Identification of Factors in Implementation of Agile Manufacturing

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Abstract— Agile manufacturing, as a new manufacturing paradigm, requires a systematic study of its enablers to aid in successful adoption and implementation of the concept and practice. Agile manufacturing is a term applied to an organization that has created the processes, tools, and training to enable it to respond quickly to customer needs and market changes while still controlling costs and quality. But, implementation of agile manufacturing is not an easy task as it is full of lots of hurdles. The main objective of this paper is to identify the critical factors which help in the successful implementation of agile manufacturing in manufacturing organization.

Key words: Agile Manufacturing, Factors, Identification, Implementation, Organization

I. INTRODUCTION TO AGILE MANUFACTURING

Agile Manufacturing (AM) is a relatively new operations concept that is intended to improve the competitiveness of firms. Manufacturing/service processes based on AM are characterized by customer-supplier integrated processes for product design, manufacturing, marketing, and support services. Agile manufacturing requires enriching of the customer; cooperating with competitors; organizing to manage change, uncertainty and complexity; and leveraging people and information (Gunasekran and Yusuf, 2002). Agility addresses new ways of running companies to meet these challenges. Agility is about casting off those old ways of doing things that are no longer appropriate - changing pattern of traditional operation. In a changing competitive environment, there is a need to develop organizations and facilities significantly more flexible and responsive than current existing ones (Gunasekran, 1999). In this study we focus on the relationships among the enablers. Even after 15 years of development and refinement, the agile manufacturing paradigm can still be considered in its infancy. Initial investigation relating to enablers of agile manufacturing and agility has been empirically tested (Hoyt et al., 1997).

The scope of agility has ranged from simple flexibility discussion to an all-encompassing operationally strategic concept used to manage all aspects of an organisation. We seek to help provide greater insight into the factors and relationships of agile manufacturing through the development of a TISM-based model of the relationships among the various management practices and strategies that are recognized as agility enhancers. The development of this relationship among the various agility enhancing management practices shall be of great help for the academia as well as practitioners while treading the path of adoption of agility and agile manufacturing.

The main objectives of this paper are:

1) To identify, rank and relate the various enablers of agile manufacturing using the expert opinion.
2) To provide a framework of relationships among enablers using TISM
3) To present the managerial implications of this research.

II. LITERATURE REVIEW

The main purpose of this literature review is to get information about the agile manufacturing from the Reference books, magazines, journals, technical papers and web sites. Hasan et al. (2009) identify and determine a relationship among the various enablers for the agile manufacturing philosophy and studied the ISM model of enablers of agile manufacturing. A. Gunasekaran (1999) studied framework for research and development for agile manufacturing. The subject of AM needs more feasibility studies from the perspectives of establishing VE, temporary alliances and their implications on the relationship with labor unions and jurisdictions. Yusuf et al (2002) considered the potential importance of agile manufacturing in 21st century manufacturing competitiveness; an attempt has been made in this paper to reexamine the scope, definitions and strategies of AM. In addition, a framework has been presented as a basis for understanding the major strategies and relevant technologies of AM. Patel et al. (2014) reviewed a wide range of recent literature on agile manufacturing. AM assessment tool and conclude that the research may be further continued by implementing Model for Enhancing Total Agility Level (METAL) in many more companies. Sanchez et al. (2001) concluded that agile manufacturing systems are born as a solution to a society with an unpredictable and dynamic demand, and with a high degree of mass customization in its products. It is the strategy that many enterprises are adopting as a solution to the new market opportunities and proposed a classification scheme with nine major research areas: (i) product and manufacturing systems design; (ii) process planning; (iii) production planning, scheduling and control; (iv) facilities design and location; (v) material handling and storage systems; (vi) information systems; (vii) supply chain; (viii) human factors; (ix) business practices and processes. Elkins et al. (2004) studied the hypothetical decision of whether to invest in a dedicated, agile, or flexible manufacturing system for engine and transmission parts machining. These decision models are a first step toward developing practical business case tools that help industry to assess the value of agile manufacturing systems. Singh et al.(2012) studied the interpretive structural modeling (ISM) and total interpretive structural modeling (TISM) based quality framework model has been developed to understand the mutual interactions among the variables and to identify the driving and dependence power of these variables. Amma et al.( 2011) studied the TISM model of various enablers of cloud computing. Interpretive structural modeling is a well proven tool for finding the interrelationship among the enablers.
Total Interpretive structural model is an essential innovative version of interpretive structural modeling technique (ISM). In Total Interpretive Structural Modeling (TISM), influence/enhancement of enablers and their interrelationship is considered. Total interpretive structural model steps are identification of elements, pair-wise comparison, level partition, interaction formation, diagraph representation and formation of total interpretive structural model.

Literature on agile manufacturing can be categorized into four areas: Strategies, Technologies, Systems, and People. ‘Strategies’ can be sub-classified into Virtual Enterprise (VE), responsive supply chain, advanced manufacturing techniques, material requirement planning and Concurrent Engineering (CE); ‘Technologies’ into Information Technologies (IT); ‘Systems’ into design systems, Production Planning, rapid prototype and Control (PPC) systems, and system integration and database management; and ‘People’ into knowledge workers, top management support, team work and employee empowerment, and training and education. These 17 sub-classifications can be viewed as agile manufacturing enablers. These 17 enablers will be adapted and refined with further support from literature, experts’ and academic opinion.

A. Advanced Manufacturing System:
This system should be aimed at extending the capabilities of existing parametric CAD/CAM systems, which can be linked to a system such as Pro/Engineer or Master Series. An Internet-assisted manufacturing system would be appropriate for agile manufacturing practice (Patel et al., 2014). It may consist of a CAD/CAPP/CAM. A conceptual model to illustrate the concept and enablers of agile manufacturing. Integrated Central Network Server (CNS) which links to local FMS or CNC machines by means of cable connections. After a local user inputs the product information, the CNS can generate complete CAD/CAPP/CAM/CAA files and control the remote FMS or CNC machines to accomplish the whole production process. This system uses the Internet as an interface between a user and the CNS, and allows a local user to operate ‘remote’ machines connected to the Internet. (Wang et al., 1996)

B. Top Management Support:
Top management support is vital for any successful project completion. Top management support is needed for budgeting, for providing funding and suitable resources to project team and create conducive organization. Implementing agile manufacturing sometimes requires drastic changes in the way business and operations are carried out in a fashion very similar to business process re-engineering. Whether or not an organization wishes to pursue agile manufacturing is a strategic decision. To bring in and accommodate such strategic change requires total support of top management in terms of providing necessary technical and financial support, together with employee empowerment for improving the co-operative supported work in a physically distributed VE (Gunasekaran and Yusuf, 2002).

C. Responsive Supply Chain:
The responsive supply chain (RSC) addresses new ways of running companies to meet these challenges. RSC represents a global industrial paradigm for manufacturing in the twenty-first century. In a changing and competitive environment, there is a need to develop in a cost effective solutions to organizations and facilities that are highly flexible and responsive to changing market/customer requirements (Gunasekaran and Yusuf, 2002). The objective here is to describe a framework for building a supply chain that is flexible and responsive. “A Manufacturing system with extraordinary capability to meet the rapidly changing needs of the marketplace. A System that can shift rapidly amongst product models or between product lines, ideally in real-time response to customer demands.” AM requires firms to adapt to the strategic requirements of the supply chain. Strategic agility planning requires a strong partnership between suppliers and customers, and information systems for effective supply chain management (Naylor et al., 1999).

D. Rapid Prototyping:
Rapid Prototyping (RP) can be defined as a group of techniques used to quickly fabricate a scale model of a part or assembly using three-dimensional computer aided design (CAD) data. Rapid Prototyping has also been referred to as solid free-form manufacturing; computer automated manufacturing, and layered manufacturing. RP has obvious use as a vehicle for visualization. In addition, RP models can be used for testing, such as when an airfoil shape is put into a wind tunnel. RP models can be used to create male molds for tooling, such as silicone rubber molds and investment casts (Chandramohan and Marimuthu, 2011). The purpose of RP Technology is to produce physical models quickly. This allows designers to not only communicate their ideas to others with the use of an actual object, but also to run functionality tests. In the end, final products can be brought to market faster and with better quality (Armano, 2001).

E. Advanced QC Technique:
Quality is a universal value and has become a global issue. In order to survive and be able to provide customers with good products, manufacturing organizations are required to ensure that their processes are continuously monitored and product qualities are improved. Manufacturing organization applies various quality control techniques to improve the quality of the process by reducing its variability. A range of techniques are available to control product or process quality. These include seven statistical process control (SPC) tools, acceptance sampling, quality function deployment (QFD), failure mode and effects analysis (FMEA), six sigma, and design of experiments (DOE) (Judi et al., 2011).

F. Skilled Worker:
Agile manufacturing warrants a workforce that is adaptive to different roles and responsibilities in an environment of abrupt and often unanticipated change. Not only will the worker be familiar with the company’s product line but also in the partnering atmosphere that exists across organizations. Human resources may be called upon to provide expertise in skills that vary substantially from those to which he has been accustomed (Hasan et al., 2009).
common for different tasks to involve similar skills. For instance, a manufacturing system may involve several types of welding tasks, all of which can be done by welders. Traditional process layouts organize manufacturing operations largely on the basis of function. In modern cellular layouts, functional skills are distributed throughout the plant, which is one reason cross-trained workers are typically used to staff manufacturing cells (Hoop et al., 2004).

G. Training and Education:
Agile companies are committed to continuous workforce training and education and see it as an investment rather than a cost, for the reason that trained and educated employees are significantly better problem-solvers and problem-preventers, and both these attributes contribute to agility (Hasan et al., 2009). It is not clear yet what sort of training and education required to motivate the employees to take part in the development of AM. This section spells out some of major training and education requirements in AM environments. Agile manufacturing has different requirements of workforce as compared to that of traditional systems and they are: (i) closer interdependence among activities, (ii) different skill requirements, usually higher average skill levels, (iii) more immediate and costly consequences of any malfunction, (iv) output more sensitive to variations in human skill, knowledge and attitudes and to mental effort rather than physical effort, (v) continual change and development, and (vi) higher capital investment per employee, and favor employees responsible for a particular product (Pinochet et al., 1996).

H. Team Work:
A team has a results driven structure when it is organized according to the goal that it has to attain. Team structure comprehends the process, the communication channels, the roles, and the skills of the team members. It is a hygiene factor. In fact, its presence makes achievement possible, but doesn't motivate people, and its absence is certainly demotivating since it can make achievement, at best, difficult, and at worst, impossible. They found that all the highly effective teams always had these characteristics
- A clear, elevating goal
- A results-driven structure
- Competent team members
- Unified commitment
- A collaborative climate
- Standards of excellence
- External support and recognition
- Principled leadership (Asproni, 2004)

I. Employee empowerment:
Employees who are granted the power to take charge at work feel an increased sense of responsibility, accountability, and ownership for their work. They work diligently to meet project deadlines and organizational goals. They feel energized to do what it takes to get the job done and to do it right. All of these reasons fuel an empowered employee to be more productive, providing better performance results for the organization (Wagner & Harter, 2006)

J. Concurrent Engineering:
CE plays a significant role in the design and operations of agile manufacturing enterprise, and in almost all the rest of enablers of agile manufacturing, e.g. virtual enterprise formation, rapid-partnership formation, rapid-prototyping and integrated product/production/business information systems. For example, there are tools available such as QFD for the implementation of CE in virtual enterprise formation and rapid-partnership formation. Similarly, CE can be used in the partnership formation process. For example, the Characteristics of partner-firms and the product requirements can be matched using QFD, taking into account all the downstream non-value-adding activities. The Implementation of CE in agile manufacturing can include: the involvement of a Manufacturing process as early as possible; increase in cost awareness; recruitment of key players; the offer of training to key employees; the exploitation of CAD’s power and application of analytical tools (Garrett, 1990). Agility in manufacturing requires a change around the formation of product development teams, and managing change in a manufacturing environment requires a more systematic method of concurrently designing both the product and the downstream processes for production and support. This systematic approach is fundamentally known as CE (Gunasekaran, 1999).

K. Production Planning and Control:
The following aspects are to be considered for PPC in agile manufacturing environments: modeling of evolutionary and concurrent product development and production under a continuous customer’s influence real-time monitoring and control of the production progress in a virtual company a flexible or dynamic company control structure to cope with uncertainties in the market adaptive production scheduling structure and algorithms to cope with uncertainties of production state in a virtual company modeling of production states and control system in a virtual company the reference architecture for a virtual company (Hasan et al., 2009) Production planning, scheduling and control is concerned with manufacturing the right product types, in the right quantities, at the right time, at minimum cost and meeting quality standards. Production planning, scheduling and control are the heart of manufacturing firms (Sanchez and Negi, 2001)

L. Proper Database Mgt. & System Integration:
Agility imposes special requirements on the information systems used to run an enterprise. In addition to satisfying the traditional requirements, an agile enterprise information system must be able to be reconfigured in a very short time and should be able to include parts of information systems from other companies if a Virtual Corporation is required to meet the market demand. The traditional, common shared data base model of integration has severe problems in this environment. The Systems Integration Architecture (SIA) is based on a new, transformation model of integration and provides sets of high level services which allow information system modules, including foreign modules, to be rapidly reconfigured. These services include the management of information (naming, locations, format, "les structure and data access type) as well as the relationships among data
sets, communications between objects on heterogeneous computer systems, wrappers for legacy software, diverse control approaches, composition of modules into processes and user interfaces. SIA also should allow for the integration of functions and control as well as data. (Jharkharia and Shanker, 2005).

M. Continuous Improvement:
We define CI more generally as a culture of sustained improvement targeting the elimination of waste in all systems and processes of an organization. It involves everyone working together to make improvements without necessarily making huge capital investments. CI can occur through evolutionary improvement, in which case improvements are incremental, or though radical changes that take place as a result of an innovative idea or new technology (Jharkharia and Shanker, 2005).

N. Material Requirement Planning:
MRP stands for material requirement planning. It is a computer based system that takes master production schedule (MPS) to explode it into required amount of raw materials, parts, sub-assemblies, and assemblies needed in each of the planning horizon, and then reducing these material requirements to account for materials that are in inventory or on order and finally developing a schedule of order for purchased materials and produced parts over the planning horizon. In simple terms American Production and Control Society (APICS) defines it: "MRP constitutes a set of techniques that use bill of material, inventory data, and the master production schedule to calculate requirements for materials" Manufacturing companies with the MRP based production system are most likely to determine their production planning based on the forecasts for future demand. It is known that accurate forecast is the generally available over initial periods. for the rest of the periods such figures are indeterminable (Hasan et al., 2007).

O. Virtual Enterprise:
A virtual organization is the integration of core competencies distributed among a number carefully chosen but real organizations all with similar supply chain focusing on quick to market, cost reduction and quality (Elkin et. al, 2004). It is essential to develop VE in a more productive way by reducing the time and cost as well as delivering goods/services in a competitive manner in global markets. The following steps can be employed for developing a VE: (a) identify the corporate objectives; (b) based on the multiple manufacturing performance objectives, identify the product/service requirements from suppliers; (c) select partners based on the core competencies using a suitable supplier ranking system; (d) using the time scale, which should be rather short, link it all as a VE with the help of automation and IT. (Hasan et al., 2007)

P. Use of Information Technology:
In a global manufacturing environment, information technology plays a dominant role of integrating physically distributed manufacturing firms. Critical to successfully accomplishing AM are a few enabling technologies that include robotics, Automated Guided Vehicle Systems (AGVSs), Numerically Controlled (NC) machine tools, Computer-Aided Design (CAD)/Computer-Aided Manufacturing (CAM), rapid prototyping tools, Internet, World Wide Web (WWW), Electronic Data Interchange (EDI), Multimedia and Electronic Commerce (Gunasekaran, 1999). The impact of IT can not only improve productivity and quality of production, and service activities, but also enable enterprises to intelligently alter themselves. Through IT enterprises can collaborate with each other to accommodate various customers’ demand, changes in tastes, design, time and quality while keeping the cost at a reasonable level (Hasan et al., 2009).

Q. Focus On Core Competencies:
Core competence may be associated with the corporation’s workforce and product and identified at two different but related levels, the individual and the firm. The core competencies of individual include their skills, knowledge, attitude and expertise. For core competence to be of strategic importance and bring long term benefits to the corporation it must meet three conditions. Core competence should provide capability for multi-venturing and access to a wide spectrum of markets. It should also strongly enrich customer valuing of end products and be difficult for competitors to copy. Creating and building core competencies is, however, not an easy task. Management, who have the sole responsibility for core skills and knowledge acquisition, must begin by listing the company’s main capabilities and identifying the missing links (Yusuf et al., 1999).

III. Conclusion From Literature Reviews
Lean manufacturing paradigm does not effectively support new product development to respond quickly in accordance with customers, dynamic demand. This limitation of lean manufacturing paradigm is overcome by Agile Manufacturing. During the conduct of this literature review, the Agile Manufacturing (AM) assessment tools and frameworks contributed in the above paper analyzed. So, this paper tries highlighting the main factors which helps in the implementation of agile in manufacturing organizations. These critical factors will enable the organization to develop proper strategies for effectively utilizing them in the successful implementation of Agile Manufacturing.

IV. Future Research
1) Investigation to prepare agility assessment model
2) Implementation of Agile Manufacturing paradigm in Indian industry
3) Enhancing total agility level through assessment and model making of agile enablers

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REFERENCE