ENABLERS AND BARRIERS FOR INTEGRATED LEAN-GREEN-AGILE MANUFACTURING SYSTEMS

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ABSTRACT

Newer manufacturing strategies have emerged to face the increasing customer demand in global competitiveness. Sometimes it is more challenging to serve a highly dynamic and individualized market with more innovative products. The modern manufacturing predominately focus on minimizing the cost, needs of ever changing market with varying demand pattern practices with eco-friendly design, greener production, recycling, and reuse with a focus on minimizing the expenses associated with manufacturing. The integration of lean-green-agile manufacturing new age strategies is the need of the 21st century. The enablers and barriers play a crucial role in the adoption of these strategies. Our study focuses in small and medium enterprises as they act as the backbone for economic growth of the country. The influence of these enablers and barriers is the matter of investigation which is addressed by the present study through Delphi survey methods. The outcome of the research would facilitate the policy makers in the industry and government to frame policies for adapting the integrated approach of manufacturing.

Keywords: Lean Manufacturing, Green Manufacturing, Agile Manufacturing, Enablers, Barriers, Delphi Survey Methods
1. INTRODUCTION

In India, small and medium enterprises (SME) contribute about 95% of the total industrial units. Moreover it accounts to 6.11% of manufacturing GDP in the year 2017. SMEs create job opportunities and acts as suppliers to large organization. The present industrial scenario is craving for a sustainable system that focuses on growth without compromising the ability of the future generations to meet their needs and demands [1]. For any industry to achieve sustainability their primary focus will be on economic prospects, ecological balance and social responsibility [2]. The past practices indicates the studying the green manufacturing or lean manufacturing or agile manufacturing separately. The lean manufacturing in system’s level saves cost by minimizing wastes in the manufacturing system thereby focusing on the economic prospects; the green manufacturing strategy saves environment by reducing emissions and resource use thereby addressing the environmental aspects; and the agile manufacturing strategy acts at customer satisfaction by providing the required product of their choice in time thereby addressing the social dimension. A holistic approach has to be developed to integrate lean, green, and agile strategies. The objective is to find the enablers and barriers for the holistic approach. These enablers and barriers are helpful in establishing the integrated lean green and agile manufacturing system in Indian SMEs. The rest of the paper is as follows: the research background is provided by section 2 followed by methodology in section 3. Section 4 provides the discussion of the research. Section 5 presents the conclusion from the study followed by acknowledgements and references.

2. RESEARCH BACKGROUND

Lean Manufacturing (LM) is aims at maximizing the capacity and the utilization without involving any extra cost in it and also minimizing the excess inventories [3]. LM involves the manufacturing the product from development to distribution and at the end to the customers [4]. During the recent times, the amalgamation of the lean with social approaches has gained attention in area of academic research. It is totally based on the challenging the competitive pressure with limited resources [5]. Green manufacturing aims at minimum negative effect on environment while designing, manufacturing, delivering, and disposing the products and are economically viable. Green manufacturing implementation is possible only when the government joins hands with the industry in a strategic way. There is a need to understand the relationship of various enablers facilitating the implementation of GM in industry. Many researchers have talked about certain green production practices both quality wise and variety [6]. Green practices companies ensures sustainability along with financial stability.[7-8]. The agile manufacturing aims at satisfying the individual customer with variety, speed and flexibility. Producer centered customer relationships are established through interaction [9]. Eventually, the firm looks like virtual company or collaborative ventures with flexibility and cooperation at stake [10]. Agile manufacturing has interested both industrial and academic communities. The four main principle of Lean, Green and Agile manufacturing has been summarized in Table 1. A holistic system which addresses the above strategies of manufacturing systems has to be developed. So, identification and analysis of enablers and barriers is attempted in the present study.
Enablers and Barriers for Integrated Lean-Green-Agile Manufacturing Systems

<table>
<thead>
<tr>
<th>Lean Manufacturing</th>
<th>Green Manufacturing</th>
<th>Agile Manufacturing</th>
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<tbody>
<tr>
<td>Minimal Change</td>
<td>Pollution prevention</td>
<td>Enrichment of customer</td>
</tr>
<tr>
<td>Quality first</td>
<td>Design for environment</td>
<td>Enhancement of competitiveness</td>
</tr>
<tr>
<td>Flexible product line</td>
<td>Focuses on both process and products for environment</td>
<td>Expecting change</td>
</tr>
<tr>
<td>Continuous improvement</td>
<td>Risk minimization</td>
<td>Leverage the impact of people and information</td>
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3. METHODOLOGY

Through literature analysis and review with industrial experts’ ten enablers are identified. The identification of these enablers is done with clear relevance of these enablers with the strategies on lean, green and agile manufacturing. The description of the 10 enablers is mentioned below:

Supplier Participation (E1): Close contact with supplier for flexible deliveries helps to reducing waste. Proper training helps to impart these strategies in full scale. Top Management Commitment (E2): Top management beliefs, practice, commitment, transparency in information sharing, and regular conduct of management-employee meetings, are some attributes of these holistic systems. Work Force (E3): Flexible multi skilled workforce, Job rotation system, more aware, trained workforce and higher innovative capacity are in demand in lean, green and agile manufacturing systems [11].Work place (E4): Eco-friendly and worker friendly work place, automated and collapsible setups, jigs and fixtures, well equipped service centers help in building a flexible workplace. Human Resource Management (E5): Coordination, Co-cooperativeness, active participation, firm faith and spirit, decision making capability among the employees are very important for Holistic setup. Resource utilization (E6): Use of advanced optimization techniques to maintain minimum inventory levels and hence to reduce waste. The use of natural resources in sustainable manner. Information Technology centered (E7): cross functional communication across departments. Elimination of paper work, good environmental education, and effective communication through technology has a greater focus on holistic approach. Customer relationship management (E8): contact with customer, customer feedback and participation. Customers and eco-friendly production and products, encouraging customers for newer products. Customer Feedback (E9): Recognizing the VOC (Voice of customer), empowering the employee, social cultural response of customer towards green practices, perception of increased product quality [12]. Product Life Cycle management (E10): Recycling towards waste elimination, Proper and safety disposal of end products may lead to environment protection, efficient reusing and recycling. The following are the six barriers identified and selected for the purpose of study are presented below: Organizational Culture (B1): Management resistance to the holistic approach, weak organizational structure and hierarchy, restrictive policies and lack of empowerment and involvement from both internal and external stakeholders. Business Climate (B2): Industrial specific business process, Low green manufacturing practices, very low flexibility to respond to changing customer demand. Lack of legitimacy in the holistic approach. Poor supplier performance, Issues in supplier selection. Financial barriers (B3): Financial commitment of the top management for flexible agile manufacturing scenario, procurement challenges, existence of sunk cost, high cost of manufacturing certification and verification, difficulties in acquiring the capital . Government Regulation (B4): Poor support from regulating bodies, Lack of guidelines procedure, Lack of training for holistic approach. Technological and societal challenges (B5): Lack of newer technology, process and people, Lack of state of art Rand D and testing facilities, societal inclination towards green practices.
Workforce related (B6): Poor knowledge and understanding of the work force, resistance to change, insufficient training, fear of job rotation, job security.

Delphi method is used to examine the identified enablers and barriers to identify the key enablers and barriers. Delphi survey method is a proven data collection methodology that structures the group communication process. The procedure is carried out with a panel of experts, who examine the semi-structured questionnaire as an instrument, answered by the industrial respondents. [13] Two rounds of questionnaire are used for data collection, which are briefly described as follows, In first round, the panel of experts completes the first questionnaire which answers the following question: What are the most important enablers and barriers for SMEs to implement integrated lean green agile manufacturing practices?. The consolidated the list of enablers and barriers are send the experts for verification. Following this, consensus is achieved through the meeting with the experts. Approximately 10 industrial experts contributed to this survey.

4. DISCUSSION
The enablers are categorized into 10 categories and the barriers into six categories. Upon preliminary finding the top critical enablers are Top management beliefs and practices and the customer perception of increased product quality. It is believed that the holistic integrated approach will increase the profit and competitiveness in local and global market. In addition the top barriers which hinder the implementation of these strategies are inadequate R and D, design and testing and weak organisational structure and hierarchy. Most of the SMEs do not have structured environmental management systems and generally lack a prominent R & D support due to financial and technical constraints. Thus the findings will be beneficial for moving towards the integrated lean, green and agile manufacturing practices

5. CONCLUSION
The study focuses on identification of enablers and barriers on the implementation of integrated Lean, Green and Agile manufacturing practices in SMEs in India. Through a comprehensive literature survey the appropriate enabler and barriers are identified. The first round of Delphi surveys was carried through industrial experts in SMEs. The study provides an overview on the list of enablers and barriers on the implementation of integrated Lean Green and Agile manufacturing practices. Still a detailed second and third round survey has to be made with all the stakeholders concerning the implementation.

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REFERENCES
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