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A Study on Degree of Importance of Green Manufacturing Elements in Production Sectors using Statistical Approach

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Abstract: The word Green has been started to ring all over the world and it has made the production sectors to whirl around the concept of Green manufacturing (GM), an emerging tool of environmental sustenance in this present scenario. The doors of the customers are always in open state for the products made out of GM which is a manifestation of several elements. GM is an environmental oriented aspect that indeed gains the belief of the customers by adding glow to the product which altogether contributes to the core constituents of production sectors (PS). In recent days almost all the production companies are employing the elements of GM to keep them refrain from rigid environmental regulations. The prime motive of practicing GM by the PS is to minimize the generation of waste and promote environmental sustainability. The rate of Product Production Process depends on the inventory at hand, which vividly states that a suitable framework for the formulation of economic production inventory model incorporating the cost parameters of GM has to be implemented. To achieve it the elements of GM that has high importance on PS have to be analyzed so that the prime elements and its associated costs estimators can be added to inventory model. This research is intended at devising an environmental production quantity mode and it strongly emphasize that green manufacturing will become one of the production sector's greatest strategic challenges from business and marketing perspective.

Key words: Green manufacturing · Production sectors · Degree of importance · Inventory model

INTRODUCTION

Presently the PS are bounded with strict enforcement of laws that foster them to imbibe novel techniques for their production. As PS bear the great responsibility of satisfying the demand of the customers and promoting the environmental sustainability, they plan sustainable programs for their production to decrease the impact of their activities. To implement their environmental plans an appropriate scaffold has to be laid and the most fitting one is Green Manufacturing, an environmental technology which minimizes human and ecological risks; increases cost effectiveness; accelerates process efficiency; designs products and processes that are environmentally useful. The motive of industrial sectors is cost minimization and profit maximization, though GM is mandatory in these days, they feel that employing it, is not easy as inculcation of innovative technology and its related costs of execution may hurdle their usual process. There are many reasons for it in accordance to the sectors. GM is not a single aspect whereas it is an embodiment of many elements which focus on possible ways of channelizing the environmental strategies.

For the successful run of PS inventory at hand is essential, to determine the optimal order quantity and the time of ordering inventory model is formulated. The total cost function of the model comprises of costs such

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as ordering, purchasing, producing, processing and holding. Product nature decides these costs, therefore GM incorporating costs must also be included to devise green inventory model. The elements of GM are many in number, not all can be implemented, but the important elements and its allied costs should be included in the total costs function for a global outcome.

This research work briefly discusses about the elements of GM and determines the importance of it. The paper is organized as follows: section 2 briefs the literature review; section 3 explains the elements of GM; section 4 elucidates the methodology; section 5 discusses the results of the collected data and section 6 concludes the paper.

Literature Review: The economic order quantity (EOQ) model was first developed by Harris [1] in 1920s which was later extended as economic production quantity (EPQ) models by replacing the assumption of simultaneous replenishment by the one that replenishment order is received at a constant finite rate over time. A wide range of advancement in the development of inventory models took place with the motive of withstanding the challenges faced in the competitive and complex markets. Juan has presented a brief description about various EOQ and EPQ models that reflect the needs of manufacture and logistics. Researchers modified the economic centered inventory models by the inclusion of various costs such as backorder cost Teunter [2], inspection costs Ben –Dayo *et al*. [3], shortage costs Jason *et al*. [4], switching costs Ahmed *et al*. [5], etc to the classical costs components of EOQ model (costs of ordering, purchasing and holding). They also designed inventory models to handle the situations of deteiorating items Gede *et al*. [6], ameliorating items Heung, [7], imperfect items Salameh *et al*. [8]. Also the financial concept 'trade credit' is merged with inventory models to facilitate smooth relationship between the retailers and customers Yong *et al*. [9]. Thus many inventory models were formulated which benefited the manufacturing firms by all means. Later as the environmental issues started surfacing and becoming a public concern Richter picked up the problem of Schrady Schrady [10] who had developed an EOQ model with instantaneous production, repair rate and no disposal and discussed the same with disposal Richter [11]. Generally the items that are produced are expected to be of good quality, but due to certain inevitable reasons defects occur which are rectified by subjecting those defective items to remanufacturing sector. But it is not possible to repair all the defects, so the share of the products not provided for repair is called waste disposal rate Richter [12]. This is how the environmental oriented inventory models originated. The economic centered inventory models get transformed to environmentally sustainable inventory models with the inclusion of the environmental costs. Based on the corporate environment protection responsibility, Huang Jing has given a complete definition of Environmental Costs Huang jing *et al*. [13]. In precise Environmental Costs of a firm relates to all costs incurred in its relation to environmental damage and protection. More specifically it comprises of the costs associated in dealing with waste and emission treatment. In a case study of environmental management accounting (EMA) the environmental costs in a Canadian paper mill was estimated. In their analysis waste and emission treatment was one of the four main costs categories which had further seven sub cost categories such as Depreciation for related equipment, Maintenance of operating materials and services, Related personnel, Fees, taxes and charges, Fines and penalties, Insurance for environmental liabilities, Provisions for cleanup costs and remediation Robert *et al*. [14]. In addition to the above mentioned costs the other associated costs of waste treatment and disposal costs are the rental coss of the containers used for the separation of waste and the sewage costs of the effluents Hermine *et al*. [15] Therefore it is very clear that the environmental costs mainly comprise of pollution abatement costs which are the costs associated with waste treatment to promote pollution free environment. Maurice has formulated an environmentally responsible inventory model which comprises of social cost Maurice *et al*. [16] Manish *et al*. [17] Nivetha *et al*. [18]. These inventory models comprise of waste mitigation costs but they have not focused on GM processes. The origin of the concept of GM has started from 1990s, since it is a recently blossomed phenomenon the studies on it are few. Christine [19] has discussed the overall notion of GM highlighting on it, followed by him many researchers have presented another structure of GM in various dimensions and also a wide range of analytical tools such as Life cycle analysis, design for the environment, screening methods and risk analysis to present the conception of GM in a different form Pauleo *et al*. [19]. This research work is carried out to integrate GM with inventory model and to determine the core element of GM to be included in inventory model which is a step for creating green environment.

Elements of Green Manufacturing:

Table 3.1: Elements of GM

S.No	Green Manufacturing Elements	Detail
1.	Waste Management	The concept of waste has double meaning. It includes both non – marketable product and non – product output. Non-marketable product accounts to the material that don't enter the production process and the products that are unfit for repair. Non – product output comprises of solid waste, waste water and air emissions.
2.	Pollution Mitigation	The industrial sectors are the major source of pollution and its hazardous effects must be minimized.
3.	Environment Sustainability	It involves making responsible that will reduce the business's negative impact on the environment.
4.	Eco-efficiency	It focuses on delivery of goods and services to satisfy the customers by reducing the ecological impacts.
5.	Eco Design	It is an approach of designing a product compatible to the environment
6.	Product Quality Sustenance	It is an act or process of sustaining the quality of the product.
7.	Credibility of the customers to the product	The quality of being trusted by the customers is much important for propagating it.
8.	Healthy life style	The greener process will pave way for better life style
9.	Reliability of the customers	The consistency for continuous persistence of purchase
10.	Cost Effectiveness	Producing the product without costing a lot of money
11.	Use of modern technology	Application of innovative and novel tactics for production
12.	Cleaner Production	It is a preventive, company – specific environmental protection initiative
13.	Green Engineering	It refers to the design, commercialization and use of processes and products that are feasible and economical to minimize the harmful effects to human health and the environment
14.	Eco Audit	Systematic assessment of organization's operations
15.	Carbon Foot printing	It is a tool that indicates the green house gas emissions, amount of fossil fuels, carbon emission usage.
16.	Life Cycle Assessment	It provides the estimation of cumulative environmental impacts that being obtained from all the stages of product's life
17.	Design for the Environment	It is an approach to reduce the overall human health and environmental impact of a product and process
18.	Environmental management system	It is a step to ensure well management of environmental activities of the production sectors
19.	Environmental impact Analysis	It is to analyze the impact of environmental effects.
20.	Ecology Sustenance	To Maintain the ecological frame work

MATERIALS AND METHODS

The necessary elements of GM have to be identified for further development of the inventory model. The steps that are involved in this methodology are

- Research Design
- Instrument
- Survey participants
- Data Collection and
- Data Analysis

Let us see the above steps in brief as follows

Research Design: This study employed non-experimental quantitative research. Specifically, the design involves mail survey method which is the most frequently used descriptive research design. This research design requires responses from production sectors personnel and further requires quantitative data analyses. To increase the internal and external validity, the sampling procedure in this study applied the stratified random sampling technique.

Instrument: A survey was designed to find out the most important elements of GM which are easy to implement in production sectors. The survey consists of comparison based on following common parameters. The parameters are waste management, environmental sustainability, eco design.

Survey Participants: A questionnaire regarding the importance of GM elements was designed and distributed/ mailed in various production sectors. This study uses a mail survey to distribute and gather data. A mail survey provides the most appropriate method to obtain relevant, up-to-date information from a large number of production sectors.

Data Collection: Data were collected following the self-administered mail survey method. Self administered mail survey has the advantages of relatively low cost and easy access to widely dispersed samples. These people were also assumed aware of the general characteristics of the production sectors.

In mailing, the survey sends with:

- The cover letter that informed an overview of the aim of the survey, identification of the researchers.
- Details of the GM elements chosen for survey.

After sending the questionnaire, the gratitude for their cooperation was conveyed to them.

Data Analysis: The data were analyzed with the help of ANOVA (Analysis of Variance) Technique. The ANOVA technique is important in the context of all those situations where we want to compare more than two populations such as in comparing the yield of fruits from several varieties of seeds. In such circumstances one generally does not want to consider all possible combination of two populations at a time for what would require a great number of tests before we would be able to arrive at a decision.

RESULTS

The questionnaire was distributed in 40 production sectors taking one employee from each production sector at top management level. The questionnaire was collected from all the PS successfully with a very good response. Then the responses were analyzed. The mean score for each element was calculated. Table 5.1 reveals the degree of importance.

The following table gives the mean score 160 of Degree of Importance of GM in PS.

Table 5.1: Degree of Importance of GM elements in Production Sectors

		RESPONSE					
S.No	Green manufacturing elements	4	3	2	1	0	Mean Score (0-160)
1	Waste Management	23	10	6	1	0	135
2	Pollution Mitigation	11	17	11	1	0	118
3	Environment Sustainability	14	18	6	2	0	124
4	Eco-efficiency	5	20	12	3	0	107
5	Eco Design	14	15	9	2	0	121
6	Product Quality Sustenance	13	20	2	5	0	121
7	Credibility of the customers to the product	10	15	13	2	0	113
8	Healthy life style	10	15	14	1	0	114
9	Reliability of the customers	7	20	9	3	1	109
10	Cost Effectiveness	9	13	10	2	6	97
11	Use of modern technology	10	14	10	3	3	105
12	Cleaner Production	7	15	12	5	1	102
13	Green Engineering	11	9	15	4	1	105
14	Eco Audit	9	15	14	1	1	110
15	Carbon Foot printing	4	14	10	8	4	86
16	Life Cycle Assessment	9	10	11	6	4	94
17	Design for the Environment	6	21	10	3	0	110
18	Environmental management system	5	10	17	8	0	92
19	Environmental impact Analysis	5	17	12	5	1	100
20	Ecology Sustenance	9	15	9	5	2	104

CONCLUSION

It is vivid that waste management, environment sustainability, Eco design, product quality sustenance and pollution mitigation are the prime elements of GM. The other important elements are healthy life style, credibility of the customers to the product, eco audit, design for the environment, reliability of the customers, use of modern technology, green engineering, ecology sustenance, cleaner production. The elements of low importance are cost effectiveness, Life Cycle Assessment, Environmental management, Carbon Foot printing.

The costs associated with these prime elements can be incorporated to the inventory model so as to build environmentally oriented model for a global outcome.

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