Green Manufacturing and Operational Performance of a Firm: Case of Cement Manufacturing in Kenya

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Abstract

Green Manufacturing includes all practices connected with ecological concerns that constantly incorporate environmental manufacturing processes and products. Green Manufacturing considers decrease from the start or prevention, recycling and green product designs. It focuses on the greening production stage where pollutants are largely generated. The outcomes of these strategies would be no pollution, defects, downtime and zero inventories. The study sought to establish the relationship between green manufacturing practices and operational performance of a selected cement manufacturing company in Kenya. Secondary data on green manufacturing practices and operational performance was collected for a period of 4 years from 2011-2014. The results indicate a significant relationship between green manufacturing practices and operational performance. There is also compliance with the Kenya's environmental management and co-ordination regulations for 1999 on the part of the cement manufacturing firm. The study emphasises the implementation of green manufacturing projects that would focus on eliminating or controlling all kinds of pollution in its conclusion.

Keywords: Green Manufacturing; Emissions; Dust; Pollution; Waste Management**;** Operational Performance

1.0. Introduction

The concept of green manufacturing has gathered considerable attention globally. Numerous environmental safety measures have been passed as laws by different nations to help enforce green manufacturing in different industries. The Montreal protocol on ozone layer depletion; Rio declaration; the Kyoto protocol and Johannesburg declaration on sustainable advancement; and the ISO 14000 on environment management systems and standards; Hazardous substance use restriction, eco-design requirements for using products, registration, evaluation, and authorization of chemicals and packaging of waste directives (Chuang & Yang, 2014). The laws are either national or joint efforts for different countries to help shape sustainable manufacturing and advancement (Chuang & Yang, 2014). This study examined green manufacturing from two main theories: Stakeholder's theory and Institutional theory. Emissions and energy efficiency are the main environmental challenges of cement manufacturing plant in Kenya.

1.1. Green Manufacturing

Green Manufacturing includes the entire practices connected with environmental concerns that endlessly incorporate eco-friendly manufacturing processes of goods. It involves transforming raw materials into finished goods that leaves less environmental hazards but with high efficiency (Van Berkel, Willems & Lafleur, 1997; Hui, Chan & Pun, 2001). Green manufacturing considers source reduction or prevention, recycling and green product designs (Porter & Linde, 1995).

Sivapirakasam, Mathew and Surianarayanan (2011) identified green manufacturing as a transformation process that maximises on the consumption of resource with high reliability and less ecological hazards. This is accomplished by innovatively designing of products and processes. Green manufacturing alternative can be divided into five major areas: product and production process changes, changes of raw materials, internal re-use of wastes and better housekeeping (Dornfeld, 2009).

Greening of industry means adopting strategies that would minimize pollution and wastage that is generated during manufacturing. It gives many chances for reducing costs, meeting environmental principles, improved corporate image and minimising health risks. The aim of green manufacturing is to reduce, control, avoid and prevent wastage during production. It's a strategy that protects environment, consumers, workers and at the same time improving industrial efficiency, profitability and competitiveness.

The vision of green manufacturing strategy is to create harmonious conditions between commerce and their surroundings. The mission is value creation by producing more with fewer resources through adopting green manufacturing strategies (Sivapirakasam, Mathew & Surianarayanan, 2011). The outcomes of these strategies should be no pollution, defects, downtime and inventories (Dangayach & Deshmukh, 2001). Industries should develop strategies that will overcome these challenges and this could be through: green technology innovation; learning and environmental technology innovation, continuous improvement to environmental health hazards. Considering the views of stakeholders would also be critical in this case (Miller & Ross, 2003).

1.2. Operational Performance

Operational performance is the degree to which quality, speed, dependability, flexibility and cost are fulfilled at any point in time in production and delivery of products and services. Businesses regularly review various performance measures through the assessment of results, production, demand and operating efficiency. This creates a more objective sense on business operation and whether improvement is needed. The generic performance objectives can be aggregated into composite measures, like customer contentment, overall service level and operational agility; or by means of measures like achieving market targets, financial, operations, overall strategic objectives and even environmental objectives. Comprehensive performance measures have greater strategic relevance in the overall performance of the business (Acquilano, 2005).

Development of quality policy systems, encouragement of green culture and commitment to quality improvement is vital to ensuring product reliability, durability, functionality and environment quality. Performance measures should focus on preventing non-conformance in production (Chen et al, 2008). According to Slack (1983), quality can be looked at from different dimensions like: customer complains, wastage, claims on warranty, malfunction, satisfaction levels and environmental impact. This is achieved through consistency in total quality management and adoption of green manufacturing strategies that are highly reliable in meeting consumers green needs. Operations with high internal dependability are more effective.

Dependability saves time by ensuring that production resources allocated are used effectively and efficiently. Poor use of time would be converted into extra cost. The main benefit of speed delivery in manufacturing depends on how operations are enhanced. Response to outside customers is significantly improved through quick decision making and flow of materials and information. According to Chase, Jacobs and Acquilano (2005), strategically, flexibility means a company being able to offer a broad variety of products to its clientele. It encompass four aspects: Time needed to innovate and design new goods and time to change operational schedules; it's able to modify and mix of different products; Machine change-over time; Average batch size; its ability to change the time used to produce and to increase activity rate and average/maximum capacity of production (Slack, 2005).

Flexibility is a very important concept for manufacturing firms. First, there are a lot of dynamics associated with manufacturing operations especially due to changes in customers need. Second, there is a lot of innovation in green production technology like the use of robots to eliminate exposure of employees to health hazards. Third, flexibility is a strategy that is used by manufacturing firms to ensuring their green objectives are achieved (Slack, 2005). Cost management is a universal operational objective for all manufacturing plants and it should be low to match with the levels of quality, speed, dependability and flexibility. Cost can be achieved by developing a strategy that is inclusive of total quality management and environmental impacts.

Green Manufacturing should strategically reduce a percentage of all costs including costs of sourcing for raw materials, production, and supply chain costs; maintenance, replacement and any other costs associated with green products. Improving other operational performance objectives is critical since they affect the costs of production. High-quality operations adopt lean strategies in their manufacturing operations (Chase et al., 2005).

1.3. Green Manufacturing and Operational Performance

Green Manufacturing is an important driver for manufacturing industries to meet their operational performance like cost reduction; good corporate image, less environment health hazards and competitiveness.

Reduced pollution helps to reliably achieving some of the operational objectives like cost reduction which improves competitiveness (Porter & Linde, 1995). The logic in preventing pollution corresponds to the quality management guidelines that are critical to prevent errors at the early stage as opposed to correcting after production (Imai, 1986). Inefficiencies in cement manufacturing firms are signified by pollution which is non recoverable cost (Shrivastava & Hart, 1992). It's therefore critical to integrate total quality management programs with pollution elimination strategies and involve employees and green teams (Lawler, 1986).

Pollution can significantly be reduced through continuous improvement strategies that are focused on green manufacturing (Rooney, 1993). Pollution prevention is a sign of reliability in a manufacturing setting. It helps manufacturers to save on equipment installation, manages waste and pollution and it also optimises on the production resources. Reduced amount of waste means a better consumption of production resources by using fewer raw materials to produce more with less cost of managing scrap (Schmidheiny, 1992). Eliminating emissions helps to eliminate liability claims from the stakeholders because it greatly supports compliance (Rooney, 1993). Taylor (1992) suggested that implementing green operations practices is a strategy toward achieving environmental health and safety. This eliminates environmental disputes costs, environmental accident, ban and loss from customer boycott.

Flexibility allows for innovation in product and process that helps to improve company performance, build capacity and create competitive advantages. Dependability ensures effectiveness and efficiency of production resources and saves time and other associated costs. Environmental requirements, costs, consumer dynamics, competition and market dynamics are crucial elements in green operational performance and capacity for manufacturers. Excellence in operations is just one requirement but sustainability is overall since it enables industries to meet current needs without compromising the future generations' ability (Camisón & Villar López, 2010). Green manufacturing practices are associated with environmental concerns through continuous integration of environmental friendly products and processes to eliminate pollution and reduce environmental health exposures (Hui, Chan & Pun, 2001). This helps to optimise resources, improve reliability and industrial ecology in green cement manufacturing (Sivapirakasam et al., 2011). These practices could be grouped into product strategies that embrace industrial ecology throughout the product lifecycle. These process strategies optimise resources, ensure energy efficiency and eliminate environmental health risks (Van Berkel, Willems & Lafleur, 1997).

1.4. Cement Industry in Kenya

Building and construction sector is rapidly growing at an average rate of 14.2% which is highly correlated to a country's economic performance. The growth is in tandem with increased housing construction including funded housing development projects, the commercial construction boom from foreign investment and government, donor-funded spending on the country's mega infrastructure projects and the entry of new cement producers and extensive capacity expansion by existing players in response to increasing competition. Cement production expanded at an average rate of 11.6% from 2.41Million tons to 4.09 Million tons in 2011, 5.19 million tons in 2014 and 5.23 million tons in 2015. This rise in production led to the consistent over-supply of cement during this period (Kenya National Bureau of Statistics, 2016).

Given an estimated industry capacity utilization rate of about 72%, this glut supply could be much higher if installed capacity was to be fully utilized. As at the end of 2015, the local cement industry included six cement companies with mines concentrated in three sites across the country: Bamburi Cement Limited, Athi River Mining Limited, East African Portland Cement Company Limited, National Cement Company Limited, Mombasa Cement Limited and Savannah Cement Company. The main environmental challenges in cement industry are particulate and gaseous emissions and energy efficiency. Particulate emissions include various types of dusts, that is, total dust, fugitive dust and respirable dust which can be a local nuisance and health hazard.

Gaseous emissions from cement manufacturing plants include: carbon dioxide, carbon monoxide, sulphur and nitrogen oxides (Oss & Padovani, 2003).

1.5. Research Problem

Global warming is considered a major global environmental challenge and cement manufacturing emission are considered a major cause (Shraddha & Nehal, 2014). Cement Manufacturers have recognized that climate change is rampant and is accompanied with risk and opportunities and this makes green performance measurement crucial for them to master.

Cement manufacturing uses a lot of energy especially during clinkerization and calcinations that produces emissions like nitrogen oxides, sulphur oxides, carbon dioxide and particulate matters which can be a local nuisance and health hazard (Shraddha & Nehal, 2014). Other hazardous air emissions comprise of metals, hydrochloric acid vapor and chlorine (Oss & Padovani, 2003). The greenhouse gases from the cement industry will continue to increase because of increased demand for houses (Brueckner, 2000). It is assumed that cement industries are the main sources of pollution in areas they are located and there is need for control the environmental concerns. Local communities have threatened legal actions against cement factories. The National Environmental Management Authority (NEMA) is always on the watch and will issue improvement notices and orders demanding that urgent actions be fixed where necessary. It was therefore feasible that there are more permanent solutions to achieving pollution reduction or elimination. This is a subject of major research that will ensure development of strategies for sustainable cement manufacturing. Environmental impact of any new process or technology should be considered at procurement stage through proper consultation. It’s for this reason that this study sought to establish the relationship between green manufacturing practices adoption and operational performance using the case of a cement manufacturing plant in Kenya.

1.6. Research Objective

The objective of the study was to establish the relationship between adoption of green manufacturing practices and operational performance by a cement manufacturing firm in Kenya.

1.7. Value of the Study

The findings of the study are a valuable addition to knowledge on green operations that provides theoretical insights on adoption of green manufacturing practices in cement manufacturing. Green Manufacturing strategies that have been used by cement industry can be borrowed from the study including the need for more awareness and training to unbolt potential for competitiveness. The finding of the study can be used to protect our environment by ensuring sustainable manufacturing is adopted through sustainable production processes, which would also enhance stakeholder’s dynamic needs that are beneficial. Policy makers and the government can use the results of this study in developing economies to set environmental standards to attract investors, formulating strategic responses to the factor influencing the adoption of green manufacturing practices and support green manufacturing practices in the industrial division. It also provides valuable conceptual and procedural suggestion to pursue more studies in green manufacturing area.

2. Literature Review

2.1. Introduction

Green Manufacturing includes all practices that use raw materials with reasonably minimum negative impact on the environment but with high efficiency.

2.2. Green Manufacturing Practices

Greening of industry means adopting strategies that would minimize pollution and wastage that is generated during manufacturing. It gives many chances for reducing costs, meeting environmental principles, improved corporate image and minimising health risks. The aim of green manufacturing is to reduce, control, avoid and prevent wastage during production. It’s a strategy that protects environment, consumers and workers at the same time as improving industrial efficiency, profitability and competitiveness.

2.2.1. Waste Management and Minimization

Sarkis and Rasheed (1995) described green manufacturing system to be those that can reduce, remanufacture, recycle and reuse their waste. Mohanty and Deshmukh (1998) proposed that building green manufacturing systems require: assessment, foundation, waste minimisation and eco-efficiency.

For effective adoption of green manufacturing system and pollution reduction it's important to consider the hierarchy of control starting with elimination, isolation, substitution, engineering and administrative controls. Sharma, Sharma, Chattopa dhyaya, and Hloch (2011) mentioned processes like recycling, reusing, refilling just to mention a few as examples of green manufacturing approaches. Strategies for waste management can be divided into a hierarchy of treatment options which include prevention, control and recycling optimally the final disposal and improved monitoring. Waste prevention strategies that eliminate waste at the source are cost effective if properly implemented, while disposal is the least desirable. Prevention of waste focuses on reducing the amount of waste generated initially that would make it less problematic and cost effective in disposing.

Emphasis of this principle is put on greener production within industries and this is achieved by influencing markets to demand greener products (Kummer, 1999). Waste that cannot be prevented should be recovered and recycled. Most countries have laws that guide on management of industrial ecology. Different industries have different ways of recycling waste into valuable energy that reflect or make up for some cost saving like recycling of excess heat to heat water. There is need to pursue strategies meant to reduce toxicity through recycling, waste stabilization to reduce volume before disposal or creating limited use by-products when waste can't be prevented (Von, 2004).

Optimum final disposal and improved monitoring strategies are critical for industrial waste like; incineration, sanitary landfill on sites. However European Union has strict emission standards that control incineration to reduce the dioxins and acid gases emissions. Dioxin gases are environmental hazards and they include: sulphur dioxides, nitrogen oxides and hydrogen chlorides (Von, 2004). End-of-pipe treatment technologies are strategies that aim at controlling emission and waste within legally acceptable limits of discharge. This strategy requires ongoing cost and they release hazardous components to the environment for numerous years.

Data on dust emission can be used to show how the plant's operations contribute to wastage. The researcher collected monthly statistics on the dust emission and the cost of producing clinker for a period of four years. This will help in developing appropriate total maintenance strategy for the plant that will ensure maximum reliability of the plant that will ensure efficiency in the production resources. It will also be analyzed to assess the contribution it has on the cost of producing clinker, depending on how much waste is recycled and what goes wasted.

2.2.2. Energy Efficiency and Fuel Substitution

Demand for green products is increasing as technologies that can eliminate the use of fossil fuel are adopted (Mohanty, Misra & Drazal, 2002). Alternative fuels could be adopted in green manufacturing like: biomass, geothermal, hydrogen power, solar, wind and waste-to-energy. Coal has a bearing on the magnitude of carbon dioxide emissions from manufacturing process (Wright, Boundy, Perlack, Davis & Saulsbury, 2006). Product substitution involves replacement of materials with others that require less energy to process or using component that reduces emission like use of fuel that don't contain carbon (Young, 1996). Energy consumption can be reduced by modifying to adopt more efficient manufacturing process or by adopting green technologies that reduce energy consumption and hazardous emissions. This could be through electricity reduction or by reducing or eliminating fossil fuel required (Scarlat & Banja, 2013). Energy efficiency is measured by comparing the energy used versus the goods produced. It's better to get more output from the energy provided through improved operation of energy and process systems and this translates to cost saving through less energy loss. Energy efficiency can be achieved by new heating technology innovation. Improved energy efficiency can provide economic, social and environmental benefits to an economy (Scarlat & Banja, 2013).

Cost of burning clinker and electric energy consumption in kilowatts was compared to establish a relationship. Monthly secondary data was collected on the amount of electricity used in Kilowatts and cost of producing clinker for a period of four years. This was also related the cost of burning clinker when various alternative fuels are used. This was to be used in determining which projects to be implemented to ensure that there was energy efficiency in the plant. It also helped in making appropriate selection and usage of the alternative fuels available.

2.2.3. Process Design, Modifications and Upgrades

Tseng, Huang and Chiu (2012) come up with four classes of green manufacturing innovations: managerial, product, process and technological innovation. To become the green manufacturer, the new technologies and the process optimization are adopted gradually to guarantee the development into ordering, coordination, high-efficiency and continuation.

To recognize the greening, it's important to have: The orderliness of the manufacturing process; proper coordination of manufacturing process; high-efficiency and continuation of manufacturing process. Research on new green techniques like: new energy source, recycling of waste and other ecological waste treatment technologies has been critical. Other green production programs that manufacturers can implement to reduce their environmental impact include: having a comprehensive environmental management systems that will manage manufacturing processes from sourcing of raw materials to disposal of waste. This should incorporate all the legislations that are relevant in guiding such operations (Tseng, Huang & Chiu, 2012) Production cost at the clinker burning level was compared when recycled waste used and when electricity as used. This was used to establish how cost of production during burning was affected by the use of recycled waste. Monthly secondary data was collected on recycled waste (fuel oil, alternative fuels, other biomass, and waste oil) and costs used for burning for a period of four years. This was used to make decisions on the cost effective way of burning clinker.

2.3. Theoretical Foundation of the Study

The theoretical review of green operations management practices focused on stakeholder and institutional theories.

2.3.1. Stakeholders Theory

Freeman (1984) defines stakeholders as an organization or individual whose activities are either affected by the firm or affects the way the firm operates like: employees, investors, and customers. This theory describes how genuine issues of relevant stakeholders are included in operations decisions to achieve their goals and strategic direction of the firm (Donaldson & Preston, 1995). According to Hart (1995), developing and implementing proactive strategic environmental commitment means understanding stakeholder's needs based on historical environmental performance, organizational structure and the competitive position of the company. Stakeholders scrutinize the short and long-term risks and opportunities in relation to green manufacturing adoption (Donaldson & Preston, 1995). It's strategically beneficial and innovative to incorporate and manage stakeholders concerns in a way that guarantee strategic success and competitive advantage (Freeman, Martin, & Parmar, 2007).

2.3.2. Institutional Theory

This theory examines how company operations are influenced by external pressures (Hirsch, 1975). Organizations operate within a social network and a strong motivating force behind firm behaviour is socially based and that it is embedded within institutions and interconnected organizational networks (Iacobucci & Hopkins, 1992). These social-cultural pressures forced on organizations to persuade adoption of green manufacturing practices and structure is emphasised (Scott, 1992). DiMaggio and Powell (1983) explained three forms of isomorphic drivers mimetic, coercive and normative that influences management decision. Coercive isomorphic forces are driven by those in authority like the government and its associated agencies (Rivera, 2004). Normative isomorphic forces are important in ensuring conformity to perceived legitimacy in relation to green manufacturing and environmental management practices by different firms (Ball & Craig, 2010). Mimetic isomorphic forces are in control if companies copy successful strategies (Aerts, Cormier & Magnan, 2006). New cement plants are trying to adopt green manufacturing technologies to deal with challenges existing company's face. Cement firms are under pressure to environmentally friendly since rapidly changing global competitive economy will make them vulnerable to stringent public policies, law suits or consumer laws that would affect operational performance of manufacturing firms.

2.4. Empirical Review

There have been widely reported studies and articles about the status of adoption of green manufacturing efforts and operational performance worldwide. Many of these studies investigate the successes made in the area of green production and the sacrifices that needs to be made to realize environmental sustainability. Inman (2002) did literature review on operations management in the context of green ecology explaining how industries are influenced to formulate strategic changes in manufacturing, with key focus on challenges of rolling out green manufacturing projects among electronics manufacturers. Udomleartprasert (2004) concluded in his study that processes, materials, work environments, packaging, and waste management systems are some of the critical issues that determine the success of green manufacturing adoption. Rusinko (2007) studied the relationship between green manufacturing operations and the related competitive advantages in manufacturing firms and results were positive. Perrow (2011) examined China‘s policy of producing now and clean up later, and realized that public opinion is changing in China.

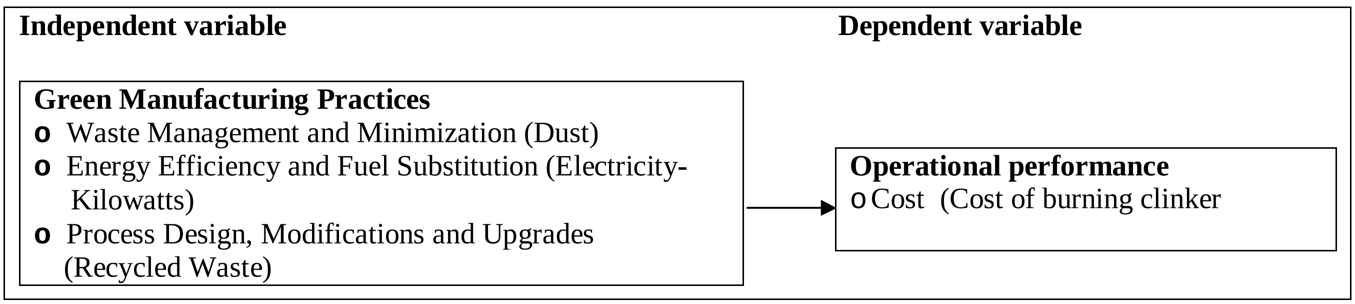
Being one of the highest producers of cement, ordinary citizens are demanding better environmental regulation because of the level of pollution. China's environmental problems are not from the lack of related laws but from the lack of law enforcement. DiPietro, Cao and Partlow (2013) conducted a study on green practices in upscale food service operations. He adopted a survey design and the outcomes indicated embrace green products awareness but there is still need for more campaign. Smith and Perks (2010) studied the perception of consumers concerning greening the manufacturing industry using quantitative research design.

The finding showed that manufacturers are the main sources of pollutants that cause global warming and it's important for them to recognise the consequences of their operations. Procedures have been put in place to facilitate green manufacturing adoption in various manufacturing industries.

2.5. Conceptual Framework

The conceptual framework for the study was developed based on the framework of green manufacturing by (Dornfeld, 2009) who suggested that Green manufacturing options can be grouped into different ways like: product, production and raw materials changes, internal re-use of wastes and better housekeeping. The elements of green manufacturing options was used to represent independent variable and operational performance represented the dependent variable as illustrated in figure 2.1

Figure 2.1: Conceptual Framework



2.6. Research Hypothesis

From the theoretical and empirical literature review, the study proposes the following hypothesis to explain the relationships that is outlined in the conceptual model.

Hypothesis: adoption of green manufacturing practices has a direct impact on the operational performance.

3. Methodology

A case study research design was used since it examined practices of a single firm. The design is flexible research and useful in studying issues related to sustainability and institutional systems. The dependent variable was operational performance measure and independent variables were green manufacturing practices. The objective of study was to establish the relationship between the two variables. A cement manufacturing firm in Kenya was chosen because it is age, production capacity and that it links to other companies and it was important to understand what was borrowed from international green technologies. Monthly secondary data was collected from the historical records for a period of 4 years from 2011 to 2014. Data on three green manufacturing practices collected included: amount of recycled waste, amount of electricity used in kilowatts and amount of dust emissions. Operational performance measure data collected include cost of burning clinker.The relationship between the independent and dependent variables were analyzed by use of regression analysis. The following regression model was utilized; $Y= a + b_1X_1 + b_2X_2 + b_3X_3$ Where: Y= is the dependent variable, an operational performance measure represented by cost of burning clinker in Kenyan shillings. $X_{1....}$ X_3 = are green manufacturing variables- the independent variable, where: X_1 = Recycled waste in Tons, X_2 = Electricity in kilowatt and X_3 = Dust emission (mg/nm3)

3.1. Secondary Data

Secondary data on green manufacturing measure was collected on three areas which included recycled waste, electricity consumed, dust emission and cost of burning clinker was the operational performance measure and respective data was used.The finding are as shown n table 1.

Table 1: Operational and Green Manufacturing Practices Data

Year	Month	Operational performance measure	Green manufacturing practices		
		Y_1 (Cost of Burning Clinker)	X_1 (Recycled waste)	X_2 (Electricity in kilowatt)	X_3 (Dust emission)
2011	Jan	8218749753	1228	9225576	507
	Feb	7168630891	575	8566969	590
	Mar	6967185635	651	9566788	372
	April	10137294819	545	6542178	372
	May	8878550284	669	8770498	622
	June	10219487061	726	9979368	365
	July	7086866327	640	8271773	285
	Aug	11248991773	747	8477512	285
	Sept	10346582153	642	8937961	1266
	Oct	9671993506	528	8704600.6	691
	Nov	15182295295	426	8164501.8	232
	Dec	8058735509	562	8503305	230
2012	Jan	7835055766	528	8642352.8	225
	Feb	10220721719	527	8901203.1	502
	Mar	10873237103	515	8481971	500
	April	13987034720	505	7706745	496
	May	10481703021	553	9019936	472
	June	10712801051	536	9536689	473
	July	14727043294	400	5923460	120
	Aug	9091617157	717	9313186	173.9
	Sept	8901082224	604	9212151.7	120.9
	Oct	8748411829	598	9779802	120.9
	Nov	11103535681	523	8521228	120.9
	Dec	7457483166	671	8981807	120.9
2013	Jan	5864580441	494	9618756	120.9
	Feb	12590145534	486	8688198	121
	Mar	5826271101	687	8091719	123.8
	April	7473024425	649	8222151	121.9
	May	7583416320	891	8882009	122.5
	June	10491781175	768	8014484	121.7
	July	8499035827	821	8743862	124.2
	Aug	11885325036	689	8271779	127.4
	Sept	9184780586	640	8158943	121.5
	Oct	6993726440	791	8319410	130.5
	Nov	6962939917	2257	9444888.2	124.8
	Dec	7304032956	3181	8915542.3	138.6
2014	Jan	7513971670	4399	8411982	153.9
	Feb	9320102346	103623	7915855.9	121.5
	Mar	5205835829	33970	7952122.5	121.5
	April	6498543749	32792	8710056.9	120.8
	May	5290265066	39348	7920953.9	125.6
	June	6714056686	1476	9023657.3	132.7
	July	6898145897	1332	8603135.9	128.7
	Aug	7137206345	1203	8338585.4	124.4
	Sept	10428424807	1272	8302555	122.1
	Oct	7548960684	1393	9460058.2	128.2
	Nov	6897671831	1652	9826388	124.2
	Dec	7384465342	1845	8880580	124.6

Source: Research Data, 2015

3.2. Green Manufacturing Practices

On waste management there was an increased consumption of alternative fuels from 7,939; 6,677; 12,354 and 224,305 tons from 2011 to 2014 respectively. The monthly averages were: 662 tons; 556.4 tons; 1029.5 tons and 18692 tons respectively from 2011 to 2014. Alternative fuel substitution rate increased continuously from 2012 to 2014 by 3.33%; 2.37%, 6.72% and 11.91%. This is because of the benefits derived from using the alternative fuels like reduced Carbon dioxide emissions, whenever coal is used. Some cement companies have targets of replacing the total amount of clinker burning fuel with alternative fuel which was a key reason for increased usage.

Energy efficiency is measured by comparing the energy used versus the goods or services delivered and electricity was a critical cost element in cement production. Electricity data collected from the historical records showed: 8,642,586 kilowatt, 8,668,378 kilowatt, 8,614,312 kilowatt and 8,612,161 kilowatt between 2011 and 2014 respectively. Process design, modifications and upgrades determined the amount of dust that was emitted. Dust Emissions data was collected from the historical records of cement production operations. Dust emission levels were: 484.8 mg/Nm3; 287.1mg/Nm3; 124.9mg/Nm3 and 127.3mg/Nm3 from 2011 to 2014 respectively. However, dust from some operations is not continuously monitored like spillages that occur during cement operation processes that may not appear significant.

3.3. Operational Performance

Electricity, transportation, limestone, coal and margin inputs account for 80% of clinkers total cost. The operating efficiency in cement production is judged by the utilization capacity and the economical use of major inputs, such as limestone, coal, transportation fuel oils, and electricity consumption per ton of cement produced. The kiln is very sensitive to control strategies, because poorly run kiln can easily double operating costs, produce poor quality and increases emissions. The objective of kiln operation is to produce clinker with the required chemical and physical properties, at the maximum rate, while meeting environmental standards and at the lowest operating cost possible.

The preprocessing system involves three steps: drying or preheating, calcining and clinkerisation. Burning of clinker is done by coal, fuel oil and alternative fuels that are part of the clinker production costs. The researcher sought to find the cost of burning clinker and the findings were summarised as follows: 113,185,363,006, 124,139,726,731, 100,659,059,758 and 86,837,650,252 from 2011 to 2014 respectively. Comparing the cost of burning clinker and the amount of alternative fuels used, as the amount of alternative fuel increases the cost of clinker production reduces. This means that the use of alternative fuels reduces the cost of burning clinker. The findings were summarized as follows: 113,185,363,006, 124,139,726,731, 100,659,059,758 and 86,837,650,252 from 2011 to 2014.

4. Data Analysis and Discussions

The main objective of the study was to establish the relationship between green manufacturing practices and operational performance. The green manufacturing practices measures recycled waste, electricity consumed and dust emission. The operational performance measure was the cost of burning clinker. In order to achieve this objective the data was subjected to correlation and regression analysis with recycled waste, electricity consumed and dust emission as the independent variables and the cost of burning clinker as the dependent variable. The results are shown in table 2

Table 2: Correlations Analysis

		Recycled waste in tons	Electricity in kilowatt	Dust emission in milligrams per nm3	Cost of burning Clinker
Recycled waste in tons	Pearson Correlation	1	-.198	-.167	-.169
	Sig. (2-tailed)		.177	.256	.251
	N	48	48	48	48
Electricity in kilowatt	Pearson Correlation	-.198	1	.093	-.342*
	Sig. (2-tailed)	.177		.532	.017
	N	48	48	48	48
Dust emission in milligrams per nm3	Pearson Correlation	-.167	.093	1	.255
	Sig. (2-tailed)	.256	.532		.080
	N	48	48	48	48
Cost of burning Clinker	Pearson Correlation	-.169	-.342*	.255	1
	Sig. (2-tailed)	.251	.017	.080	
	N	48	48	48	48

*. Correlation is significant at the 0.05 level (2-tailed).

The results from table 2 show that electricity consumed and dust emissions are the variables that have a significant relationship with the cost of burning clinker with p-values of 0.017 and 0.08 respectively. Recycled waste had a p-value of 0.251 and hence was dropped from the analysis. The remaining variables were then subjected to regression analysis producing the results in table 3.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.448[a]	.200	.165	2132871459.55154	1.733

a. Predictors: (Constant), Dust emission in milligrams per nm3, Electricity in kilowatt

b. Dependent Variable: Cost of burning Clinker

From Table 3, the coefficient of correlation r = 0.448. This shows that there is a positive relationship between the green manufacturing practices retained in the model (electricity consumed and dust emission) and cost of burning clinker. This coefficient of correlation was tested for significance as follows:

Step 1: Stating the hypotheses

H_0: r = 0 (the relationship between green manufacturing practices and operational performance is not significant.)

H_1: r ≠ 0 ((the relationship between green manufacturing practices and operational performance is significant)

Step 2: Level of significance

Significance α = 0.05 and this is a two tailed test.

Step 3: Decision rule

Degrees of freedom = n – 2 = 48 – 2 = 46; Therefore, $t_{0.05,\,46} = 2.013$

The decision rule will therefore be, reject the null hypothesis if the computed t does not fall in the region: 2.013 ≤ t ≤ 2.013

Step 4: Test statistic

$$t = r\sqrt{\frac{n-2}{1-r^2}} = 0.448\sqrt{\frac{48-2}{1-0.200}} = 3.397$$

Step 5: Conclusion

Since the computed t (3.397) fall in the rejection region, the null hypothesis is rejected implying that the relationship between the green manufacturing practices (of recycling waste and dust emission) and operational performance is significant.

To test the overall significance of the model, ANOVA was done. The results of ANOVA are shown in table 4.

Table 4: Anova Table

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	51269847610581156000	2	25634923805290578000	5.635	.007[b]
	Residual	204711329833627400000	45	4549140662969497600		
	Total	255981177444208540000	47			
a. Dependent Variable: Cost of burning Clinker						
b. Predictors: (Constant), Dust emission in milligrams per Nm^3, Electricity in kilowatt						

From table 4, it can be observed that the p value (0.007) is less than the level of significance (0.05) implying that the overall model is significant. The next step involved testing the significance of individual parameters. From table 5, it can be seen that all the parameters in the model are significant as indicated by their p-values of 0.000, 0.008 and 0.036 which are all less than 0.05. This implies that their inclusion in the regression model is justified.

Table 5: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Co linearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	17968964884.85	3585906445.983		5.011	.000		
	Electricity in kilowatt	-1145.904	415.545	-.369	-2.758	.008	.991	1.009
	Dust emission in milligrams per nm3	3029466.187	1401444.207	.289	2.162	.036	.991	1.009
a. Dependent Variable: Cost of burning Clinker								

From table 5, the model will appear as follows:

$$\mathbf{Y = 17968964884.85 - 1145.90\, X_1 + 3029466.19\, X_2}$$

Where Y is the cost of burning clinker, X_1 represents electricity consumed in kilowatts, X_2 represents dust emissions in mg/Nm^3 The model shows that electricity consumed (X_1) is negatively related to cost of burning clinker (Y), and dust emissions (X_2) is positively related to cost of burning clinker as shown by their coefficient values. This means that if you increase the amount of electricity consumed by reducing the amount of alternative fuels used, it will increase the total cost of burning clinker. While if you reduce the amount of electricity by increasing the amount of alternative fuel used, it will reduce the cost of burning clinker. In order to check the suitability of the regression model and therefore its reliability, several tests were performed to check if the model violated important assumptions of regression. These included normality, multicollinearity, autocorrelation and heteroscedasticity.

Testing for Normality

The Shapiro-Wilk's Test statistic shown in table 6 was used to test for normality as follows:

Table 6: Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	.127	48	.051	.970	48	.243
a. Lilliefors Significance Correction						

Step 1: Hypotheses

H_0: the residuals follow a normal distribution with a mean of zero.

H_1: the residuals do not follow a normal distribution.

Step 2: Level of significance,

The level of significance, $\alpha = 0.05$

Step 3: Decision rule

Reject the null hypothesis if p-value is less than 0.05

Step 4: Test-statistics

Shapiro – Wilk's statistic – 0.970 and p - value = 0.243

Step 5: Decision

Since the p-value (0.243) is more than the level of significance (0.05), the null hypothesis is not rejected, implying that the residuals follow a normal distribution with a mean of zero.

Checking Multicollinearity

In order to check for multicollinearity, the correlation coefficient between electricity consumed and dust emission was evaluated for significance (r = 0.093, p- value = 0.532). Since the p-value is greater than 0.05, the relationship between electricity consumed and dust emission is not significant indicating absence of multicollinearity. Additionally, the variance inflation factors (VIF) of 1.009 and 1.009 show that multicollinearity is not a problem in this model since they are both less than 5.

Testing for Autocorrelation

To check presence of autocorrelation, the Durbin-Watson test was conducted as follows;
Step1: Stating the hypotheses
H_0: $\rho = 0$ (autocorrelation is absent)
H_1: $\rho > 0$ (autocorrelation is present)
Step 2: Level of significance
Level of significance, $\alpha = 0.05$
Step 3: Decision rule
Number of independent variables, k = 2; Number of observation, n = 48. From the Durbin-Watson tables, d_l =1.449 and d_u = 1.623
Step 4: Test statistic
From table 3, the Durbin-Watson test statistic, d = 1.733
Step 5: Conclusion
Since computed d (1.733) is greater than d_u (1.623), the null hypothesis is not rejected implying that there is no autocorrelation.

Testing for Heteroscedasticity

To begin with, the macro syntax by Gwilym Pryce on Breusch-Pagan and Koenker was run in SPSS producing the following output:
Run MATRIX procedure:
BP&K TESTS
==========
Regression SS 11.2853
Residual SS 91.3316
Total SS 102.6168
R-squared .1100
Sample size (N) 48
Number of predictors (P) 2
Breusch-Pagan test for Heteroscedasticity (CHI-SQUARE DF=P) 5.643
Significance level of Chi-square df=P (H0: homoscedasticity) .0595
Koenker test for Heteroscedasticity (CHI-SQUARE df=P) 5.279
Significance level of Chi-square df=P (H0: homoscedasticity) .0714
------ END MATRIX -----
Due to a small sample size of 48, the Koenker Test for Heteroscedasticity was found to be suitable as follows:
Step 1: Stating the hypotheses
H_0: There is no heteroscedasticity in the data (data is homoscedastic).
H_1: There is heteroscedasticity in the data.
Step 2: Level of significance
The level of significance, $\alpha = 0.05$
Step 3: Decision rule
Reject the null hypothesis if the p-value is less than 0.05
Step 4: Test statistic
From the output of SPSS, Koenker test statistic = 5.279 and p-value = 0.0714
Step 5: Conclusion

Since the p-value (0.0714) is greater than the level of significance (0.05), the null hypothesis is not rejected implying that the data is homoscedastic. The above tests confirm that the model is reliable and can be used for prediction purposes. It is therefore safe to conclude that green manufacturing practices adoption is significantly related to operational performance. The discussion follows.

5. Conclusion, Implications and Limitations of the Study

5.1. *Conclusion*

The study concludes that adopting green manufacturing practices leads to enhanced operational performance. This has been demonstrated using the case of a cement manufacturing firm in Kenya. The cost of burning clinker is significantly reduced by using more environmentally friendly alternative fuel and putting in place mechanisms to reduce dust emission. This means that firms that adopt green manufacturing strategies are able to produce at minimal cost and have less health environmental impact that would enhance long-term global competitive environment. Therefore it is recommended that manufacturing firms should adopt green manufacturing practices as this will enhance their operational performance thus making them more competitive.

Another important observation from the study is that the environmental challenges in the cement manufacturing industry are experienced due to lack of enforcement of environmental laws and regulations. This was also the case in the study of Perrow (2011) who observed that China‘s environmental problems are not from the lack of related laws but from the lack of law enforcement. This conclusion is in line with the findings of other scholars like: Inman (2002), Udomleartprasert (2004), DiPietro, Cao, and Partlow (2013) and Smith (2010). However, it can be disputed that the degree of the challenges may vary for different cement industries or other manufacturing firms because of institutional policies and other industrial productivity factors. Enforcement of environmental laws will help the cement manufacturing firm to adopt the green manufacturing strategies in all levels of cement manufacturing processes, which will positively impact the operational performance. As much as efforts to adopt green manufacturing can be seen, there is still room to improve the existing state and even introducing advanced technologies from the wider cement industry.

5.2 Implication of the Study

It was hypothesised that the adoption of green manufacturing practices is positively related to the operational performance of a firm. The findings of this study confirmed this hypothesis. This is in line with the finding of Rusinko (2007) who established that green manufacturing operations is positively related to competitive advantage of manufacturing firms. Therefore, the study extends literature by supporting the argument. This provides a justification for the adoption of green manufacturing practices.

The study also advances the understanding of green manufacturing performance relationship in Kenya and by extension in East Africa. The concept of green manufacturing is not as diffused in East Africa as it is in the developed world. Lack of empirical research in this region is a key strength of this study. This is a pioneer study in the context of East Africa and is therefore expected to increase the level of adoption of green manufacturing practices by manufacturing firms in the region.

5.3. Limitations of the Study and Suggestions for Further Research

A key limitation of this study is its focus on only one firm, a cement manufacturing firm. Therefore the findings may not be generalized to all manufacturing firms around the world. Future research should also seek to establish the findings beyond the context of East African manufacturing firms by empirically testing the relationship suggested in this study in other contexts (that is, countries, industries, cultures and supply chain entities). Further, this study did not make an attempt to control for other variables that have the potential to affect the operational performance of the firm.

Future studies should benefit from experimental research design which would allow the researcher to control for important variables which have a relationship with the operational performance of the firm. This would ensure that the effect on operational performance is only attributed to adoption of green manufacturing practices and not as a result of a change in any other variables.

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