Identification & Prioritization of Agile Manufacturing Enablers for Small and Medium Scale Industries

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Abstract. In Indian economy the small and medium scale industries are playing a significant role in manufacturing sector, global competition and dynamic demand of customer poses a big challenge in front of manufacturing industry. To mitigate this challenge the concept of agile manufacturing stood as a big relief. Agile manufacturing focuses on customer demand by giving quick response to the changes in product. Enablers are essential methodology which are significant to achieve agility. This research is divided in two parts: first part consists of Identification of Agile Enablers through extensive literature survey; second part focuses on prioritizing the identified enablers by using analytical hierarchical process (AHP). This research aims to find the solution for the problem statement given by TTC MIDC Industry Association, formerly known as Small Scale Entrepreneurs Association, Navi Mumbai, to identify the most essential enablers for implementation of Agile Manufacturing in Indian Small and Medium Scale Manufacturing industry.

1. Introduction

Rapid industrial growth gives birth to the new innovative methods and tools. The changing interest of customer is becoming very complex and dynamic with market competition. Every manufacturing industries are struggling to fulfil customer demand and try to withstand in today’s competitive world. Over the time the manufacturing evolved from four major manufacturing paradigms such as Craft production, Mass production, Lean manufacturing and Agile manufacturing. The world began to observe the drastic competition in the manufacturing sector during the 1980’s in order to face this, world witnessed the birth of agile manufacturing. Agile manufacturing paradigm focuses on meeting the needs of customers while manufacturing high standards of quality and controlling the overall costs involved in the production of a particular product. Building a robust framework need to identify the enablers that can help in accelerated manufacturing process Enablers act as a value-added work objects which allow estimating, obtaining visibility, getting feedback and exhibiting results. Enablers are categorized into three major type Exploration, Architecture and Infrastructure. Exploration enablers supports research prototyping and other activities needed to develop customer needs to evaluate alternatives Architecture are to build a smooth and fast development in an organization. Infrastructure enablers supports the business development and quality checking by helping in high quality testing and thus aids to faster development. In order to get the concrete solution, identified enablers need to be analyzed through
various tools of statistical analysis and modelling. A framework is based on the concept of bridging the system gaps and make it dynamic and responsive, which can contribute towards the accelerated an agile manufacturing processes. Analytical Hierarchical Process is the multicriteria decision making process for a complex problem. This method has been found to be most effective and practical that can solve complex and unstructured decision. In this paper AHP is used to prioritize agile manufacturing enablers based on questionnaires.

2. Literature Review

Small-scale manufacturing industry will play a crucial role in the Indian economy in the future. It has also been observed that many units in the SME sector are plagued with technological stagnation and their quality, efficiency and productivity have declined over the years except for a few progressive units that have incrementally improved their performance. Manufacturing sector need the reorganized approach to face the challenges in the global market of 21st century in which the customer is in the center and must be satisfied in all manners. The need of customer is now highly specific and rapidly changing. Therefore, in this competitive environment the new term emerged as Agile Manufacturing. The concept of AM was originally introduced in the report entitled “21st Century Manufacturing Enterprise Strategy” and published by the Iacocca Institute of Lehigh University (Goldman and Nagel.,1991) as an option for managing firms in a dynamic world. (Ramesh and Devadasan.,2007) studied the literature dealing with AM criteria and derived the meaning and definitions of AM. Further, the criteria enunciated in certain papers were identified, these findings were used to design a 20 criteria agile model .(Vazquez-Bustelo and Avella.,2006) presented an initial approach to AM based on case studies on four factories in Spain. An AM conceptual model has been drawn up and several hypotheses inferred based on conclusion of case studies. Yusuf et.al (1999) identified the drivers of agility and discusses the portfolio of competitive advantages that have emerged over time because of the changing requirements of manufacturing. To further understanding of agility, authors reviewed the meaning of agility from different perspectives and suggests a comprehensive definition which can be adopted as a working definition by practitioners. Four underlining concepts of agility has emerged from the working definition and presents a representation of these concepts and their interactions. Finally, authors highlight some of the key enablers of agility and identified potential future research directions.

Gunasekaran et. al. (1998) presented a conceptual framework for the development of an agile manufacturing system and future research directions are presented in this paper. Proposed framework by author considers the customization and system integration with the help of business process redesign, legal issues, con-current engineering, computer-integrated manufacturing, cost management, total quality management and information technology on the other hand. Sanjay Kumar et. al (2013) utilized literature review approach to identify important enablers to implement lean six sigma concept. Twenty-six enablers have been identified from the literature and subsequent discussions with experts. Through this work authors contribute to identify the enablers to implement lean six sigma concept.

Aravindraj and Vinodh (2014) developed a 40-criteria agility assessment model. Besides computing agility level, the gaps across agile criteria have been identified and actions for agility improvement were subjected to implementation in the case organization. Routroy and Arjun Shankar (2015) proposed a methodology for measuring supply chain agility by capturing multiple experts’ judgement regarding the Agile Manufacturing Enablers (AMEs). AMEs are defined as the parameters that have the capability to enable or enhance the present level of agility in the manufacturing system. Sarode et.al (2008) provided an extensive literature review for identification of performance measures, which in turn forms a basis for establishing a framework for performance measurements in supply chains. Ching et.al (2006) developed the absolute agility index, a unique and unprecedented attempt in agility measurement, using fuzzy logic to address the ambiguity in agility evaluation and presented the approach and a framework of a fuzzy agility evaluation. Shin, H. et.al. (2015) developed theoretical connection between strategic agility of Korean SMEs and its underlined dimensions such as technology,
capability, collaborative innovation, organizational learning and internal alignment, and then proposed the conceptual model for investigation nomological network of influence among strategic agility, operational performance and firm performance. Majority authors focused on the strategic agility however it cannot influence financial performance directly or indirectly through operational responsiveness.

Potdar et.al. (2017) proposed a methodology using Interpretive Structural Modeling (ISM) integrated with Fuzzy Matriced Impacts Croises Multiplication Appliqueaux Clasment (FMICMAC) algorithm for systematic analysis of impediments of AM. To demonstrate its practicality, a case study was conducted in an Indian automobile manufacturing company. Jinturkar et.al (2014) provided a systematic approach towards the application of FAHP to supplier selection problem. Authors used FAHP to find the importance degree of each criterion as the measurable indices of the supplier. Extensive analysis of the results shows that selection of an appropriate supplier would result in improving effectiveness of supply chain.

Tseng et al. (2011) suggests a new agility development method for dealing with the interface and alignment issues among the agility drivers, capabilities and providers using the QFD relationship matrix and fuzzy logic. Eleonora Bottani et.al. (2010) has given empirical investigation performed on sample of 190 both small scale and medium scale companies, the result of analysis provided detailed investigation of the agile paradigm and outcome suggests new taxonomy for agile attributes and enablers. However, the whole findings and analysis of data was based on the email bound questionnaire, keeps the scope for the vague data also the hypothesis established is relevant to the European companies.

Ajay Gurudev et.al. (2016) proposes a set of critical success factors (CSF) for evaluating AM. He has used AHP to prioritize these factors for high performance. Author focused on only one OEM industry, which may limit the usage of the CSF for all. There is a need to carry out proposed technique in several industries for improvement of practical validity of the models developed. Soltan and Sherif (2015) presented a hierarchic framework which can be used to measure the leanness, agility, legality and overall performance of an enterprise. This enables using the multi-criteria decision-making methods especially AHP and ANP. However, his work is concentrated on decision making and lacking the capability address the issues of AM, which need the flexible and scalable manufacturing capability of the manufacturing unit. Potdar et.al.(2017)proposed a generic benchmarking framework for enhancing agility along with step by step implementation process. The proposed framework provides a systematic direction for measuring and enhancing agility on a continuous basis, said framework is conceptually developed and not empirically validated. Therefore, requires the validation in general. There is a need to investigate and study the implementation issues of this proposed benchmarking model in different manufacturing sectors.

Potdar and Routroy (2017) proposed a methodology by combining fuzzy analytic hierarchy process (FAHP) and performance value analysis (PVA) to analyze AM performance along specified time line. This proposed approach is applied to an apparel supply chain considering three-time horizons. Methodology should be tested by applying to various manufacturing units. Also, only two expert groups judgements are obtained. Therefore, there is a possibility of the judgements suffering from respondent bias. This methodology could also be modified by employing other multi-criteria decision-making techniques like fuzzy TOPSIS, etc. in the place of FAHP in order to limit the unreliability of results produced by FAHP which occurs when the number of attributes being compared becomes large. Yusuf et.al. (1999) identified the drivers of agility and discusses the portfolio of competitive advantages that have surfaced over time as a result of the changing requirements of manufacturing. To further understanding of agility, authors reviews the meaning of agility from different perspectives and suggests a comprehensive definition which can be adopted as a working definition by practitioners.

Campanelli and Fernando (2015) has conducted Systematic Literature Review (SLR) on studies published from 2002 to 2014. These studies have been identified as case studies regarding the empirical research, as solution proposals regarding the research type and as evaluation studies regarding the research validation type. However, the major problem in SLR is to handle the bias in proper way and validate the study. Sreenivasa et.al. (2012) proposed 30 criteria AM assessment tool. Using this tool, the
total agility level in a pneumatic enabling products manufacturing company was assessed. After a comprehensive analysis, the drag and failure factors that prevent this company from becoming agile were identified. Allotment of marks to each 30 AM criteria need extensive research in the form of case studies and findings need to analyzed with the help of various statistical methods and tools. Pavan kumar et. al. (2016) identified and analyzed the Agile Manufacturing Barriers (AMBs) for establishing a cause and effect relationship among them. A methodology is proposed using fuzzy Decision-Making Trail and Evaluation Laboratory (DEMATEL) to capture multiple expert’s qualitative judgments for mitigating the impact of the AMBs. The proposed methodology was applied to an Indian automobile manufacturing company for validation. Results are specific to Indian Automobile industry, which cannot be generalized for every manufacturing unit.

Author Soni and Kodali (2012) addressed the issue of lack of standard constructs in frameworks of lean, agile and leagile supply chain. This objective is achieved by evaluating reliability and validity of lean, agile and leagile supply chain constructs in Indian manufacturing industry. Principle component analysis is performed on these constructs to find out the pillars of each type of supply chain followed by evaluating reliability and validity of these pillars to establish the underlying constructs. Finally using the results of the study, a framework for lean, agile and leagile supply chain is proposed. As the research construct is based on the survey which need to extend to all manufacturing and service domain.

3. Problem Description

Small and Medium Scale Enterprises (SMSE) manufacturing units are struggling to cope with the growing global competition; they are influenced by intense foreign competition, rapid technological change, shorter product life-cycles and customers who are seeking for customized products and services at a greater speed. There is a need to have simple to implement and usable framework which can adopt the change and fulfill the increased demand of current market. The challenge of deploying the best practices in organization to create competitive advantage becomes more crucial as:

- The marketplace is competitive and the rate of innovation is rising, so that Agile Manufacturing must evolve and be assimilated at an ever-faster rate.
- Competitive pressures forcing industry to reduce the size of the workforce which may put impact on quality production and customer satisfaction.
- Any change in strategic direction may result in changing manufacturing process and loss of knowledge in a specific area. Employees have less time for this.
- Wastage of time and money on satisfying the customer requirements in the absence of proper agile methodology.

4. Identification of Enablers

In the process of identification of enablers number of research work is reviewed. From the extensive review of 71 research papers following enablers are identified and summarized as follows. Summary of enablers was carried out author wise on the basis of 12 set of enablers as shown in Table no.1. It shows the involvement of authors research work with reference to the enablers.
### Table 1: Author-wise Literature Review of Enablers

| Sr No | Author                                      | Management Responsibility (MGR) | Manufacturing Management (MFM) | Workforce (WOF) | Technology (TECH) | Manufacturing strategy (MFS) | Knowledge Management (KNM) | Information Technology (INT) | Supply Chain Management (SCM) | Marketing Management (MAM) | Social Factors (SOF) | Quality Assurance & Quality Control (QAQC) | Customer Relationship Management (CRM) |
|-------|---------------------------------------------|---------------------------------|--------------------------------|----------------|------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|----------------|-----------------------------------------------|---------------------------------|
| 1     | Jain, S et.al. (1995)                       | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 2     | Cho, H. et al. (1996)                       | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 3     | Gunasekaran and Angappa (1998)              | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 4     | Y.Y.Yusuf et al. (1999)                    |                                 |                                | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 5     | Sharifi H. and Zhang, Z. (1999)             | ✓                               | ✓                              | ✓              | ✓                | ✓                           |                             |                             | ✓                           |                             |                |                                |                                  |
| 6     | Sharp et al. (1999)                        |                                 |                                |               |                 |                             |                             |                             |                             |                             |                |                                |                                  |
| 7     | Gunasekaran, A., (1999)                    | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 8     | Zhang, Z. and Sharifi, H. (2000)           | ✓                               | ✓                              | ✓              | ✓                | ✓                           |                             |                             | ✓                           |                             |                |                                |                                  |
| 9     | Sharifi, H. and Zhang, Z. (2001)           | ✓                               | ✓                              | ✓              | ✓                | ✓                           |                             |                             |                             |                             |                |                                |                                  |
| 10    | Hormozi, A.M., (2001)                      | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 11    | Gunasekaran, A. Yusuf, Y.Y. (2002)         | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 12    | Conboy, K. & Fitzgerald, B. (2004)         | ✓                               | ✓                              | ✓              | ✓                | ✓                           |                             |                             | ✓                           |                             |                |                                |                                  |
| 13    | Deshayes, L. et al. (2005)                 | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             | ✓                           |                             |                |                                |                                  |
| 14    | Lin et al. (2006)                          | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 15    | Vázquez-Bustelo, D. and Avella (2006)      | ✓                               | ✓                              | ✓              | ✓                | ✓                           |                             |                             | ✓                           |                             |                |                                |                                  |
| 16    | Lin et al. (2006)                          | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 17    | Ye-zhuang (2006)                           | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             |                             |                             |                |                                |                                  |
| 18    | E. Ferna and D. Va (2007)                  | ✓                               | ✓                              | ✓              | ✓                |                             |                             |                             | ✓                           |                             |                |                                |                                  |
| No. | Authors and Year | References |
|-----|------------------|------------|
| 19. | Sherehiy B.et al (2007) | ✔ ✔ ✔ ✔ ✔ |
| 20. | Vázquez-Bustelo, D (2007) | ✔ ✔ ✔ ✔ ✔ |
| 21. | Zhang, Z. and Sharifi, H (2007) | ✔ ✔ ✔ ✔ ✔ ✔ ✔ |
| 22. | Ramesh, G., S. R. Devadasan, (2007) | ✔ ✔ ✔ ✔ ✔ |
| 23. | Chandna,R., (2008) | ✔ ✔ ✔ |
| 24. | Erande, A.S. and Verma, A.K. (2008) | ✔ ✔ ✔ ✔ ✔ ✔ |
| 25. | Hasan, M.A., Shankar, R., Sarkis, J (2009) | ✔ ✔ ✔ ✔ |
| 26. | Ganguly,A. et al. (2009) | ✔ ✔ ✔ |
| 27. | Loforte Ribeiro, F. and Timóteo Fernandes, M., (2010) | ✔ ✔ ✔ |
| 28. | Abbas Toloie Eshaghy(2010) | ✔ ✔ ✔ ✔ ✔ ✔ |
| 29. | Bottani, Eleonora, (2010) | ✔ ✔ ✔ ✔ |
| 30. | Ismail, H.S et al. (2011) | ✔ ✔ ✔ ✔ |
| 31. | Y. Tseng and C. Lin, (2011) | ✔ ✔ ✔ ✔ ✔ ✔ ✔ |
| 32. | Yauch, C.A., (2011) | ✔ ✔ ✔ |
| 33. | Mashayekhi, A.N.et al.(2011) | ✔ ✔ ✔ ✔ ✔ ✔ |
| 34. | Vinodh, S. and Kuttalingam, D., (2011) | ✔ ✔ ✔ |
| 35. | Mishra, S et al. (2012) | ✔ ✔ ✔ ✔ |
| 36. | Flumerfelt (2012) | ✔ ✔ ✔ ✔ |
| 37. | Sreenivasa, C.G et al (2012) | ✔ ✔ ✔ ✔ |
| 38. | Mohd.Asif Hasan Joseph Sarkis | ✔ ✔ ✔ ✔ |
| 39. | Aravind Raj, S.et al.(2013) | ✔ ✔ ✔ ✔ ✔ |
| 40. | Chang, A.Y., et al (2013) | ✔ ✔ ✔ ✔ |
| 41. | Mishra, S.(2013) | ✔ ✔ ✔ |
| 42. | R. Dubey and A. Gunasekaran,(2014) | ✔ ✔ ✔ ✔ |
| 43. | Avazpour, R.et al. (2014) | ✔ ✔ ✔ ✔ |
| 44. | Zhang, M et al(2013) | ✔ ✔ ✔ ✔ ✔ |
| 45. | Aravindraj, Sakthivel, and S. Vinodh, (2014) | ✔ ✔ ✔ ✔ |
| 46. | Sherehiy, B(2014) | ✔ ✔ ✔ |
| 47. | Faisal, M. and Al-Esmael, B.A(2014) | ✔ ✔ ✔ |
| 48. | Mishra, S (2014) | ✔ ✔ ✔ |
| 49. | Holzner, P.,et al. (2015) | ✔ ✔ |
| 50. | Vinodh, S. and Aravindraj, S., (2015) | ✔ ✔ ✔ ✔ ✔ |
51 Jayakrishna, K et al. (2016) ✓✓✓✓✓
52 Swagatika Mishra ✓✓✓✓✓
53 Stettina, C.J. and Hörz, J., (2015) ✓✓✓✓✓
54 Thilak, V.M.M et al. (2015) ✓✓✓✓✓
55 S. Routroy et al. (2015) ✓✓✓✓✓✓✓
56 Soltan, H. and Mostafa, S. (2015) ✓✓✓✓✓✓✓
57 Routroy, Srikanta, and Arjun Shankar (2015) ✓✓✓✓✓✓✓
58 Shrikanth Routroy ✓✓✓✓✓✓✓
59 Rahul Sindhwani ✓✓✓✓✓✓✓
60 Dev et al. (2016) ✓✓✓✓✓✓✓
61 Leite, M. and Braz, V., (2016) ✓✓✓✓✓✓✓
62 Sindhwani, R. and Malhotra, V. (2016) ✓✓✓✓✓✓✓
63 Metaxas, I.N., (2016) ✓✓✓✓✓✓✓
64 Pavan Kumar Potdar et al. (2016) ✓✓✓✓✓✓✓
65 Maria. do Rosário Cabrita, M.et al, (2016) ✓✓✓✓✓✓✓
66 Dev, C et al. (2016) ✓✓✓✓✓
67 Pavan Kumar Potdar et.al, (2016) ✓✓✓✓✓
68 Bölükbaş, U. and Güneri, A.F., (2017) ✓✓✓✓✓
69 V. K. Mittal et al. (2017) ✓✓✓✓✓
70 Potdar, Pavan Kumar et al. (2017) ✓✓✓✓✓
71 Potdar, Pavan Kumar et al. (2017) ✓✓✓✓✓

5. Research Methodology

Based on the problem description and literature survey, following steps were identified for research work. Proposed methodology consists of five steps as shown in Figure 1. Proposed research methodology, which includes Extensive literature survey on Agile manufacturing followed by the implementation of AM enablers by sorting of research work on the basis of enabling and categorization. First step, include the literature survey of the latest research in the Agile Manufacturing. The next step is identification of enablers from extensive literature survey from the research work on the enablers. In the third step, questionnaire is designed for pilot study to identify the sample size. A detailed questionnaire is designed for ranking the enablers, which is to be filled by the various manufacturing units in Maharashtra and Silvasa, Diu Daman U/T. Responses of the various stakeholders are collected through online form and personal interview. Use of statistical tools is proposed for the evaluation of raw information to assign the ranking to enablers. Final step in the proposed research methodology is
formulation of framework model to be implemented with expected outcome and future research direction.

Enablers were identified after extensive literature survey, based on number of research papers. A pilot study was designed to gather information prior to a larger study to improve the final result of research. Pilot study result was processed to get the sample size to be targeted. New questionnaire was designed to capture the input from various manufacturing units. Questionnaire were distributed in physical as well as online format (https://forms.gle/tKBEwyyynk7NDd5Vf9) to capture the input from the manufacturing units outside Mumbai and Maharashtra state.

Data received through online form and physical form were analysed and processes to prioritize the agile manufacturing enablers using AHP, pairwise comparison matrix of 12 enablers are shown in table 2 and ranking of enablers are shown in table 3.

**Sampling Analysis**
A pilot study was conducted on 15 respondents from the personalities working in various fields. A summary of their responses and calculation thereof is attached in Appendix, sample size is calculated by following formula.

\[
n = \frac{z^2 \sigma^2}{e^2}
\]

Where,
- \(n\) = size of the sample,
- \(z\) = the value of the standard variate at a given confidence level,
- \(\sigma\) = standard deviation of observed values,
- \(e\) = acceptable error.

**Design of Questionnaire**
Questionnaires are designed to facilitate data collection. The two phases of data collection are discussed as Phase I: Pilot survey gives the Overview of Enablers and Phase II gives the essential Enablers. The questionnaire includes initial information like type of company, production type, industry sector, Employee strength, respondent work experience, employee size and annual turnover are summarized. Various industries from Maharashtra, Silvasa, Diu -Daman are considered for pilot survey.
In AHP pair-wise comparisons were conducted at levels, first at specific enablers and then essential level of enablers as shown in figure 2. An improved nine-point scale is used to assign relative weights to pair-wise comparisons between category of enablers and subcategory of enablers.

![AHP framework for prioritizing Agile Enablers](image)

**Figure 2. AHP framework for prioritizing Agile Enablers**

**Data Collection and Analysis**

This research tries to targeted managers at middle and higher level of management from various manufacturing industries in India. Before the commencement of this research, pilot study was conducted with sample size of 15 industry representatives, academician and researchers. Obtained sample then evaluated and analyzed statically, as a result a sample size of 210 received from the population. An online questionaries’ was drafted to record the input from the various industry representatives. Recorded data is analyzed by multi-criteria decision-making approach i.e. AHP to prioritize the enablers. Data obtained through various industry segments were processed with the help of statistical tool.

**Table 2  Pairwise Comparison Matrix**

|       | MGR | MFM | WOF | TECH | MFS | KNM | INT | SCM | MAM | SOF | QAQC | CRM |
|-------|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|------|-----|
| MGR   | 1   | 0.5 | 5   | 1    | 1   | 3   | 4   | 2   | 4   | 3   | 1    | 2   |
| MFM   | 2   | 1   | 3   | 2    | 2   | 3   | 2   | 1   | 2   | 3   | 2    | 1   |
| WOF   | 0.2 | 0.33| 1   | 1    | 2   | 2   | 4   | 3   | 4   | 4   | 3    | 0.33|
| TECH  | 1   | 0.5 | 0.5 | 0.5  | 1   | 1   | 3   | 2   | 2   | 1   | 1    | 0.33|
| MFS   | 1   | 0.5 | 0.5 | 0.5  | 1   | 1   | 3   | 2   | 2   | 1   | 3    | 1   |
| KNM   | 0.33| 0.33| 0.5 | 0.5  | 1   | 1   | 1   | 2   | 2   | 1   | 1    | 0.5 |
| INT   | 0.25| 0.5 | 0.25| 1    | 0.33| 1   | 1   | 0.5 | 3   | 1   | 1    | 0.5 |
| SCM   | 0.5 | 1   | 0.33| 1    | 0.5 | 0.5 | 2   | 1   | 4   | 1   | 2    | 0.33|
Prioritizing the Agile Manufacturing Enablers.
These are the resulting weights for the criteria based on pairwise comparisons
Number of comparisons = 66
Consistency Ratio, CR = 8.6%
Principal eigen value = 13.452

After calculating all parameters with AHP final result with prioritize ranking is obtained as follows.

**Table 3 Ranking of Enablers**

| Cat | Priority | Rank | (+) | (-) |
|-----|----------|------|-----|-----|
| MGR | 15.0%    | 1    | 11.9% | 11.9% |
| MFM | 13.9%    | 2    | 7.3%  | 7.3%  |
| WOF | 10.9%    | 4    | 5.6%  | 5.6%  |
| TECH| 7.6%     | 6    | 3.7%  | 3.7%  |
| MFS | 8.5%     | 5    | 4.2%  | 4.2%  |
| KNM | 5.6%     | 9    | 2.3%  | 2.3%  |
| INT | 4.8%     | 10   | 2.0%  | 2.0%  |
| SCM | 6.7%     | 7    | 3.4%  | 3.4%  |
| MAM | 3.4%     | 12   | 1.4%  | 1.4%  |
| SOF | 4.6%     | 11   | 1.6%  | 1.6%  |
| QAQC| 5.7%     | 8    | 3.5%  | 3.5%  |
| CRM | 13.3%    | 3    | 7.2%  | 7.2%  |
Figure 3, shows consolidated result obtained in stacked bar format for the respective criteria. X-axis represents the various criterias and Y axis showing priority percentage.

6. Result and Conclusion
In this study various research work based on 184 leading researchers work were studied and analyzed, as per research requirement; best 71 research papers were shortlisted for identification of enablers. The identified enablers then summarized with reference to 85 sub criteria’s which were defined for 12 categories of enablers. The proposed framework will guide the ordinary skill worker to adopt the concept of Agile Manufacturing in a simpler way. It will also provide a systematic path to manage the productivity of the manufacturing units with higher level of scalability by maintaining the agility with utmost customer satisfaction. Hence adoption of this framework will lead to improvement in the customer satisfaction, overall reduction in wastage and resulted in to higher overall productivity.

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