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Exergy analysis for aluminothermic processing of waste materials

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Abstract

The analysis of material and energy balance can be done using concept of exergy, which is a measure of available energy in the system [1]. Exergy losses indicate the place of degradation in the process; thus, it implies improving of selected process.

The aluminothermic reduction process is an attractive method for immobilization of hazardous waste, and for utilization of valuable elements from the waste [2]. The exergy calculation relies on the material and energy balance calculation and standard chemical exergy of the elements. For the purpose of material, energy, and exergy balance calculation discrete non-commercial software was developed [3]. The waste materials used in these calculations are Electric-arc furnace dust (EAFD, mostly Fe and Zn oxides) and the Mill scale (mostly Fe oxides) [4].

Calculated exergy efficiency for aluminothermic processing of waste was 94.6%. All the heat released by exothermic reactions was used for producing the iron, the slag and the crude ZnO dust. Comparing to the conventional carbothermic reduction process in the DC electric-arc furnace with the same materials (for which exergy efficiency was 56.5%) this is much higher. The irreversible exergy losses of the aluminothermic process are 398.2 kWh/t of produced iron. The further processing of slag and dust is required, as well as in the case of the carbothermic reduction process, so that the real value of exergy efficiency of the process will be somewhat lower than the calculated.

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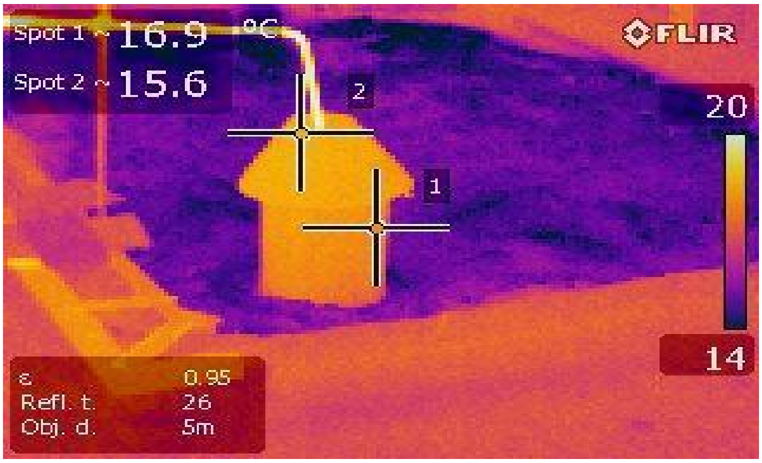

a)

Input stream	***B_h***				
	B_{el}			$\sum_i n_i \Delta G^\circ_{f,i}$	
	EAFD	Al	Mill Scale		
	2398,7	4660,1	2692,3	-2443,2	
	Σ = 7307,9				
Output stream	***B_h***				ΔH_{un} ΔH_{un}[1]
					-1838,3
	B_{el}			$\sum_i n_i \Delta G^\circ_{f,i}$	ΔG_{un}
	Iron	Slag	Dust[2]		-1633,5
	2171,8	6717,1	836,4	-4449,1	$\boldsymbol{\Delta G_{uk}}$
	Σ = 5276,2				Σ =-1633,5
	Σ = 6909,7				

[1] Heat released by aluminothermic reactions; [2] Crude ZnO

b)

a) Set-up of the laboratory aluminothermic reaction process, followed by thermal imaging camera; b) Exergy balance for aluminothermic processing of waste

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