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Sustainability evaluation of a typical cement production chain in China – An emergy perspective

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Abstract

Cement production has drawn great attention on account of its high consumption and emission during its production process, which impeded system sustainable development. It has been a hot issue to assess the potential effect of environmental emissions and optimizes the production process. In this paper, emergy analysis is conducted to quantify the quality and hierarchy of the resources, products and services and calculate the eco-environmental supports and socioeconomic investments for integrated ecological economic assessment from perspective of ecological economic system. Meanwhile, regarding production process, socio-economic system and ecological economic system, carbide slag substitution scenario, maize straw fuel substitution scenario, and waste heat recovery scenario are respectively set up to account the resource conversion and recycling utilization efficiencies with comparison to baseline, thus quantifying the energy conservation and emission mitigation effects for cement industry. Finally, oriented to the emergy-based sustainability indicator, the ternary emergetic diagram will be conducted to identify the optimization allocation mode of various ecological elements during the cement production process and overcome the difficulty of process optimization for traditional emergy analysis in the future work.

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Keywords: Cement Production; Raw Material and Fuel Substitution; Emergy Analysis

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1. Introduction

Cement production brought a huge environmental burden due to its high consumption and emission during its production process, which impeded system sustainable development. It has been a hot issue of resource utilization and regional development to systematically account the input of cement production, assess the potential effect of environmental emissions and optimize the production process. As a systematic method, emergy has widely used to evaluate the ecological support based on eco-environmental supports and socioeconomic investments [1-2]. However, there are fewer researches contraposed to cement industry. Mikulcic et al. (2016) compared the environmental impact of different cement production processes based on emergy analysis and ecological footprint, and pointed out that carbon dioxide emissions can be reduced effectively by reducing the use of fossil energy and improving energy efficiency [3]. This paper aims to undertake an emergy assessment of a typical 2500 t/d new suspension preheater dry process (NSP) cement production line in China, accounting and optimizing the new dry process of cement production, comparing its sustainable transformation with carbide slag substitution scenario (CSSS), maize straw fuel substitution scenario (MSFS), and waste heat recovery scenario (WHRS).

The remnant of this paper is organized as follows. Section 2 introduced the study site, emergy diagram and data sources. Section 3 demonstrated the emergy accounting results and the scenario optimization analysis. Finally, basic conclusions and further discussion were given in section 4.

2. Methodology

2.1. Study site

The goal of this study is to appraise the sustainability of a typical new suspension preheater dry process (NSP). The study area located in Guizhou province, which enjoys a subtropical humid monsoon climate. The average annual temperature is 12.3 degree Celsius, annual precipitation is 1223.6 mm, and annual average sunshine hours for 1555.6 hours, average wind speed 2.4 m /s. The considered functional unit is the Portland cement production for one year with a clinker production scale of 7.75E+05t/a. Materials consumed in the whole production chain are showed in Table 1.

Table 1. Consumption of major materials

Item	Quantity(Unit: t/a)
Limestone	9.24E+05
Sandstone	1.34E+05
Flyash	8.45E+04
sulfuric-acid residue	3.52E+04
Gypsum	3.30E+04
Admixture	2.39E+05
Coal	7.99E+04

2.2. Emergy evaluation