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A critical review on energy use and savings in the cement industries

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ABSTRACT

The cement sub-sector consumes approximately 12–15% of total industrial energy use. Therefore, a state of art review on the energy use and savings is necessary to identify energy wastage so that necessary measures could be implemented to reduce energy consumption in this sub-sector. In this paper energy use at different sections of cement industries, specific energy consumption, types of energy use, details of cement manufacturing processes, various energy savings measures were reviewed and presented. Various energy savings measures were critically analyzed considering amount of energy that can be saved along with the implementation cost. Amount of CO_2 reduction has been presented along with the payback period for different energy savings measures as well.

This study complied a comprehensive literature on the cement industries in terms of Thesis (MS and PhD), peer reviewed journals papers, conference proceedings, books, reports, websites. It has been observed that China producing major share of global cement production. Coal contribute major share of fuel used in cement industries. However, along with conventional fuels, industries are moving towards the use of alternative fuels to reduce environmental pollution. It was reported that cement industries are moving from wet process to dry process as it consume less energy compared to wet process.

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1. Introduction

Industrial sector energy consumption varies from 30% to 70% of total energy used in some selected countries as reported in the literatures [1–9]. A sizeable amount of energy is used in manufacturing cement. Therefore focus should be given on the reduction of energy and energy related environmental emissions locally and globally [10–14]. It was reported that this segment of industry consumed about 12% of total energy in Malaysia [15] and 15% of total consumption in Iran [15,16].

Being an energy intensive industry, typically this segment of industry accounts for 50–60% of the total production costs [17]. Thermal energy accounts for about 20–25% of the cement production cost [18]. The typical electrical energy consumption of a modern cement plant is about 110–120 kWh per tonne of cement [19]. The main thermal energy is used during the burning process, while electrical energy is used for cement grinding [20]. Fig. 1 shows electrical and thermal energy flow in a cement manufacturing process.

World demand for cement was 2283 million tonnes in 2005 and China accounted for about 47% of the total demand. It is predicted that the demand will be about 2836 MT in the year 2010. China will increase its demand by 250 million tonnes during this period. This increase will be higher than the total annual demand for European Union [22]. It was reported that Japan and the US, India is the fourth largest cement-producing country in the world. Mandal and Madheswaran [23] reported that production of cement increased from 2.95 million tonnes in 1950–1951 to 161.66 million tonnes in 2006–2007 in India. Table 1 shows the annual production of cement for few selected countries around the world. Table 2 shows the anticipated demand for cement in different continents along with the growth rate up to the year 2010.

Specific energy consumption in cement production varies from technology to technology. The dry process uses more electrical but much less thermal energy than the wet process. In industrialized countries, primary energy consumption in a typical cement plant is up to 75% fossil fuel and up to 25% electrical energy using a dry process. Pyro-processing requires the major share of the total thermal energy use. This accounts for about 93–99% of total fuel consumption [20,25,26]. However, electric energy is mainly used to operate both raw materials (33%) and clinker crushing and grinding (38%) equipment. Electrical energy is required to run the auxiliary equipment such as kiln motors, combustion air blowers and fuel supply, etc. (22%) to sustain the pyro-process. Fig. 2 shows the electrical energy consumption per tonne of cement production for selected countries around the world. About 94% of the thermal energy requirement is met by coal in the Indian cement manufacturing and the remaining part is met by fuel oil and high speed diesel oil. Natural gas is not sufficiently available for the cement industry in India [27]. The final energy mix of an industry is dominated by coal and oil as presented in Tables 3, 5 and 6.

About 29% of the expense is spent on energy, 27% on raw materials, 32% on labor and 12% on depreciation in a cement industry. Therefore, cement industry is characterised by intensive industry throughout its production stages and the calcination of its raw

Table 1
Global cement production statistics for the year 2005 [24].

Sectors	Production (MT/yr)	Share (%)
China	1064	46.60
India	130	5.70
United states	99	4.30
Japan	66	2.90
Korea	50	2.20
Spain	48	2.10
Russia	45	2.00
Thailand	40	1.80
Brazil	39	1.70
Italy	38	1.70
Turkey	38	1.70
Indonesia	37	1.60
Mexico	36	1.60
Germany	32	1.40
Iran	32	1.40
Egypt	27	1.20
Vietnam	27	1.20
Saudi Arabia	24	1.10
France	20	0.90
Other	392	17.20
World	2284	100

Table 2
Demand for cement (million tonnes) for different continents [22].

Demand for cement	2005	2010	Growth rate (%)
North America	179	200	2.9
Western Europe	208	236	2.2
Asia/Pacific	1500	1900	5.2
Other regions	405	500	4.7
World cement demand	2283	2836	4.7