements (emission limit value for NO_x: 200 mg/m^3; for NH_3: 30 mg/m^3) have resulted in the fact that in the meantime nine SCR plants are in operation and more will be commissioned in the near future. Both the high-dust and the tail-end version have been installed. Additional experiences are

Source: SCHWENK Zement KG

Figure 1: DeCONOx plant in a German cement works

available from an Austrian cement plant where the so-called semi-dust process is applied.

TOC and CO abatement

In addition to the further development of the standard SCR process, other emission abatement technologies have emerged which can reduce not only the NO_x and NH_3 emissions but also other flue gas components. The operational experiences from the SCR projects have shown that organic compounds are also decomposed at the catalyst material but not short-chain hydrocarbons (C_1, C_2). Furthermore, the DeNOx catalyst does not affect the CO concentration.

Therefore, other multi-component abatement technologies have been developed to achieve not only a NO_x reduction, but also a significant TOC and CO reduction. The DeCONOx process (see **Fig. 1**), which was invented by the Austrian equipment supplier SCHEUCH, is a combination of a tail-end-SCR and a thermal post-combustion of organic pollutants and CO. First operational experiences have successfully been gained in cement plants in Austria and Germany.

In any case, the competent authorities have the option to grant derogations for the emission limit value. For CO, the IED does not include a specific limit value, but only the requirement for the authorities to set a concrete individual value. However, the conditions in the combustion chamber of a DeCONOx plant result in an effective burn-out of CO and the achievement of very low emission levels.

In addition, other catalytic NO_x reduction technologies like the AutoNOx process (developed by CTP – See **Fig. 2**) and the CataFlex process (FLSmidth) with catalytic filter bags are being investigated in the cement industry and will become more important in the coming years.

Source: OPTERRA/CTP

Figure 2: First AutoNOx plant in a German cement works

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