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A Review on Implementation of agile in manufacturing industries using key enablers

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Abstract - *Intense competitive situations in the market have led to growing attention being paid to customer needs, of which speed, time and customized services are of vital importance. The need for a method of rapid and cost-effective means of developing products and production facilities has led to the concept of agile manufacturing.*
Mass markets are fragmenting into niche markets and customers wanted to be treated as individuals, because of these rapid changes, it is important for industries to turn towards agile manufacturing for future sustenance. Agile manufacturing is an approach towards developing a competitive advantage in competency for organizations to deal with uncertainties in today's fast-changing environment. Its focus is to have rapid and continuous full-scale quality production and reposition to meet customer requirements.
In this paper, an attempt has been made to find out the different models and approaches used to accomplish agile manufacturing, such as: Decision models to study the hypothetical decision of whether to invest in agile against other manufacturing systems, Conceptual model for organizations to become agile, framework to work on important area and assess the agility level of the company utilizing questionnaire using key enablers like Virtual enterprise, Concurrent engineering, Rapid prototyping etc, evaluate manufacturing sector through fuzzy logic approach. After construction, these models have been implemented in different industries to examine the feasibility of these models. Based on their outcomes it is evident that agile manufacturing system of reconfiguration of the manufacturing sectors is required to survive the fast changing market environment.

Keywords: Agile manufacturing, decision tree, agility framework, key enablers.

1. INTRODUCTION

Increase in competition has formed the need for enterprises to adopt innovative business strategies and technologies to produce high-quality products, to reduce manufacturing cost and lead time. Within such a setting, focus is given to the ability of an industry to quickly respond to customers' requirements and design, develop and delivery of quality product to the market in the shortest possible time. [9]

Mass markets are fragmenting into niche markets due to rapidly changing customer demands. In order to cope with these changes, companies are motivated to improve their performance. Manufacturing has undergone many progressive stages in going from a craft industry to mass production, and then to lean manufacturing gradually towards agile manufacturing. [5] A new paradigm known as agility is being promoted as the solution for maintaining competitive leadership in this new environment. Agile manufacturing is a rising technology for an enterprise to realize quick responsiveness to the fast changing environment and customers demands by focusing on improving the competitiveness through cooperative working.

1.1 Agile manufacturing conception and enabling technologies

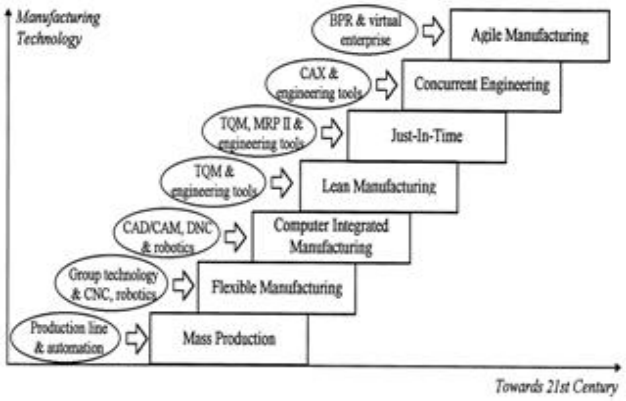

Figure 1: Development in manufacturing technology.

As shown in Figure 1, [9] manufacturing industry has experienced some notable changes, from mass production through flexible and lean manufacturing and finally to agile manufacturing philosophy, in the past two or more decades. The changes are directly created by the requirements for products' price, quality, delivery performance, customer choice, etc., which results from factors like unexpected changes in market environment, globalization of market, variation in customers' demands, customer-designed products, and shortened product life cycle [9]. These factors have a great impact on all of the manufacturing-related activities such as marketing, order, planning, design, manufacturing, job shop control, assembly, delivery, maintenance. [8]

1.2 Agility theory

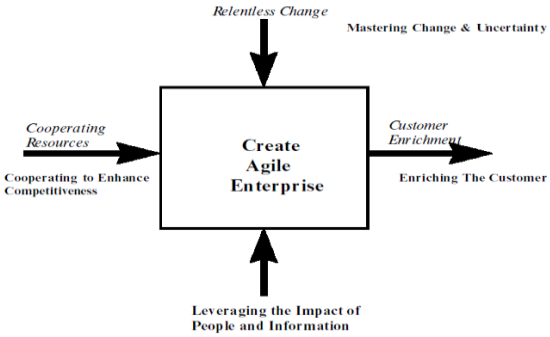

Figure 2: Four dimensions of agility: a systems perspective.

In order to plan for agile business processes a thorough understanding of what can be termed `agility theory' is necessary [10]. The manufacturing environment has undergone several transitions, from the craft industry, to mass production, and now the newest archetype, agility. In order to facilitate the understanding of the new paradigm of agility, the Agility medium has introduced four dimensions of agility to convey the holistic approach involved. The dimensions may be viewed systemically as shown in Figure 2. [13]The four basic elements include Cooperating to Enhance Competitiveness, Enriching the Customer, Mastering Change and Uncertainty, and Leveraging the Impact of People and Information.

2. METHODOLOGY

Agile manufacturing can be by merging all the existing resources like people, technology and organization into an independent unit which is capable of accomplishing short product development cycle times and responding rapidly to any sudden market changes.

Debra A. Elkins et al [3] considered agile manufacturing system from an automotive industry viewpoint and provided an influence diagram utilizing which a spreadsheet model and a decision tree model to study the theoretical decision to invest in agile against other systems for engine and transmission parts machining was developed as shown in Figure 3.

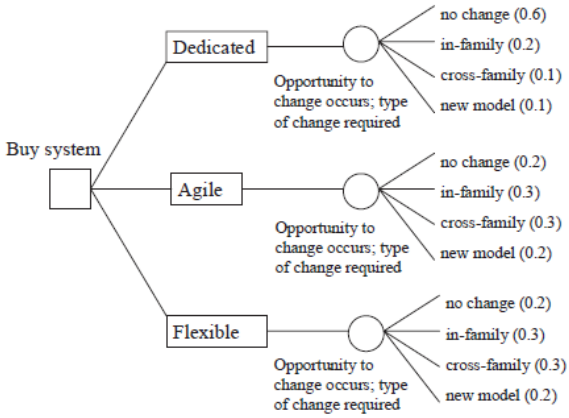

Figure 3: Decision tree model

He provided two decision models to get a clear perception on the advantages of agility. An influence diagram is created to identify the key information required for comparison between flexible, dedicated and agile systems. Using the identified key characteristics, a spreadsheet model is created as shown in Table 1 to calculate cumulative net present value of profits for system purchase decisions made under changing product quantity and combination , system timing, availability of new product introductions. The cumulative Net Present Value (NPV) for a system type for month k (0<k<180=15years) is given by:

Cumulative NPV at month k =∑netprofiti (1+discount rate/month)-i[3]

	Dedicated system	Agile system	Flexible system
Initial investment costs	$50,000,000	$60,000,000	$70,000,000
Changeover costs	$50,000,000	$10,000,000	$20,000,000
Changeover times	12 months	0 months	3 months
Product classes	1	1	1
Product models	A	A, B, C	A, B, C
Profit per model	$100	$100, $90, $80	$100, $90, $80
Capacity allocation to each model	100%	45%, 35%, 20%	45%, 35%, 20%
Annual fixed costs	$5,000,000	$6,000,000	$6,000,000
Variable cost per unit	$50	$60	$60
Hourly labor rate	$100	$120	$120
Labor headcount	10	10	10

Table 1: Test data for comparing dedicated, agile and flexible machining systems

Furthermore, the decision tree in his study illustrated that the cost framework of agile system has future value with low production costs compared to others for future models. From the limited study presented here, agile systems appear to provide guarantee for cost-effective rapid response to unplanned product

development and production facilities to meet irregular demand. The two decision models aids debate for automotive engineers about agile and FMSs. Portfolio analysis tools can be used to establish in the future for optimum mix of system types to meet varying demand.

While Debra A. Elkins et al makes comparison between agile, dedicated and flexible system, J.M. Sharp in his papers makes a comparison between mass, lean and agile manufacturing systems.

J.M. Sharp et al, [7] prepared tables differentiating mass, lean and agile as shown in Table 2 and the conceptual differences and relationships of the different industrial eras as shown in Table 3 and states that "It appears that there is a growing shift away from the concept of lean manufacturing, and one which is moving towards the new management philosophy of agile production". [7]
It is evident that to meet these rapid changing requirements agile manufacturing is the most suitable system, by comparison with mass and lean manufacturing as shown in Table 2.

	Mass	Lean	Agile
Drivers	• Price • Economy of scales • Stable markets • Demand led	• Market • Economy of waste • Predictable markets • Make to forecast	• Customer • Economy of diversity • Unpredictable markets • Make to order
Focus	• Equipment and Facilities	• Technology and Systems	• People and Information
Suppliers	• Many • Low level of trust • Adversarial • Relationship	• Fewer • High level of trust • (long-term) • Co-operative	• Selection from many • High level of trust • (short-term) • Shared risk/reward
Product	• Few options • Inconsistent quality	• Many options • High quality	• Customized • Fitness for purpose
Process	• Rigid • Hands on labor	• Flexible • Automated	• Adaptive • Knowledge based
Philosophy	• Authoritative	• Administrative	• Leadership

Table 2: Key differentiators

Table 3 shows most appropriate concept to meet these quick changes and must be implemented for the firms' sustenance.

Mass manufacturing	Lean manufacturing	Agile manufacturing
Invest in equipment and facilities	Invest in technology	Invest in people information systems
High touch labor	Removed layers	Multi-skilled work force
Specialization	Reduced waste	Robust, reconfigurable teams,
Little worker input	Worker input	Partnering in all stages of manufacturing
Many layers	Established teams	Self-directed work teams, management
Slow decision making	Greater dependence on suppliers	Elective Technology and information integration
Workers could buy products they made	Stable process	
Product development time in years	Product development time in months	Development time in weeks
Inconsistent quality	High quality at point of sale	High quality across product life

Table 3: Conceptual differences and relationships of the different industrial eras

To achieve agile manufacturing, the company must be World Class, and use lean manufacturing techniques .By examining the UK manufacturers in his paper he stated that, they are not as far down the course to becoming world class organizations as they had originally thought. Once, agile manufacturing was recognized and considered as an emerging new system of manufacturing, several authors came together to provide a conceptual model. This model was developed by summarizing all the literature reviewed by these authors for the corporate leaders to select appropriate items that fit their company. The proposed model is shown in Figure 4.

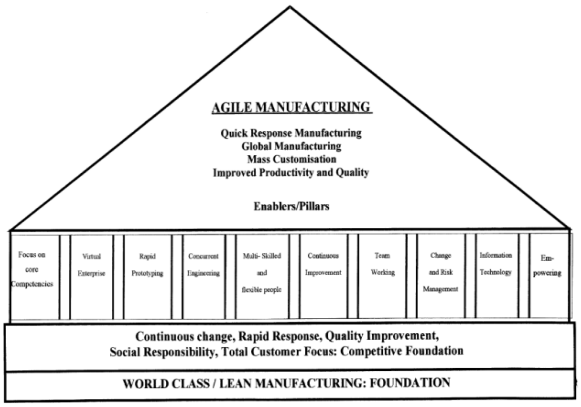

Figure 4: Theoretical model for agile manufacturing.

A number of constructs has been recognized as enablers of agile manufacturing. A similar conceptual model was developed by A. Gunasekaran [1] in turn these enablers form the constructs of the proposed model and include: core competencies, multi-skilled and flexible people, empowerment, teamwork and continuous improvement, information technology and communication, concurrent engineering and rapid prototyping, Virtual enterprises and change management [7]. The proposed models along with a

set of questionnaires were distributed to 110 UK manufacturers to evaluate the model and to measure their progress towards becoming agile manufacturing enterprises. After implementing this model in their companies, 48 companies replied to the questionnaire sent, which indicated a response rate of over 40%. Over 70% agreed that continuous training was seen, the employees' skills and knowledge are treated as assets and that their companies were investing in the core skills and competencies. Around 40% agreed that continuous improvement could be achieved through teamwork and employee decision making for their empowerment and more than 45% agreed for company alliances. From the results acquired, it could be noticed that the leading UK manufacturing companies understood the significance of the conceptual model and that these sectors are gradually turning into agile manufacturing organizations. They are progressing at varying level of speeds but they are all setting the base to have a competitive edge in the market. It is clear that the conceptual model developed by the authors can be utilized by these to assess their progress towards becoming agile manufacturing organizations.

According to A.Gunasekaran et al, [2], in his study an attempt has been made to give a real world perspective of agile manufacturing in the form of a case study. Utilizing model similar to that proposed by J.M. Sharp et al [6] the key enablers were determined and a conceptual framework was prepared to demonstrate the four key areas of organizational agility.

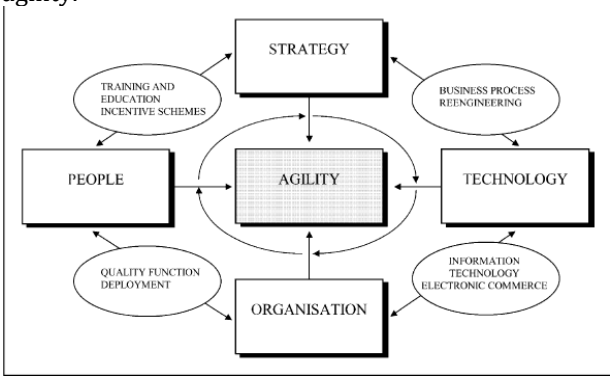

Figure 5: A generic framework for agile manufacturing.

The case study provided a base for assessing and confirms the implementation of agile manufacturing. The framework was utilized to study the four key areas of organization. An attempt had been made to address the areas of issues in GEC-Marconi Aerospace (GECMAe) company with regards to applying agile manufacturing. The study identified that, there is a division in GECMAe from being a fully agile and a fully lean enterprise. Proposals were made for products at the verge of their saturation to have a lean approach while the new products to have an agile approach. The current manufacturing problems were investigated in this study. The employees were educated and trained on various technologies along with the successful implementation of approaches like Kanbans and cellular manufacturing. GECMAe's philosophy is that buying the latest technology is of no use if redesigning or efficiency enhancements can accomplish the same end result. BPR is a concept used by employees at GECMAe for productivity and process improvement with reduction in the number of aviation. At GECMAe, software called QMAP (Quality Management Activity Processing) is used to produce tree diagrams of the activities and processes carried out within departments [2]. The diagrams are utilized to encourage employees to identify improvements or loopholes in the methods. Recommendations based on the framework were considered.

Ibrahim H. Garbie et al [6] stated that the deployment of agility concepts as the best way to measures success of companies is very significant to withstand global competition. He considers Agile Manufacturing as the next industrial revolution. Although agility is the set of competences and proficiency that these sectors need to increase in a volatile market environment, evaluating the index of agility in these sectors is still not surveyed according to its competences. [6] In his paper, a new model to evaluate the agility index/level of the manufacturing sectors based on existing technologies, level of qualifying people, manufacturing strategies, and management systems and the business process was proposed.
A fuzzy logic approach has been described in this study. By estimating the fuzziness of individual department, the aggregate of fuzziness with respect to agility measure and defuzzification value are determined using a new approach after changing certain requisites to evaluate the manufacturing sector turning towards agile. This was applied in an Egyptian firm. The outcome showed that the agility level of this firm is not high and requires development in different infrastructures to become sustainable. His paper analyzed and evaluated the manufacturing sectors taking into account issues for industry upgrading. For future research, the scholars must use the present manufacturing agility level of a sector to initiate a novel approach of reconfiguration of the manufacturing sectors to survive the fast changing market environment.

3. CONCLUSION

Areas focused by research scholars for implementation of agile manufacturing have been recognized in this paper. Industries turning towards agile manufacturing systems will be capable to respond to real time demand in volatile market environment. In order to estimate the level of agility in

various sectors, several models are developed and implemented.

By this it is clear that to sustain in this challenging market environment, both financial and non financial parameters must be measured and all the resources including human must be fully utilized. The owner of the firm must tie up with other sectors where both his and his partners' employees must be trained to possess skills to work in both the firms. The intangible aspects are important in agile manufacturing environments and are hard to quantify, for instance information and communication systems. Industries must possess the precise mixture of practices, culture, expertise, skill, knowledge and technology which is essential to attain agility in its sector. A hypothetical decision of whether to invest in agile against other manufacturing systems has been studied using decision trees and spreadsheets and by making comparison based on initial investment, changeover cost, production cost, production model it can be clearly seen that by far agile manufacturing system is most suitable and beneficial than the other manufacturing systems which efficiently and cost effectively adapts to change in demand.

An Illustration on the concept and enablers of agile manufacturing is performed and a conceptual model for organizations to become agile and confirm the same through questionnaire is studied and a framework to work on important area and provide solutions to the current and future company situations by assessing the agility level of the company utilizing questionnaire.

The major disadvantage of these models is its need for extra training of employees for implementation in their sectors. Further, research scholars can aim to develop models which are simple to implement and less time consuming process. In this paper focus is towards manufacturing industries, whereas agility models can be applicable to various other types of industries.

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