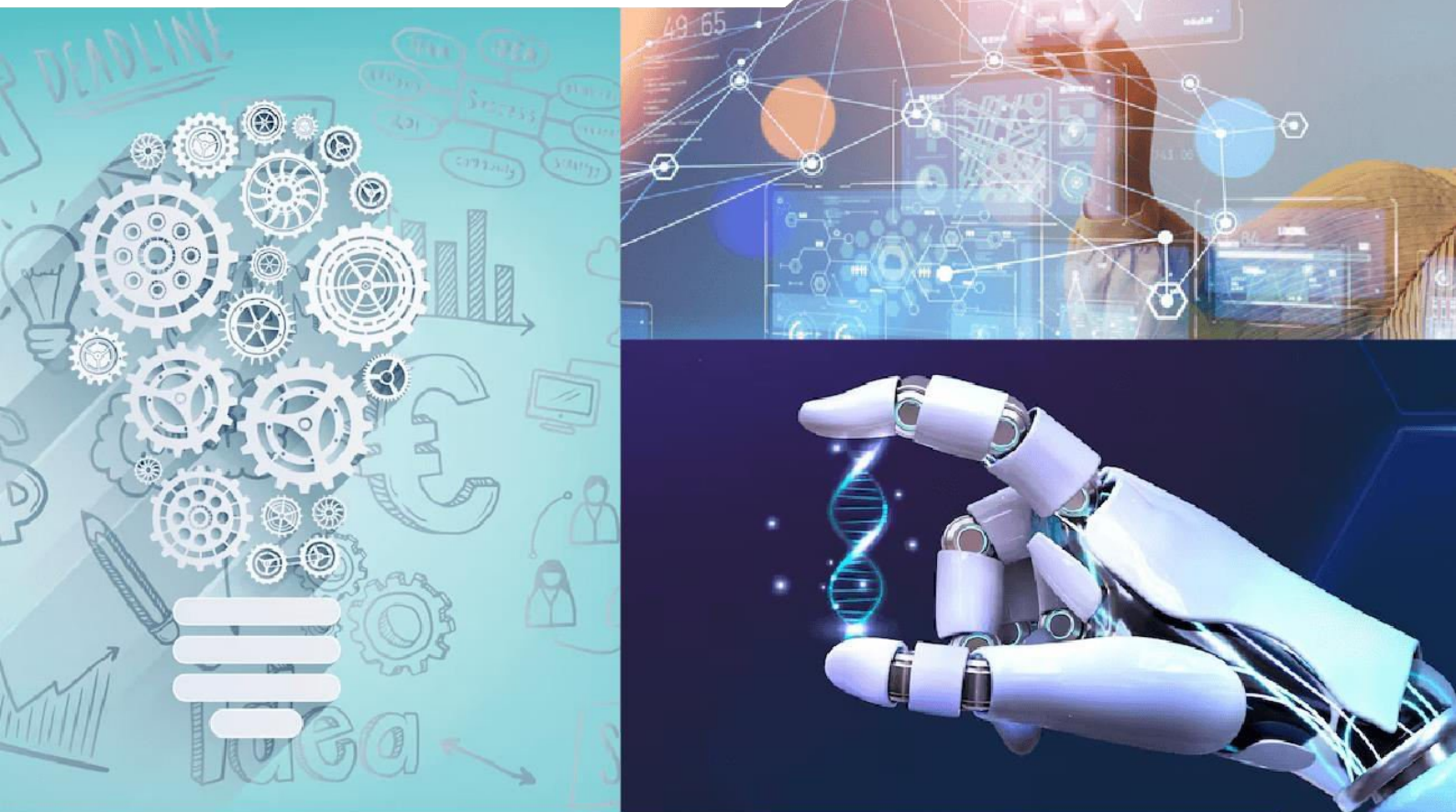




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An Analytical Study on the Impact of Sustainable Green Manufacturing Practices on Waste Management Effectiveness at Sivaramakrishna Forgings Private Limited, Chennai

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ABSTRACT: In recent years, industries are focusing more on eco-friendly methods to reduce environmental impact. This study mainly aims to examine the impact of sustainable green manufacturing practices on waste management effectiveness at SivaramaKrishna Forgings Private Limited, Chennai. It also tries to understand how the company adopts green production technologies in its operations. Further, the study looks into how efficiently resources are used and how energy conservation practices are followed. It evaluates the recycling and reuse initiatives followed in the manufacturing process. Finally, it assesses how effective the overall waste management system is within the company. Descriptive research design and convenience sampling method has been used. The sample size of this study is 120. Questionnaire has been used as a primary data. Simple percentage analysis, chi-square analysis, correlation statistical tools have been applied to reach the findings of the study. It revealed that technologies like automation and IoT support better control of waste and increase efficiency. The findings also indicate that recycling and proper waste management reduce costs over time. It concluded that sustainable practices improve both environmental protection and production performance. It suggested that companies should adopt modern technologies to enhance waste management systems. Keywords: Sustainable Green Manufacturing, Waste Management Effectiveness, Environmental Sustainability, Industrial Waste Reduction.

I. INTRODUCTION

Sustainability in the industrial world has become a significant element of contemporary production in the present competitive business world. Sustainable green manufacturing aim at the manufacturing goods through methods reduce environmental impact, save on natural resources and minimize waste production. Such practices refer to the adoption of energy-efficient technologies in production, optimization of resources, recycling, and reuse efforts and clean production processes. Such practices can be integrated to provide industries with the ability to become operationally efficient and at the same time fulfil environmental duties. The main result of sustainable manufacturing is waste management efficiency. The management of waste should entail proper segregating, recycling, re-using and disposing industrial waste in a safe manner that will reduce environmental pollution. The conventional manufacturing process has been known to produce a lot of waste, has a low level of segregation and it also has a low level of disposal modes resulting to environmental risks and increase in cost of operation. The innovative methods such as recycling systems, intelligent monitoring technologies, and energy recovery methods have enhanced the handling of industrial wastes and minimized the negative impact of the waste on the environment. The connection between green manufacturing practices that are sustainable and waste management efficiency is not new. Green production technologies result in waste reduction through waste generation at the source, optimization of resources through resource, and recycling and reusing initiatives through converting by-products into useful materials. The efficiency of the waste management systems is also augmented by the pollution prevention and technological integration. All these practices not only contribute to regulatory compliance, but also environmental sustainability and long term economic gains to industries.

OBJECTIVES OF THE STUDY

- To analyze the green production technology adoption in the company
- To examine the resource efficiency and energy conservation practices in the company
- To evaluate the recycling and reuse initiatives in manufacturing process in the company
- To assess the waste management effectiveness in the company

II. REVIEW OF LITERATURE

Gupta et al. (2025) explored the issue of integrating Lean and Sustainable Manufacturing practices to determine their effect on competitiveness and sustainability performance of Indian manufacturing industries. The research design employed a quantitative cross sectional study and a purposive sample of industry stakeholders as the sample where the data were gathered through structured questionnaires. Findings showed that stakeholder commitment is an important determinant of combined adoption of lean and sustainable practices, which subsequently leads to better environmental and market competitiveness outcomes. Manufacturing companies were proposed to optimize the lean approach and green practices to enhance the utilization of resources, minimize wastes, and enhance operations efficiency. The research also established that lean and sustainable manufacturing have synergy that enhances performance and helps in establishing more sustainable production systems in the developing economies.

Liu, Yousaf, & Rosak-Szyrocka (2024) into the integrated impact of green supply chain management practice, green innovation and zero waste management on environmental performance in manufacturing companies. The research was intended to determine relationships between these green practices and their applicability to sustainability results. The survey was used to collect data through 389 manufacturing managers and analysis of the data was conducted using SPSS and PLS SEM and purposive sampling was employed in a quantitative research approach. Findings showed that there were high positive correlations between GSCM practices, zero waste management, green innovation, and better environmental performance.

Muñoz & colleagues (2022) examined sustainable waste management approaches in manufacturing settings by studying how the concepts of the circular economy and sustainable systems can be used to attain waste minimization and sustainability performance in product lifecycles. Through quantitative content analysis of empirical evidence and individual case studies, the paper found important phases at which waste can be better controlled, such as production and consumption, disposal, and noticed such practices as recycling, reuse, and recovery of resources. The study was done on the basis of the quantitative research design which was cross sectional and based on secondary data sources such as product lifecycle reports and manufacturing reports. The results demonstrated that the combination of circular management solutions has a positive effect on waste outcomes and environmental performance. The authors proposed that policymakers and manufacture leaders must follow holistic approaches to the circular to improve waste management performance.

III. RESEARCH METHODOLOGY

This study adopts a descriptive research design. Convenience sampling is adopted in this study. Both primary data and secondary data are applied to the study. The size of the sample to be used in this study is 120 respondents. Simple percentage analysis, chi square analysis and correlation has been used in this study.

Data analysis and interpretation**Table No. 1 GREEN PRODUCTION TECHNOLOGY ADOPTION**

Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Solar-powered energy systems are utilized to support sustainable manufacturing activities	35 (29.2%)	45 (37.5%)	20 (16.7%)	12 (10%)	8 (6.6%)	120 (100%)
Automated process control systems are implemented to minimize material waste during production	40 (33.3%)	50 (41.7%)	15 (12.5%)	10 (8.3%)	5 (4.2%)	120 (100%)
Waste heat recovery technology	30	48 (40%)	22	12	8	120

is used to improve energy efficiency in manufacturing processes	(25%)		(18.3%)	(10%)	(6.7%)	(100%)
IoT-based smart monitoring systems are adopted to track energy usage and reduce resource wastage	38 (31.7%)	52 (43.3%)	14 (11.7%)	10 (8.3%)	6 (5%)	120 (100%)
Computer-aided manufacturing (CAM) technology is used to optimize production processes and reduce material waste	42 (35%)	46 (38.3%)	16 (13.3%)	10 (8.3%)	6 (5%)	120(100 %)

Source: Primary data

Interpretation: Respondents indicate that 29.2% strongly agree and 37.5% agree that solar-powered energy systems are utilized to support sustainable manufacturing, while 16.7% are neutral, 10% disagree, and 6.6% strongly disagree. Regarding the implementation of automated process control systems, 33.3% strongly agree and 41.7% agree, with 12.5% neutral, 8.3% disagree, and 4.2% strongly disagree. For waste heat recovery technology, 25% strongly agree and 40% agree, while 18.3% are neutral, 10% disagree, and 6.7% strongly disagree. In terms of IoT-based smart monitoring systems, 31.7% strongly agree and 43.3% agree, with 11.7% neutral, 8.3% disagree, and 5% strongly disagree. Concerning the use of computer-aided manufacturing technology, 35% strongly agree and 38.3% agree, while 13.3% are neutral, 8.3% disagree, and 5% strongly disagree. Overall, the majority of respondents express positive perceptions toward the adoption of green production technologies, indicating a strong emphasis on sustainability, efficient resource utilization, and environmentally responsible manufacturing practices.

Table No. 2 WASTE MANAGEMENT EFFECTIVENESS

Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Efficient waste management practices contribute to sustainable manufacturing operations	38 (31.7%)	50 (41.7%)	16 (13.3%)	10 (8.3%)	6 (5%)	120 (100%)
Sustainable waste management practices support long-term environmental protection	40 (33.3%)	48 (40%)	18 (15%)	8 (6.7%)	6 (5%)	120 (100%)
Waste reduction strategies improve environmental performance in the organization	36 (30%)	52 (43.3%)	14 (11.7%)	10 (8.3%)	8 (6.7%)	120 (100%)
Proper handling of industrial waste reduces environmental pollution	42 (35%)	46 (38.3%)	16 (13.3%)	8 (6.7%)	8 (6.7%)	120 (100%)
Waste management systems improve the overall efficiency of production processes	34 (28.3%)	50 (41.7%)	18 (15%)	10 (8.3%)	8 (6.7%)	120 (100%)

Source: Primary data

Interpretation: Respondents show that 31.7% strongly agree and 41.7% agree that efficient waste management practices contribute to sustainable manufacturing operations, while 13.3% are neutral, 8.3% disagree, and 5% strongly disagree. Regarding the role of sustainable waste management in long-term environmental protection, 33.3% strongly agree and 40% agree, with 15% neutral, 6.7% disagree, and 5% strongly disagree. For waste reduction strategies, 30% strongly agree and 43.3% agree, while 11.7% are neutral, 8.3% disagree, and 6.7% strongly disagree. In terms of proper handling of industrial waste, 35% strongly agree and 38.3% agree, with 13.3% neutral, 6.7% disagree, and 6.7%

strongly disagree. Concerning the effectiveness of waste management systems in improving production efficiency, 28.3% strongly agree and 41.7% agree, while 15% are neutral, 8.3% disagree, and 6.7% strongly disagree. Overall, the majority of respondents hold positive views on waste management effectiveness, indicating that such practices play a significant role in enhancing environmental sustainability and improving operational efficiency within the organization.

Table No.3 RESOURCE EFFICIENCY AND ENERGY CONSERVATION PRACTICES

Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Energy-efficient systems are implemented in manufacturing operations	36 (30%)	50 (41.7%)	18 (15%)	10 (8.3%)	6 (5%)	120 (100%)
Monitoring of energy consumption is regularly conducted in the production process	38 (31.7%)	48 (40%)	16 (13.3%)	10 (8.3%)	8 (6.7%)	120 (100%)
Resource conservation strategies are integrated into manufacturing activities	34 (28.3%)	52 (43.3%)	18 (15%)	10 (8.3%)	6 (5%)	120 (100%)
Efficient utilization of raw materials is encouraged to reduce production waste	40 (33.3%)	46 (38.3%)	18 (15%)	8 (6.7%)	8 (6.7%)	120 (100%)
Manufacturing processes are designed to minimize excessive use of resources	37 (30.8%)	49 (40.8%)	17 (14.2%)	9 (7.5%)	8 (6.7%)	120 (100%)

Source: Primary data

Interpretation: Respondents indicate that 30% strongly agree and 41.7% agree that energy-efficient systems are implemented in manufacturing operations, while 15% are neutral, 8.3% disagree, and 5% strongly disagree. Regarding the regular monitoring of energy consumption, 31.7% strongly agree and 40% agree, with 13.3% neutral, 8.3% disagree, and 6.7% strongly disagree. For the integration of resource conservation strategies, 28.3% strongly agree and 43.3% agree, while 15% are neutral, 8.3% disagree, and 5% strongly disagree. In terms of efficient utilization of raw materials, 33.3% strongly agree and 38.3% agree, with 15% neutral, 6.7% disagree, and 6.7% strongly disagree. Concerning the design of manufacturing processes to minimize excessive resource use, 30.8% strongly agree and 40.8% agree, while 14.2% are neutral, 7.5% disagree, and 6.7% strongly disagree. Overall, the findings show that a majority of respondents positively perceive resource efficiency and energy conservation practices, indicating a strong focus on optimizing resource use, reducing waste, and promoting sustainable manufacturing operations.

IV. CHI-SQUARE ANALYSIS: RELATIONSHIP BETWEEN GREEN PRODUCTION TECHNOLOGY ADOPTION AND WASTE MANAGEMENT EFFECTIVENESS

HYPOTHESIS TESTING

Null hypothesis (H01): There is no significant relationship between green production technology adoption and waste management effectiveness.

Alternative hypothesis (H02): There is some significant relationship between green production technology adoption and waste management effectiveness.

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	164.077 ^a	168	0.571

Likelihood Ratio	156.736	168	0.723
Linear-by-Linear Association	0.052	1	0.82
N of Valid Cases	120		
a. 195 cells (100.0%) have expected count less than 5. The minimum expected count is .03.			

INTERPRETATION: As per the above table, it is inferred that the P value is 0.571; it is not significant to 5% (0.05) significant level. The minimum expected count is 1.03. Thus null hypothesis is accepted and it is found that there is no significant difference between green production technology adoption and waste management effectiveness.

V. CORRELATION ANALYSIS: RELATIONSHIP BETWEEN RESOURCE EFFICIENCY AND ENERGY CONSERVATION PRACTICES AND WASTE MANAGEMENT EFFECTIVENESS

HYPOTHESIS TESTING

Null hypothesis (H01): There is no significant relationship between resource efficiency and energy conservation practices and waste management effectiveness.

Alternative hypothesis (H02): There is some significant relationship between resource efficiency and energy conservation practices and waste management effectiveness.

Correlations			
		Resource efficiency and energy conservation practices	Waste management effectiveness
Resource efficiency and energy conservation practices	Pearson Correlation	1	.603**
	Sig. (2-tailed)		0
	N	120	120
Waste management effectiveness	Pearson Correlation	.603**	1
	Sig. (2-tailed)	0	
	N	120	120
**. Correlation is significant at the 0.01 level (2-tailed).			

INTERPRETATION: The above table indicates that, co-efficient of correlation between resource efficiency and energy conservation practices and waste management effectiveness is 0.603**. It is below 1. So there is positive relationship between resource efficiency and energy conservation practices and waste management effectiveness.

VI. SUGGESTIONS

- To enhance the process of sustainable manufacturing, the firm needs to make more use of solar-powered energy systems.
- It is recommended that the company should go a step further and implement automated process control systems in order to reduce material wastage.
- Computer-aided manufacturing (CAM) technologies should be used to optimize the production process and minimize the amount of wasted materials in the company.
- The company needs to adopt systems that are more energy efficient to enhance sustainability in production processes.
- The company ought to have regular check up on the energy usage with the aim of detecting and eliminating inefficiencies.
- The company ought to promote the adoption of reusable materials where possible in production processes.
- The company ought to create a systematic recycling of waste materials produced in the process of production.
- Optimization of resource wastes: the firm needs to embrace effective waste management methods to promote sustainable manufacturing processes.
- The company ought to synchronize the waste management practices with the long-term environmental protection objectives.
- The company ought to use waste minimization measure in an effort to enhance environmental performance.

- To minimize the environmental pollution, the company must maintain that the industrial wastes are handled properly.
- It should also be noted that the company should constantly advance waste management system to increase the overall production efficiencies.

VII. CONCLUSION

The conclusion is that implementation of green manufacturing practices through sustainable practices influences to a great extent the effectiveness of waste management in organizations. The adoption of new technologies, including automation, monitoring via the IOT, and energy-saving systems, is critical to minimizing the amount of materials wasted, maximizing the use of resources, and improving the level of efficiency in the company as a whole. The success of these practices however is determined by the degree of implementation, consistency in monitoring and commitment of organization to the sustainability objectives. The conclusion is that sustainable waste management practices can not only help in protecting the environment but also enhance the efficiency of production in the long-term and the performance of the organization. Recycling systems, use of by-products and good management of industrial waste enhances the role of environmental responsibility and also promotes cost effectiveness. Thus, those organizations which successfully implement technological innovation as a means to sustainability are bound to demonstrate better environmental performance and sustainability of manufacturing activities over the long term.

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