Effect of waste derived fuels (SRF/RDF) composition on the cement industry environmental footprint

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EXTENDED ABSTRACT

Introduction

A solution to decreasing CO_2 emissions and waste landfilling is to replace conventional fossil fuels with alternative solid fuels (ASFs), such as RDF/SRF, derived from the effective residues' valorization of the municipal solid wastes management processes. Towards sustainable development, the cement industry can contribute to environmental protection by lowering its footprint via the effective use of ASFs. This paper studies the optimum application of RDF/SRF as an ASF in cement kilns co-processed with conventional fuels. Following this energy valorisation approach for ASFs, various toxic pollutants compounds, including HCl, HF, CO, NO_x, SO_x, PCBs, PAHs, PCDD/Fs (dioxins and furans) and heavy metals, are expected to be generated. Dioxins - furans (PCDD/Fs) and polychlorinated biphenyls (PCBs) are combustion by-products resulting from surface-catalyzed reactions of the chlorine-containing compounds. ASFs, following appropriate specifications, can be effectively incorporated in the cement production, thus covering both the high-energy requirements of the process and contributing to reducing its environmental impact. Following this approach, the goal for the drastic reduction of the landfilled wastes can be finally realized.

Keywords: *SRF, RDF, chlorine content, cement furnace, environmental impact*

Methodology

The effective co-processing of ASFs in the cement process is a promising valorisation approach (Samolada and Zabaniotou, 2014), especially if it contributes positively or at least reduces its emissions. To this respect, experimental data from various studies were collected. The ASF composition (e.g. Chlorine content) was tried to be correlated with the cement furnace dangerous emissions, including PCDD/Fs (dioxins and furans). Chlorine was found to act as a precursor in the production of these environmental harmful compounds (Conesa et al., 2011). Thus, an attempt was made to find out the appropriate ASF specifications resulting in low emission levels. The currently adopted limit for the total equivalent concentration of PCDD/Fs from combustion plants is 0.1 ng/Nm^3, while the limit for PCBs is 50 ppm. Considering a value of 498.6 g/mol for the molecular weight of decachlorobiphenyl, the limit value for PCBs was estimated to be 0.10 μg/ Nm^3. The chlorine content of the ASF was thus tried to be correlated with amount of the pollutants production, based on already reported literature data.

Results and Discussion

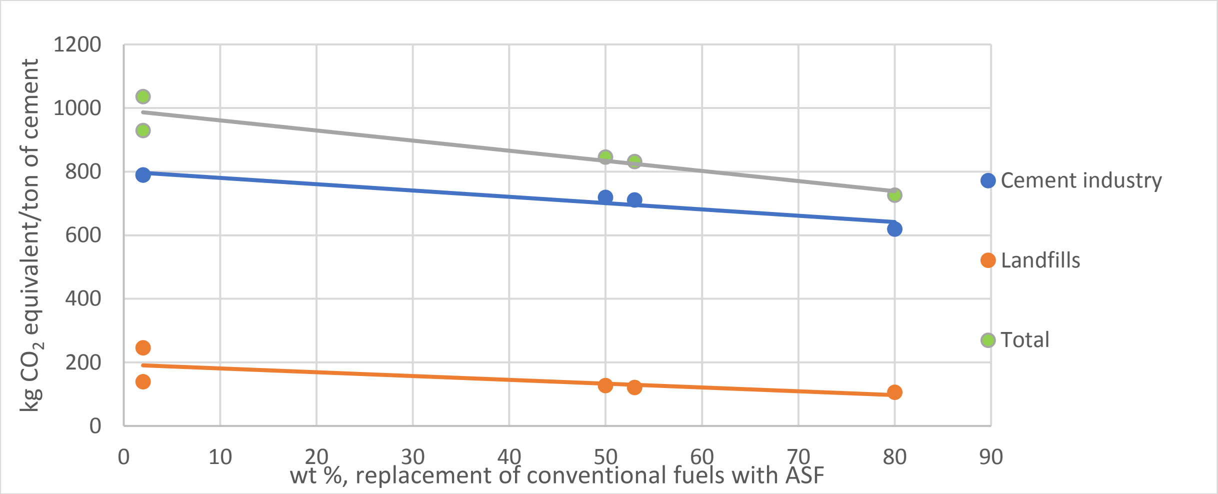
It was found that the experimental data reported for the emissions of PCDD/Fs and PCBs follow an exponential correlation with the ASF chlorine content (Table 1). A chlorine content of 0.078 wt. % found to satisfy the legal emission limits for these pollutant compounds.

Table 1: Effect of Cl content of ASFs on Pollutants (PCDD/Fs, PCBs) Concentration

Pollutant Concentration	**Equation**	**Cl content (wt %)**	
		Equation	Literature
PCDD/Fs (ng/Nm^3)	$[PCDD/Fs] = 0{,}1052 * e^{1.3927[Cl]}$	0.086	< 0.2
PCBs (μg/Nm^3)	$[PCBz] = 0{,}0646 * e^{1.6493[Cl]}$	0.078	< 0.2
Optimum concentration value		0.078	

Moreover, a correlation of the environmental footprint of cement industry was also derived and found to be reverse proportional with the fraction of the effective replacement of fossil fuels (Figure 1). It was found that replacement of conventional fuels with ASFs (RDF/SRF) results in the reduction of greenhouse gases (CO_2 equivalent), compared to the current use of fossil energy sources (pet coke) in the cement industry. This also has a positive impact on the environmental footprint of landfills, by reducing the amounts of final ash ending there. The main characteristics of an ASF for an environmentally acceptable performance of a cement furnace, as also reported in various literature sources (CSI, 2005, Kahawalage, 2022), can be summarised to the following: size ≤10mm, LHV≥ 14 MJ/kg, Cl ≤0.2 wt. %, S≤ 2.5 wt. %, Ash ≤ 30 wt. %, Moisture ≤ 35 wt % and Heavy Metals ≤ 2500 ppm.

Figure 1: Effect of ASFs replacement (%) on CO_2 equivalent emissions (kg CO_2/per ton of cement) [Reported data: García-Gusano et al. (2015), Khan et al. (2021)]



Conclusions

As the technology of utilizing alternative fuels requires continuous further research, it is important that the necessary limitations of the use of alternative fuels are determined, so that an effort can be made to address them. ASFs can play an important role with the effective substitution of fossil fuels. Moreover, ASFs with appropriate specifications (e.g SRF), can be effectively incorporated into the cement production, thus meeting both the high energy requirements of the process and the improvement of its environmental impact. Following this energy valorisation of ASFs, the goal towards almost zero amounts of landfilling wastes can be finally realized.

Literature

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