Effect of Manufacturing Activities on Lean - Green Management Integration

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Abstract

The integration lean and green management that rely on conflict, synergy and neutral attributes will bring eco-benefits to companies and introducing green as a new lean that will contribute to get better productivity while reducing the environmental effect of its activities. This paper aim is to develop paradigm that demonstrates integration of lean and green management throughout manufacturing activities, inventory, and transportation. The effect of individual activity and overall outcomes that could contribute in the lean-green management integration is also revealed. AL-Kufa /Iraq Cement plant is employed as a case study to investigate the developed methodology, and assess the interrelation throughout two key performance indicators: life cycle assessment, and lead time. Relationship matrix, Pie, and Pareto chart tools are used to assess and present results. These results show crushing process has also the major effect towards the four environmental categories. The human health impairment has major damage of 91.60 %. Therefore, it is concluded that the major challenge toward lean green integration is this production process.

Keywords: Lean, Green, Integration, Conflict, Synergy.

1-Introduction

Products with preferable environmental performance draw new customers. Lean manufacturing offer chances for improving the environmental performance of a production line. Basically, lean management focuses on eliminating waste whereas green paradigm focuses on environment friendly production, integration of these two paradigms is believed to be beneficial [1,2]. Manufacturers enable simultaneously select and join lean and green paradigms so as to make an environmental status that may decrease costs, increase profit, "Lean is Green" have been increasingly conventional [3]. Integration of lean and green management is driven by both internal and external factors. Internal factors include cost reduction and profitability, commodity risk management, and the preservation of a corporate culture. While external factors include government norms, environmental pressures, a similar focus on continuous innovation and process improvement [4,5]. Tilina et al., [6] referred lean as the catalyst for green while Roya Kalbassi believed that not only lean is beneficial for green practices but also the implementation of green practices has positive influence on current lean practices [7]. To depict the synergies, trade-offs and the cause-effect relationships between lean and green paradigms and their effect on eco-performance, relationship matrix technique is used to integrate lean and green practices to clarify their integrated impact on activities and key performance indicators [8]. Conflict isa balancing of adaptation and mitigation when it is not possible to carry out both activities fully at the same time, but synergy is the interaction of adaptation and mitigation so that their combined effect is greater than the sum of their effects if implemented separately [9]. Different performance measurements could be used to evaluate the management of waste environmental or operational performances. Life Cycle Assessment (LCA) is one of these performance measurements that is used to analyze "the environmental burden of products at all stages in their life cycle - from the extraction of resources, through the production of materials, product parts and the product itself, and the use of the product to the management after it is discarded, either by reuse, recycling or final disposal [10]. Eco-indicators _95 method that classifies the environmental impacts of a product or process through determining the characterization factors of each effect [11,112]. Whereas Value Stream Mapping (VSM) is employed to assess production lead time, VSM is also used to demonstrate and decrease the amount of lead time in the manufacturing system [13]. In the next paragraph literature review is represented that shows the worldwide researchers interest toward lean green integration throughout their different models, tools, and paradigm. This paragraph is followed by a developed lean green management methodology. This methodology is tested employing AL-Kufa Cement plant as the case study since this plant suffers from different types of waste including environmental waste. Data analysis, lean- green integration attributes are assessed, results are verified, discussed, later in the last paragraph the final conclusions and further recommendations are presented.

2- Literature review

Many researchers reveal their interest in lean-green management throughout their models, paradigms that interrelate, combine and integrate them, or by employing different tools that classify, or assess the performance of their developed system, or models.

Brasco et al., (2013) introduced an integrated approach between lean and green management named "Lean and Green". The model combines environmental sustainability and lean management within production cells. Their aim is to minimize production wastes and reduce of the process environmental impact. They employed Kaizen approach to improve mass and energy flow in manufacturing environment. Their Results show that the model reduce the use of resources from 30 to 50% while the total cost of mass and energy is deceased from 5 to 10% [14].

Rimalini et al., (2015) examined the concept that lean and green manufacturing secures both economic and environmental sustainability for the long-term growth and prosperity of the plastic industries in India by improving productivity whilst minimising the environmental impact. They used Cronbach's Alpha as tool to test hypothesis and found correlation between them. Their results show correlations between sustainable developments with lean-green practices is (0.612) this means that plastic industry in India is looking toward to lean-green practices [15].

Pegah et al., (2015) explored the possible synergetic effects between the lean philosophy and green actions in improving resource efficiency and eliminating root causes of waste in the food sector their target product is dough-based product. Through implementation of DMIC (Define, Measure, Analyze, Improve, Control) methodology. They concluded that the root cause for 50 % of the waste in the actual line is lack of knowledge on how to produce dough with low stickiness; they also stated the possibility to control this factor over a longer time period. Furthermore, they concluded the correct identification of major root because simultaneously enabled not only a lower environmental impact from waste but also cost reduction, thus more stable production process [16].

Ruisheng et al., (2015) proposed methodology to adopt and streamline some of the approaches used a case study of metal stamped parts production. Their methodology, an easy-to-track metric called Carbon-Value Efficiency, which aims to integrate metrics derived from lean and green implementation, is introduced. Their results show that Carbon-value efficiency can be improved by 36.3%, given an improvement in production lead time by 64.7% and a reduction in Carbon footprint by 29.9 % [17].

Alain et al., (2016) introduced quantitative study of lean-green integration on waste reducing techniques in manufacturing operations. They utilized design of experiments tool to measure the effect of lean /3R (Reduction, Reuse, and Recovery) matrix. Their outcomes asserted the effect of the (3R) hierarchy on advance plan to decrease waste (+1.64) respecting measured amount into case study 1 and (+1.43) respecting measured amount into case study (2). Further, the outcomes of this research illustrate that joining the two techniques improves the performance of a waste advance plan in manufacturing (+2.80) respecting measured amount into case study (1) and (+1.60) respecting measured amount into case study (2) [18].

3-Research methodology

Relationship matrix is utilized to demonstrate the effect of plant activities that include (inventory, transportation and manufacturing). The effect of each other on the key performance indicarors is assessed and the percentage of contribution in integration of lean and green management is quantified. To achieve the goal of research through an Integration of Lean - Green Management (ILGM) , research methodology is developed as shown in Figure (1). Manufacturing activities are conjugated with other important activities as inventory where in each step of manufacturing processes as raw materials, semi-finished, or finished goods inventerios are required. Since materials are dynamic vary in their transportation cost and times, thus material motion (transportation) is an essential activity to shift the inventories, raw material, semifinished and finished product from one step to another in manufacturing processes.These activites are all integrated in this methodology.Two performance measurments are interchangeably used to evalute Lean green management toward waste management.

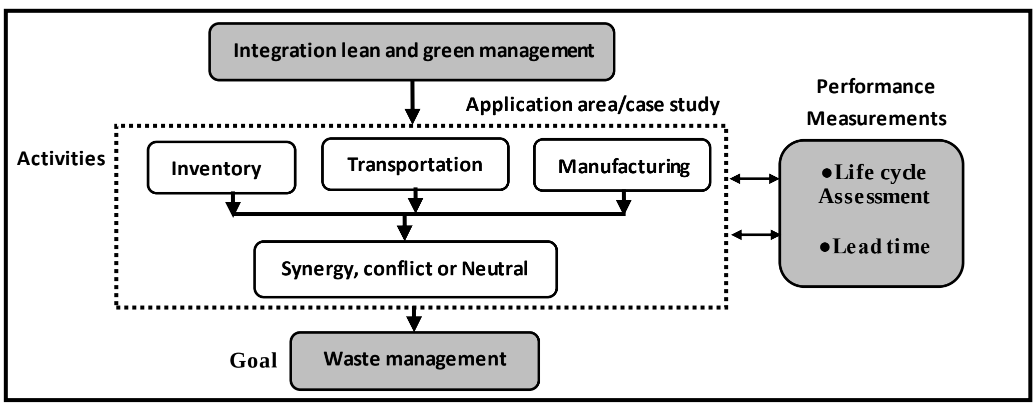

Figure.1. Developed Methodology of Integration Lean - Green management

4- Data collection and Analysis

There are (21) factories of Cement in Iraq, of production approximately (12 million) Tons on 2015 year, while the local demand is (18) million Tons per year. AL- Kufa Cement Plant is one of these plants that produce different types of Cement such as regular, resistant (currently is producing resistant) throughout wet process as this plant suffers from different waste types. Activities that represent inventory, transportation and manufacturing are considered. The environmental impact of manufacturing activities are measured using Life Cycle Assessment (LCA) and Eco-95 indicator identify the environmental impact of the above activities. Also lead time is used as operational performance indicator as the goal of research methodology is waste management. Flow diagram of AL-Kufa Cement plant and brief description of each process are shown in Figure (2), and Table (1) respectively.

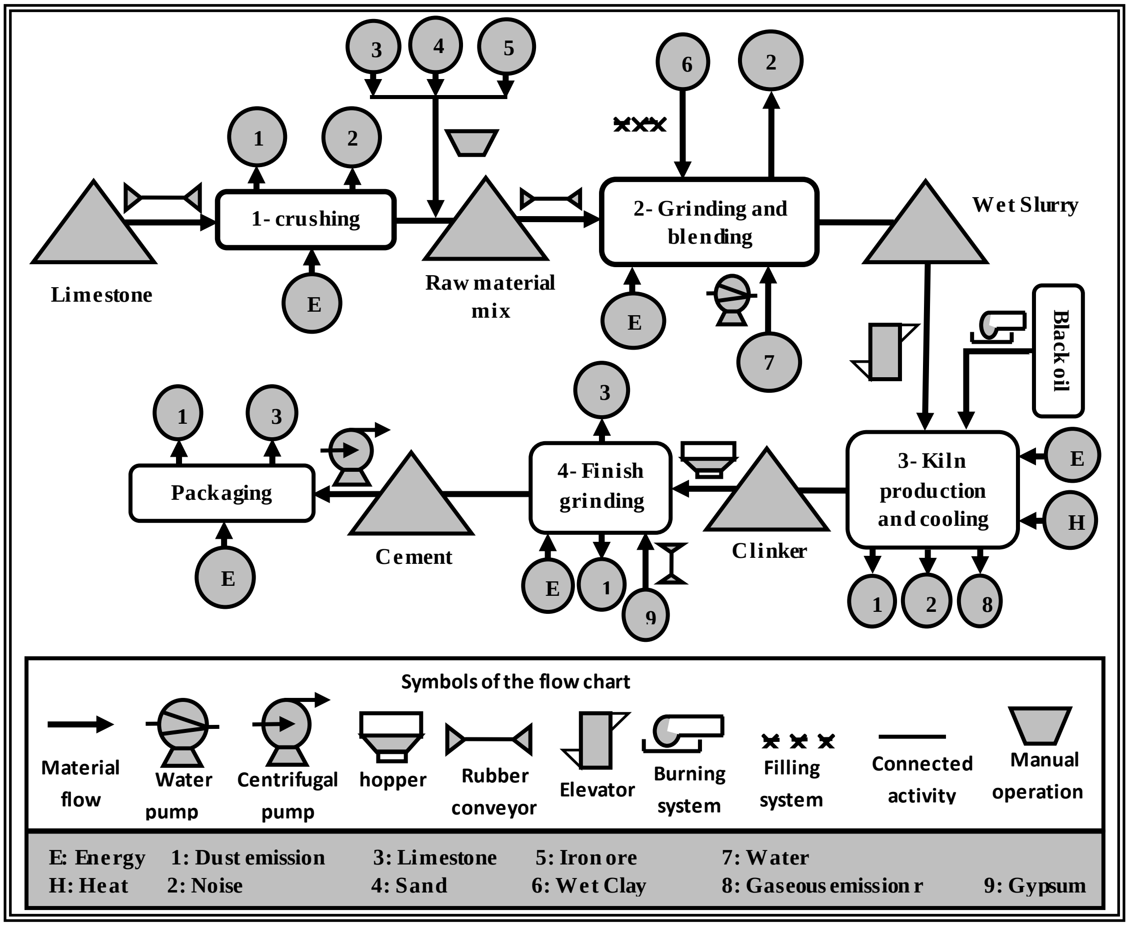

Figure 2. Flow Chart of AL-Kufa Wet Cement Manufacturing

Table 1. Brief Description of Al-Kufa Wet Cement Manufacturing

Process	Process Descriptión
1- Crushing	Limestone is broken and then transformed by conveyer belt to bring it to the plant.
2- Grinding and blending	Limestone, Clay, Sand, Iron Ore and Water are entered to grinding and blending machine with a particular percentage for each it to obtain wet slurry.
3- Kiln production and cooling	Wet slurry is fed to the rotary kiln to obtain Clinker that is passed through cooling systemto reduce temperature up to 150 C^{o}.
4- Finish grinding	Clinker with a particular percentage of Gypsum is fed to finish milling so as to obtain cement that is pumped to the packaging silos in order to be distributed.

5- Results Analysis

Through relationship matrix below Table(2) where synergy,conflict and neutal attibutes are depicted through out the activites of Al-kufa Cement manufacting plant.This table shows that the inventory is positively affected by the following processes: grinding and blending, and finish grinding (synergy) and negatively affect lean-green management through kiln production and cooling as shown in Table (2). Through this relationship matrix the transportation activities almost positively affect by crushing, grinding and blending,and kiln production and cooling. Through relationship matrix the manufacturing processes is negatively affected by crushing and finish grinding from lean and green managemen prespective. Whereas, the manufacturing processes are not affected by grinding and blending (neutral). Finally, the manufacturing is positively affected by kiln production and cooling as shown in Table (2).

Table 2. Effect of AL-Kufa Cement Plant Activities on Lean Green Management

Activities	**Management / Processes**	**Lean**	**Green**	**Attributes**
Inventory	**crushing**	–	–	**neutral**
	Grinding and blending	↑	↓	**conflict**
	Kiln production and cooling	↓	↓	**synergy**
	Finish grinding	↑	↓	**conflict**
Transportation	**crushing**	↑	↓	**conflict**
	Grinding and blending	↑	↓	**conflict**
	Kiln production and cooling	↑	–	**synergy**
	Finish grinding	↓	↑	**conflict**
Manufacturing	**crushing**	↓	–	**synergy**
	Grinding and blending	–	–	**neutral**
	Kiln production and cooling	↑	↑	**synergy**
	Finish grinding	↓	↑	**conflict**
Legend: ↑ increase; ↓ decrease; – no effect				

The effect of all activities that represent manufacturing processes, inventory and transportation through lean and green management perspective that is shown in Table (3) below, with their relative explanation, and symbols. While the graphical representation of lean Vs. green management activities are shown in Figure (3) below. Table (4) classified the overall results of each activity according to (synergy, conflict and neutral) attributes. The overall contribution to integration of lean and green management is assessed throughout Table (5).

Table 3. Ranking Values of Lean Green Management Attributes and Their Relative Symbols

Ranking Value	Relative Representation	Symbols
-4	Synergy	S1
-4	Conflict	C1
-2	Synergy	S2
0	Neutral	N
2	Synergy	S3
4	Conflict	C2
4	Synergy	S4

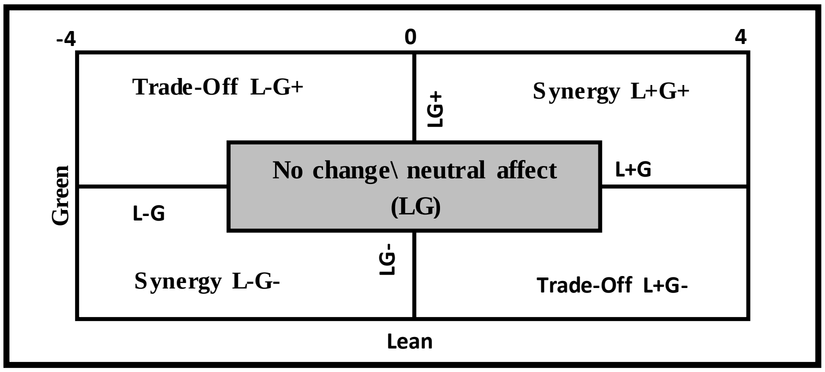

Figure 3. Lean Vs. Green Management Activities

Table 4. Activities Share Towards Lean green management

Activities\ Processes	Inventory		Trnsportation		Manufacturing	
	Overall result	LG paradigm %	Overall result	LG paradigm %	Overall result	LG paradigm %
Crushing	N	0	C_2	11.11	S2	5.56
Grinding and Blending	C_2	11.11	C_2	11.11	N	0
Kiln production and cooling	S_1	5.56	S_3	5.56	S4	11.11
Finish grinding	C_2	11.11	C1	11.11	C_1	11.11

Table 5. Overall Contribution in Integration Lean -Green Management

Overall effect	ILG paradigm %	frequency	Overall effect	ILG paradigm %
synergy	33.34	1	Synergy	33.33
		1		
		1		
		1		
conflict	66.66	2	Conflict	50.00
		4		
neutral	0	2	Neutral	16.67

6- Discussion

From Figure (4) Pie chart as statistical graphical tool that is divided into slices to illustrate numerical proportion that demonstrate the overall effect rate of activities with their contribution percentage related to the integration of lean and green management. Firstly, the synergy Pie chart (A: 4) of percentages of 9.72 %, 6.95 %, 16.67 % with respect to inventories, transportation and manufacturing respectively showing the highest synergy toward inventories. Secondly the conflict Pie chart (B: 4) with percentages of 19.44 %, 29.16 %, 9.72 % relative to inventories, transportation and manufacturing respectively whereas, the highest conflict is related to. Finally, the neutral Pie chart (C: 4) of inventory and manufacturing activities with equal percentages of contribution towards lean green management if 4.17 %, 4.17 % to inventories and manufacturing, where no existence of neutral attributes of transportation activities throughout Al-Kufa cement Plant.

Two key performance measuermements are emploed, environmental[Life Cycle Assessment (LCA)], and operational[Lead Time (LT)] performances. Life cycle assessment is employed and the environmental impact of Cement product according to Eco-indicator 95 is quantified. Where Eco-95 classify the environmental impact into four emission factors are Particulate Matter (PM), CO_2 , SO_2 , NOx and four categories are [Eutrophication (E), Acidification (A), Greenhouse effect (Ge), Winter Smog (Wg)].

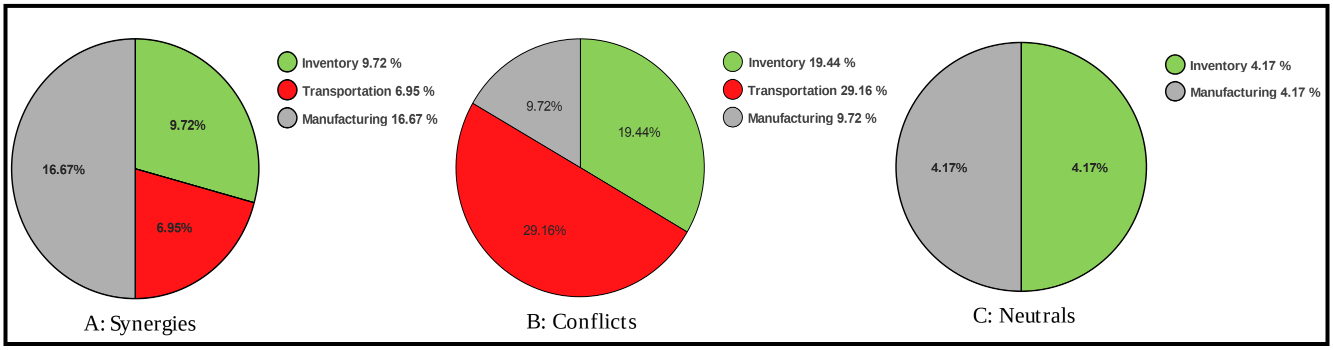

Figure 4. Pie Chart For Lean Green Management Attributes

Wastes from different manufacturing activities are generated to air as (618942) Tons of Cement is produced during year 2015 is shown in Table (6) in accordance to Medgar L, et.,al., [19]. Calculations of Air emissions kg/Ton ,emission rates , and characterization factors as shown in Tables (6, 7, 8, and 9) respectively. The results are represented with the percentages of contribution that may hinder the integration of lean - green management as shown in Figures (5, and 6) respectively. From Tables (6,8), the emission CO_2 to air is totally due to kiln production and cooling process that affect global warming , and is classified according to Eco-95 later to be included in greenhouse category. Also the data in Table 6, and 7 shows the major emissions to air are related to kiln production and cooling process. It worth's mentioning that Particular Matter (PM) values are multiplied by the precipitants efficiency of 82% for kiln production and cooling process, for finish grinding process, is 73 % at AL-Kufa Cement plant.

Table 6. Air Emission from Al-Kufa Cement Manufacturing (year 2015)

Process	Emission factor (Kg/Ton of Cement)			
	PM[19]	CO_2	SO2	NOx
Crushing	2.284	----	----	----
Grinding and blending	0.027	----	----	----
Kiln production and cooling	0.280	0.132	0.064	0.030
Finish grinding	0.025	----	----	----

Table 7. Emission Rates of Cement Manufacturing

Process	Emission Rate (Tons)			
	PM	CO_2	SO_2	NOx
Crushing	1414	----	----	----
Grinding and blending	17	---	----	----
Kiln production and cooling	31	82	40	19
Finish grinding	4	----	----	----
Total	1466	82	40	19

Table 8. Characterization Factors for Cement Manufacturing

Emissions	Characterization factor (Kg/Ton of cement)			
	Eutrophication	Acidification	Greenhouse effect	Winter smog
PM	----	----	----	1
CO_2	----	----	1	----
SO_2	1	----	----	1
NOx	0.13	0.7	----	----

Table 9. Environmental Impacts Categories for Cement Manufacturing

Emission	Environmental Impact Categories			
	Eutrophication	Acidification	Greenhouse effect	Winter smog
PM	----	----	----	1466
CO_2	----	----	82	----
SO_2	40	----	----	40
NOx	3	13	----	----
Total	43	13	82	1506
Contribution	2.62	0.790	4.99	91.60

Figure (5) illustrates contribution of effects are Eutrophication, Acidification, , Greenhouse effect, and Winter Smog in which the Winter Smog effect has major environmental contribution of 91.60 %. Figure (6) shows the damage contribution to ecosystem impairment (Ei) and human Health impairment (Hi) where the human health impairment has major value is 91.60 %.

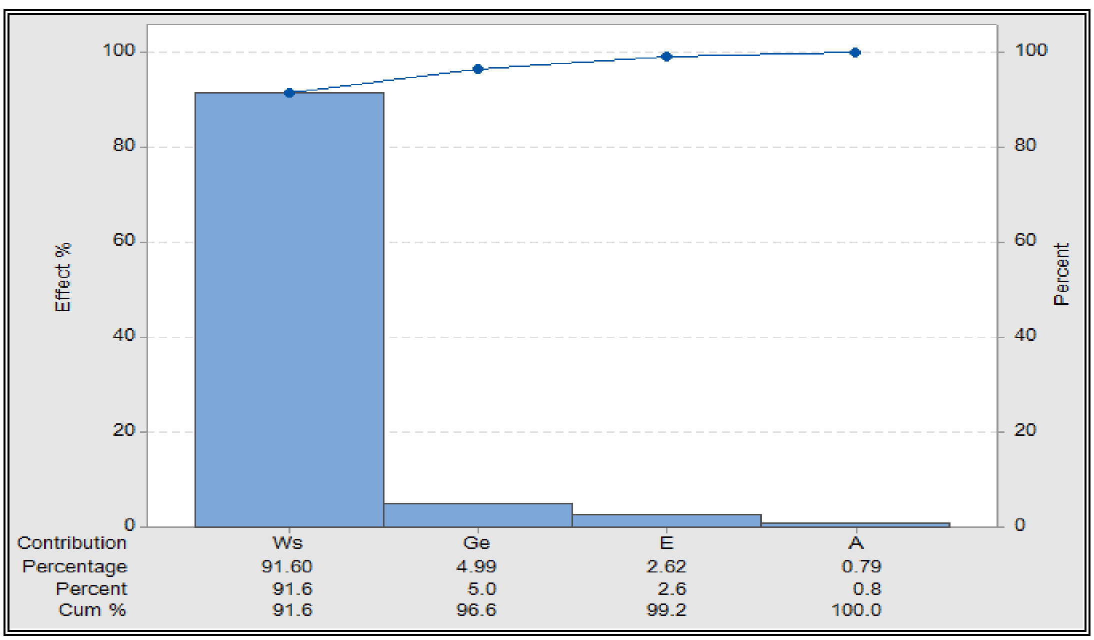

Figure 5. Contribution of Eutrophication, Acidification, , Greenhouse and Winter Smog Impact.

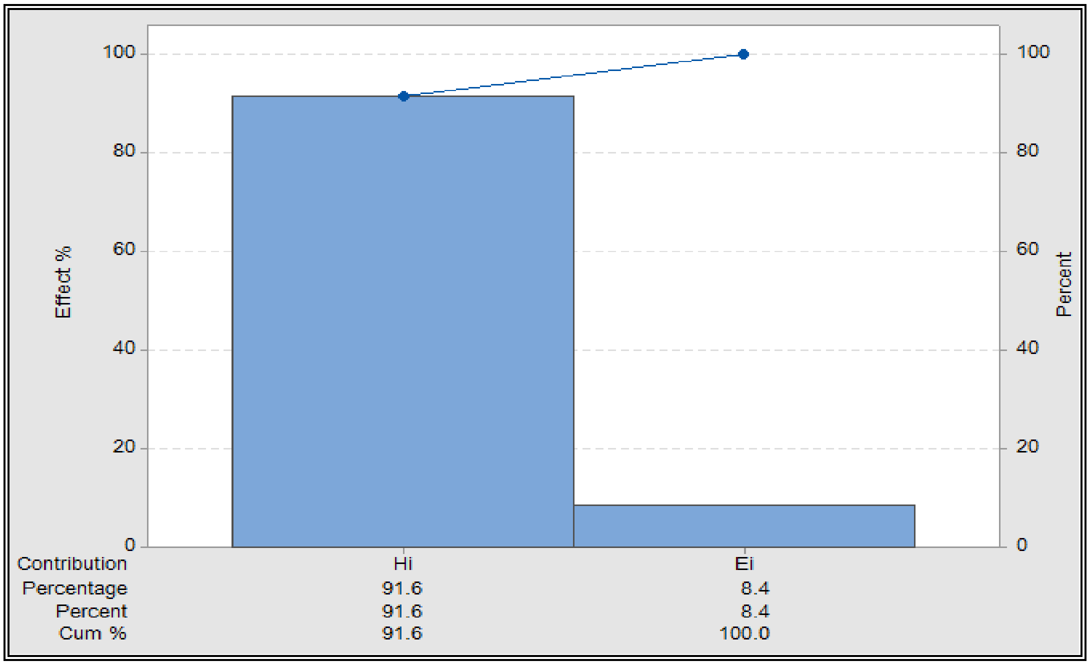

Figure 6. Contribution of Damage to Ecosystem and Human Health Impact

Value Stream Mapping (VSM) is used to assess the production lead time and processing time (needed time) though Cement manufacturing processes to produce 1719 Tons of Cement as shown in Figure (7). These values of VSM are collected for year 205,and listed in Table (10) in order to assess Waste time. From this Figure the largest total idle time is 88 hrs where the highest value (49 hrs) relative to 56 % contribution is before Kiln production and cooling.

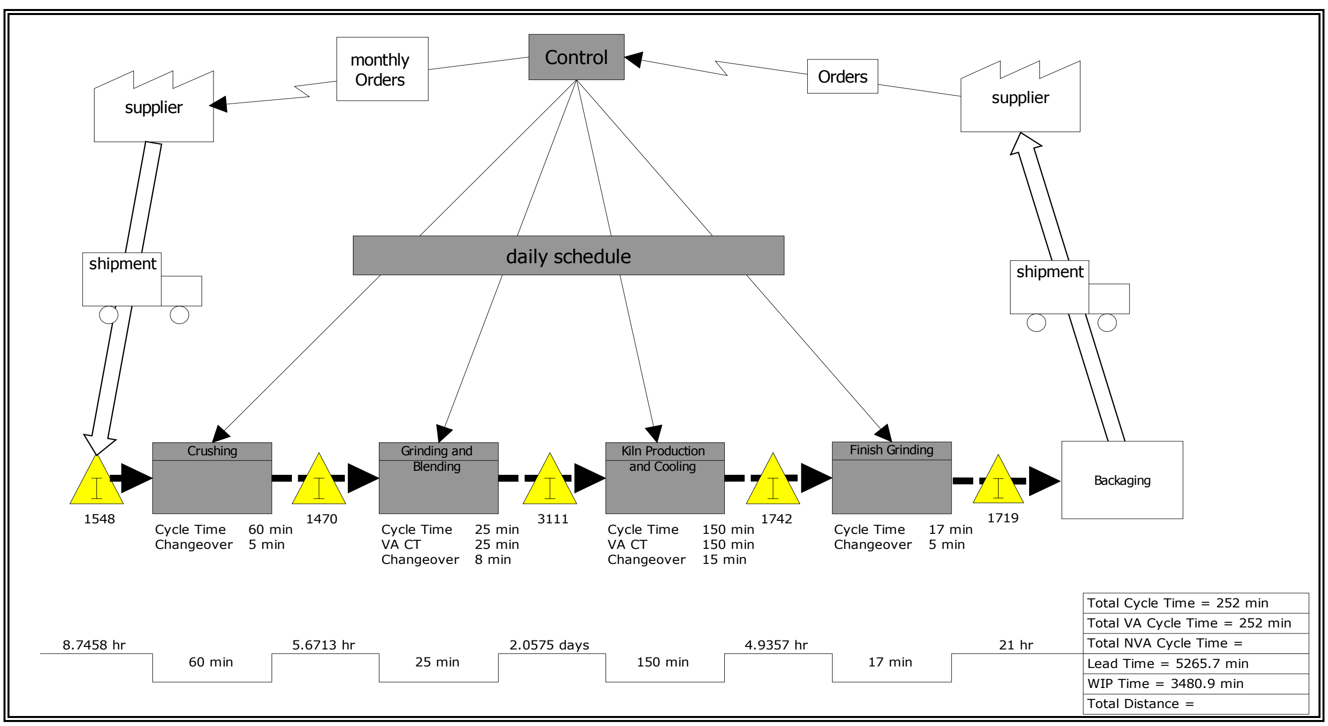

Figure 7. Value Stream Mapping of AL-Kufa Cement Manufacturing

Table 10. Lead, Waste, Needed time in AL-Kufa Cement plant

Processes	Crushing (C)	Grinding and blending (Gb)	Kiln production and cooling (Kpc)	Finish grinding (Fg)
Lead time (hors)	3433.62	18686.24	22184	12356.55
Needed time (hours)	3108	14786	18162	8973
Waste time (hours)	325.62	3900.24	4022	3383.55

From Table (10) Pareto chart is used to prioritize the waste time according to each process as shown in Fig.(8).This Fig shows that the major contribution in wasted time is almost equal through kiln production and cooling process, and grinding and blending processes of 34.6%,and 33.5% respectively ,followed by finish grinding process of 29% ,while crushing process wastage represents only 2% as shown in Figure (8). According to Table (6) kiln production and cooling has also the major effect towards the four environmental categories therefore, it is concluded that the major challenge toward lean green integration is this production process. Thus, the possible efforts should be directed toward mending and curing the wastage throughout this process thus improving the contribution towards lean green management integration.

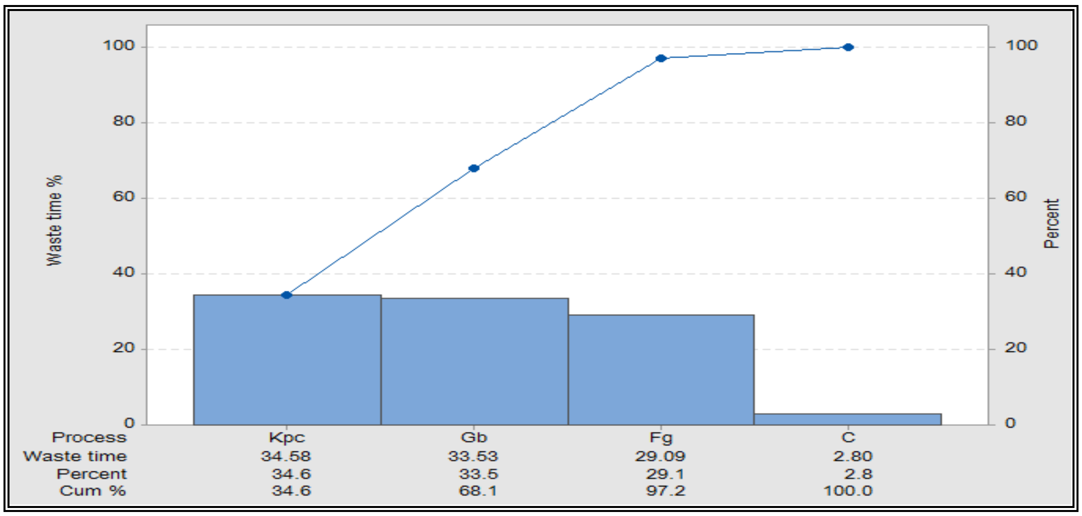

Figure 8. Contribution of Each Manufacturing Process in Waste Time

7- Conclusions and Further Recommendations

1-Synergies (S) between the Cement manufacturing processes and attributes from lean and green paradigm that will contribute to the integration of lean green paradigm is equal to 33.33 %. While conflicts (C) between the Cement manufacturing processes and attributes from lean and green paradigm is equal to 50 %. The rest proportion of neutral (N) between the Cement manufacturing processes and attributes from lean and green paradigm is equal to 16.67 %.

2- Transportation activities are accounted as the major conflict towards lean green integration by50% against both manufacturing and inventories activities.

3. Major contribution in wasted time is almost equal through kiln production and cooling, and grinding and blending processes of 34.6%, and 33.5% respectively, followed by finish grinding process of 29%, while crushing process time wastage represents only 2 %.

4- Although crushing process has the lowest waste time during production but this process has the major effect towards the four environmental categories, where the human health impairment has major damage 91.60%.

It is recommended to develop systems that control the damage throughout kiln production and crushing processes, also further researches should employ other performance measurements to investigate and assess different other aspects of lean -green management integration.

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