Implementation of Agile Manufacturing into Value Engineering Technique for Industries

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Abstract: Agile manufacturing (AM) is an application in manufacturing which aims to improve the competitiveness of firms. It is also believed that AM allows fast cost-effective responses to unpredictable and ever-changing product demand, and supports quick product launches for previously unplanned products tailored to satisfy customers. Value engineering (VE) is a systematic application of recognized techniques which identify the function of a product or service, establish a value for that function and provide the necessary function reliably at the lowest overall cost. It improves the value of a product, project or system and optimizes the life cycle cost. In this paper, combination of VE and AM was discussed in order to lower unnecessary costs, improve quality, respond quickly and satisfy customers. By implementation of these two techniques, maximum success would be attained.

Key words: Agile; Manufacturing; Value; Engineering; Implementation; Creativity.

1- Introduction

The purpose of this work is to analyze implementation of agile manufacturing into value engineering technique in industries. Agile manufacturing is about ability of the firms to survive in the competitive environment of continuous and unpredictable change by reacting quickly and effectively to market fluctuation caused by customer-designed products and services. There are some technologies which are barriers for implementing successful agile manufacturing as follows: concurrent engineering, virtual manufacturing, component-based hierarchical shop floor control system, standard for the exchange of products and information and communication infrastructure, etc. Clearly, lean manufacturing is based upon elimination of waste, quality planning and control (not TQM), Just in Time, supplier integration, automation, team working, empowerment, behavior, total preventive maintenance (TPM), delivery frequency, selling techniques, new product introduction, and agile manufacturing. [CJ1, G3, T1]. A number of research papers have been published about agile manufacturing recently [PN1, KS1, Y1, YS1]. The purpose of agile manufacturing is to lower manufacturing costs, increase market share, satisfy the customer needs, facilitate and introduce production of new products, eliminate non-value added activities and increase manufacturing competitiveness [G3, MB1, G2]. The process of agile manufacturing is characterized by product design, manufacturing, marketing, and support services.

Flexible manufacturing, elimination of waste and lean manufacturing can be applied to agile manufacturing. The main principle of agile manufacturing is that an industry, firm or an organization should consider continuous and rapid change in the competitive environment. First, a general review of agile manufacturing is provided. Then, the paper describes value engineering methodology in detail. The paper concludes with suggested implementation of agile manufacturing and value engineering for industries aimed at improving the overall system.

2- Agile Manufacturing

It is believed in the automotive industry that agile manufacturing is the solution for rapid cost-effective responses to unpredictable and ever-changing product demand, and support rapid product launches for previously unplanned products tailored to meet changing customer needs [EH1]. Agile manufacturing is an effective process for today's increasingly competitive market of fast changing customer requirements.

The main requirements of AM are enrichment of the customers, considering viewpoints of challengers, quick reaction to sudden changes, uncertainty and complexity, and leveraging people and information [G3]. Zhang et al. [ZG1] believed that purpose of using agile manufacturing is to achieve flexibility and responsiveness to the changing market needs. Critical to the success of an agile manufacturing system is to reconfigure the manufacturing cell and to integrate many disparate elements contained in cells. They also believed that quick modeling and reusable modeling capabilities are very important and necessary for agile manufacturing.
Goldman and Nagel [YS1, GN2] believed that "agility is a synthesized use of the developed and well-known technologies and methods of manufacturing. That is, it is mutually compatible with Lean Manufacturing, CIM, TQM, MRPII, BPR, Employee Empowerment, and OPT." Gunasekaran [G2, G3, EH1] describes agile manufacturing as "the capability to survive and prosper in a competitive environment of continuous and unexpected change by reacting quickly and effectively to changing markets, driven by customer-designed products and services."

Yusuf et al. [YS1] explained that the main points of the definition of various authors may be summarized as follow: "High quality and highly customized products [GN2, K1, B4, HG1]. Products and services with high information and value-adding content [GN2, GN1]. Mobilisation of core competencies [GN2, K1]. Responsiveness to social and environmental issues [GN2-K1]. Synthesis of diverse technologies [K1, B3]. Response to change and uncertainty [GN2, GN1, PP1]. Intra-enterprise and inter-enterprise integration [VK1, K1, Y2, Y3]." Yusuf et al. [YS1] suggested Table 1 which is about attributes of agility. There are 32 attributes, in 10 decision domains, of an agile manufacturing organization. The pathways and obstacles to achieving these attributes are important issues for consideration if progress is to be achieved in moving towards agility. Also important is the metrics for the processes that are required for achieving agility. If we look at the domains and attributes of Table 1, there are many important parameters which are indirectly related to brainstorming, creativity and also improvement of quality.

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<table>
<thead>
<tr>
<th>Decision domain</th>
<th>Related attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration</td>
<td>Concurrent execution of activities</td>
</tr>
<tr>
<td>Competence</td>
<td>Information accessible to employees</td>
</tr>
<tr>
<td>Team building</td>
<td>Empowered individuals working in teams</td>
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<tr>
<td>Technology</td>
<td>Technology awareness, leadership in the use of current technology</td>
</tr>
<tr>
<td>Quality</td>
<td>Quality over product life, First-time right design</td>
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<tr>
<td>Change</td>
<td>Continuous improvement</td>
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<tr>
<td>Partnership</td>
<td>Rapid, partnership formation</td>
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<tr>
<td>Market</td>
<td>New product introduction, Customer-driven innovations, Customer satisfaction</td>
</tr>
<tr>
<td>Education</td>
<td>Learning organisation, Continuous training and development</td>
</tr>
<tr>
<td>Welfare</td>
<td>Employee satisfaction</td>
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Table 1: Attributes of an agile organization [YS1].

Implementation of agile manufacturing has been a major objective of many industries, but its implementation with other techniques is more important which management must consider for better productivity and also combating the unpredicted crisis.

Kidd [K1] discussed that main resource of agile manufacturing are:
1- Management innovation
2- Employees and workers with high motivation and excellent training program
3- Intelligent and flexible technology

In their research work, Vazquez-Bustelo and Avella [VA1] mentioned that "The pioneering work done by the Iacocca Institute describes agile manufacturing as a new manufacturing infrastructure, establishing a list of systems and subsystems enabling agility, all of which are related to continuous change, responsiveness, quality improvement and social liability in environmental and working condition terms."

Just in time, waste elimination and high quality are some of the principles of lean manufacturing which are main fundamentals of agile manufacturing. It is believed that agile manufacturing has arrived as an evolutionary form of manufacturing system because it synthesizes and incorporates many prior approaches [K1, B1, J1]. Vazquez-Bustelo and Avella [VA1] drew a model (Fig.1) for agile manufacturing implementation. It shows the relations between the turbulent environment, the agile manufacturing system, manufacturing strengths and the business performance. Main factors in agile manufacturing are human resources, value chain integration, concurrent engineering, advanced technology, and knowledge management. These factors work together and output would be strength of the firm.

Figure 1: Conceptual model of agile manufacturing [VA1].

According to Goldman et al. [GN1] "an agile manufacturer must have the following four characteristics [CY1]:
1) Enrich the customer,
2) have a flexible organization that allows rapid reconfiguration of resources,
(3) Cooperate internally and with other companies in order to enhance competitiveness, and
(4) Nurture an entrepreneurial culture that leverages the impact of people and information."
"Using the description by Goldman et al., as a starting point, one work team attribute was derived for each of the agile manufacturing characteristics, resulting in the following four critical attributes for agile teams:
(1) Agile teams are multifunctional, in order to combine the knowledge and skills necessary to enrich the customer;
(2) Agile teams are dynamic and rapidly reconfigured, giving the organization flexibility and enabling rapid reconfiguration;
(3) Agile teams are cooperative, both within and between companies, to enable the intra- and extra-firm cooperation needed to enhance competitiveness; and
(4) Agile teams are virtual, which allow the company to combine resources (people and information) as needed in order to pursue entrepreneurial goals [CY1]."

In past decades, there has been an obvious change in manufacturing technology. It was initiated (Fig. 2) from mass production to flexible manufacturing and then to CIM, lean, JIT, concurrent engineering respectively. Agile manufacturing is the last methodology in technology. "The changes are directly driven by the requirements for products’ price, quality, delivery performance, customer choice, etc., which may result from the factors of unexpected changes of competitive market environment, globalization of market, a variety of customers’ demands, customer-designed products, and shortened product life cycle [CH1]."

Gunasekaran [G1] proposed a development system (Fig. 3) which is based on four main elements of technologies, strategies, systems and people. There are some common factors in the model proposed by Vazquez-Bustelo and Avella (Fig. 1) and Gunasekaran model (Fig. 3). Clearly, flexibility, fast reaction, knowledge, cost, quality, motivation, creativity, cooperation, and customer satisfaction are the most important factors which need a great deal of attention.

Figure 2: Development in manufacturing technology [CH1].

Figure 3: Development of an agile manufacturing system [G1].

3- Value Engineering

There are numerous problem solving techniques which have been used in different sectors of industries, societies, agricultures, managements and so on. Some of the techniques are: Value Engineering, TRIZ, Six Sigma, 5S, QFD and so on. But VE is one of the methods which have been used to improve the system by lowering the unnecessary costs in different areas.

Value Engineering (VE) is powerful management methodology to gain proper function of systems. Optimal allocation of costs is another important purpose of using this technique [CJ1]. Value Engineering is also a systematic and creative technique which deals with lowering the unnecessary expenses [MB1]. "Value Engineering is based on a rigorous interdisciplinary approach for solving the problems. It relies on searching the problems and then solves them. Creativity is an important factor to the VE problem solving activities that promotes "breakthrough thinking." This technique also uses a structured "job plan" that promotes consistency in application and helps assure results [G2]." Value Engineering is the systematic application of recognized techniques by multidiscipline team(s) that identifies the function of a product or service; establishes a worth for that function; generates alternatives through the use of creative thinking; and provides the needed functions, reliably, at the lowest overall cost [G3]." "Value engineering is an organized effort to get more for your money. It applies recognized techniques and tests to measure value and thus eliminate unnecessary costs in design, development, and manufacturing. It differs from cost control because it is directed toward analyzing value, not costs [T1]." "As a matter of fact, there are many different definitions about VE, but the main concept is to lower the unnecessary cost and also the quality improves or not to be decreased. It is a goal of everyday life and something that we all seek [G2]." Cell and Arratia [CA1] discussed implementing of Lean and VE.
Given that Lean is not primarily an analytic technique, Lean does not offer VE many analytic mechanisms. It does offer two elements that VE can use. First, one of the central principles of Lean is to work toward eliminating the "Seven Types of Waste."

Many researchers have been working on implementing VE technique with other methodologies in order to improve the overall productivity of the system. Sawaguchi [S1] discussed possibility of utilizing the TRIZ techniques in the new type of planning and development VE. Takemura and Sawaguchi [TS1] discussed the possibility of introducing TRIZ techniques into planning VE activities through consideration of the results of a survey on various challenges that the Japanese manufacturers face. Hamamoto [H1] summarized VE+TRIZ method and the case study of the development project of comfortable rest rooms for Shinkansen railcars in Japan. Nayak [N1] highlighted the history of Lean Manufacturing & Value Management and their development as two separate, and stand-alone tools for cost reduction & waste elimination.

3.1 – Historical Development

It is almost more than half a century that value engineering was developed. "VE had its origin during World War II, at General Electric, when innovation was required because of material shortages. Some critical materials were difficult to obtain, and a great many of substitutions had to be made. Mr. Harry Erlicker, a vice president, made the observation that many times these changes resulted in lower costs and improved products. This encouraged him to seek an approach to intentionally improve a products value. He assigned Lawrence D. Miles, a staff engineer, the task of finding a more effective way to improve a product's value. In 1947, Mr. Miles and his team developed a step-by-step system, called Value Analysis (VA), to analyze a product's cost and function to ferret out unnecessary costs. As a result of substantial investment, the new methodology, VA, was developed, tested, and proven to be highly effective. However, it wasn't until 1952 that VA began its growth throughout industry [TS2]." VE has been implemented in different sectors like industry, management, agriculture, construction, energy, and many other fields.

3.1 – Value Stream Map (VSM)

"Value Stream Map (VSM), a Lean Manufacturing tool, is a powerful tool for seeing waste, and providing the basis for moving forward eliminating waste, and identifying areas requiring improvements. A good Value Stream Map will include customers who will establish the "business case", i.e. they will tell what they want, and they will give the criteria to establish when we are effective. They will also tell where there is waste in the processes/products. Suppliers also have role in developing the Value Stream Map [N1, D1, D2, and F1]." VSM identifies followings for improvement of the system.

1. Customer requirements
2. Process waste
3. Areas generating poor quality
4. Processes lacking inter-organizational coordination
5. Labor cost
6. Material cost
7. Inventory cost
8. Maintenance cost

"Typically a Value Stream Map developed in a session is attended by representative form all organizations involved in the product flow. Value Management methodology includes creating/using Process Flow Charts and comparable tools, but it doesn't offer a mechanism quite like a Value Stream Map in Lean Manufacturing. Deliverables from a Value Stream Map include detailed description of the current process. For each step in a value stream, the map will detail flow time, cycle time, number of people involved, raw materials/work in process/finished stock inventory, change over time, yield, and other relevant information [N1]." The Value Stream Map is a tool for identifying the value stream with difficulties. Elimination of waste and lead time reduction is an important goal of this tool.

3.1 – Job Plan

The job plan is a proven format for reducing unnecessary cost in a project and it helps to maximize the productivity and effectiveness of a VE study. There are a number of different job plans in the literature. No matter how many steps there are, the process is always the same, analysis, creativity, evaluation and development. Several different job plans are shown below for illustration. In many cases, the phases may be the same but have different names [B2].

3.1.1 –Larry Miles

1. Orientation Phase
2. Information Phase
3. Creative Phase
4. Evaluation Phase
5. Planning Phase
6. Recommendation Phase
7. Implementation Phase

3.1.1 –U. S. Department of Defence

1. Orientation phase
2. Information Phase
3. Speculation Phase
4. Analysis Phase
5. Development Phase
6. Presentation and Follow-up Phase

3.1.1 –Fallon

1. Preparation Phase
2. Information Phase
3. Analytic Phase
4. Creative phase
5. Evaluation Phase
6. Presentation Phase
7. Implementation Phase

3.1.1 –Mudge

1. General Phase
2. Information Phase
3. Function Phase
4. Creation Phase
5. Evaluation Phase
6. Investigation Phase
7. Recommendation Phase

3.1.1 – Value Analysis Inc
1. Information Phase
2. Speculation Phase
3. Analytical Phase
4. Planning Phase
5. Execution Phase
6. Recommendation Phase

3.1.1 – Germany, VDI Spec. VA/E 69-910
1. Preparatory Measures
2. Determine Existing Condition: Defining functions and function costs
3. Verifying Existing Conditions
4. Generating Solutions
5. Verifying Solutions
6. Proposal and Implementation

3.1.1 – France, Specification NFx 50 152
1. Orientation
2. Data Collection
3. Function and Cost Analysis
4. Gathering and Reviewing Solutions
5. Building on Ideas
6. Present Recommendations
7. Implement Recommendations

3.1.1 – Japan
1. Information Collection Stage
2. Function Evaluation Stage
3. Creation Stage
4. Schematic Evaluation Stage
5. Detailed evaluation Stage
6. Proposal Preparation Stage
7. Proposal Follow-up Stage

3.1 – Principles for Evaluating Projects
When Lawrence D. Miles, father of Value Analysis, began practicing the discipline of Value Analysis after World War II, he laid down following 10 principles for Purchasing department to use in evaluating a product [N1].
1. Does the use contribute to value?
2. Is it cost proportionate to its usefulness?
3. Does it need all its features?
4. Is there anything better for the intended use?
5. Can a usable part be made by a lower cost method?
6. Can a standard product be found that will be usable?
7. Is it made on proper tooling – considering quantities made?
8. Do materials, reasonable labor, and profit total its cost?
9. Will another dependable supplier provide it for less?
10. Is anyone buying it for less?

"It is also important to consider that projects are becoming more complex and customers are requesting that they be built faster, less expensive, and with higher quality standards. Customers are requesting value. As value service providers, we need to deliver projects that meet, or exceed, the customers’ expectations: maximizing value and minimizing waste through strategies and techniques that enhance value [N1, LR1].” There are some common criteria between value engineering and agile manufacturing. The most important of them are cost reduction, waste elimination and voice of customer.

4- Implementing AM into VE
Mostafaeipour model (Fig. 4) has been proposed for implementing value engineering into the agile manufacturing.

![Figure 4: Mostafaeipour model for implementation of AM into VE.](image-url)

The information phase involves definition of the project, gathering the past information, limitations on the project, possible future overall changes, cost reduction, waste elimination, and customer satisfaction. The purpose of this phase is to collect all the required information for upcoming phases. In Mostafaeipour model, market needs and also unpredicted changes also must clearly be considered for information phase. In selection phase, the best candidates would be chosen for entire program. This is an important phase, because it relates to the identification of study projects and their evaluation, selection, planning and authorization. Clearly, there should be some candidates with different background of the subject. Required technologies and new strategy must be selected for further investigation. For investigation phase, the main focus is to get access to the knowledge related to the subject. The main subject is waste elimination, cost reduction, customer satisfaction, and readiness for possible crisis and changes in the future. In general, all the mentioned subjects yield to lower cost and also higher quality in order to satisfy the customers.
"Brainstorming is a group cooperative thinking methodology which yields toward the solution of a specific problem. It uses certain techniques, to stimulate the imagination and facilitate the expression of ideas [B2]. Creativity is a characteristic many people would like to possess. Most children are creative, but as they mature they seem to lose it. One of the common experiences of most adults is school, and there are those who believe strongly that our system of education squeezes all creativity from us while we innocently attend schools [B2]." Creativity is one of the main parts for all systems which a great attention is required for its implementation. "The value engineering analyst is asked to develop new ideas that go beyond the original concept of the designer. The architect and project engineer exercise creativity by formulating a combination of materials, systems, processes and techniques to accomplish a required function. The VE team, on the other hand, begins with the designer's proposed plan and develops new ideas, combinations and techniques that go beyond the architect's and engineer's normal design techniques. Creative thinking is used to go beyond our normal pattern of problem-solving, and it makes us more productive. It saves cost in construction projects and adds to the total value of the project[Z1]." We should welcome and encourage constructive ideas from the participants. Also allow them to express their ideas freely. As a matter of fact, customers and suppliers should participate in brainstorming sessions for expressing their ideas toward solution of the cases. "During speculation, a conscious effort was made to prohibit any judicial thinking so as not to inhibit the creative process. Now the ideas thus produced must be critically evaluated. With all ideas recorded, evaluate the ideas for acceptance [VE1]." In this phase, the best ideas would be selected for further study. They should be led by persuasion rather than by orders. The purpose of development phase is to get all additional data, to thoroughly analyze those best alternatives selected during the evaluation phase, and to prepare cost estimates and initial designs that will ensure acceptability and ultimate project implementation. "Development phase is for analyzing of remaining ideas for development workable solutions. Then, the ideas are thoroughly researched, preliminary designs are prepared, sketches of the proposed solution are prepared, and life-cycle cost estimates are made of the original design and of the new proposed recommendation. Background information and supporting calculations are necessary to augment and support the new recommendations. It is important that the value engineering team be able to convey the concept for their recommendation to the design engineer. If the proposal is not accepted, it would then be rejected. It may also be discarded due to lack of information. Each recommendation is presented with a brief narrative to compare the original design method to the proposed change [Z1]." Presentation in next phase after development All the recommended ideas will be in a convincing terms before the brainstorming decision would be made by the team. Decision-makers are those persons who ultimately approve the VE Team’s recommendations. Implementation is almost a final action which uses the selected proposals to a real work. The approved selected proposal must be alive and workable. Audit phase is a final and a kind of security control for the whole work in order to be sure of the adequate result of the proposed ideas.

4.1 –Feasibility of Implementing New Model

It is feasible to implement the new model in any industry, because value engineering was implemented separately into the automotive industry. Also Agile Manufacturing has been used in automotive industry too. This new model has mixed all two mentioned methodologies in order to have a better system for any firm, organization or factory. Just as Value Engineering can be applied across all stages of the decision making process, so it can be used to reduce costs across a vast range of functions and systems. A research suggested by Ibusuki and Kaminski [IK1] shows a methodology for the product development process in an automotive company, aiming at the correct systematic approach of Value Engineering (VE) and target-costing in cost management. The suggested proposed approach was validated in a case study focused on the engine-starter system of a vehicle, aiming at improved product cost, functionality and quality accomplishment, in accordance with customer needs and the company strategy. Elkins et al. [EH1] presented agile manufacturing into the automotive industry; they proposed two different models which are first step toward developing practical business case tools that help industry to assess the value of agile manufacturing systems. There was also a case study regarding of value engineering implementation into an autotomotive industry in India (Tata Motors) which was successful. The most important point about new model is that it is feasible to be implemented. Unredirected changed and also market needs must be included in information phase (Fig. 4). However, new strategy and required technologies could be easily considered in selection phase of value engineering phase. The main goal of value engineering is to create low cost and high quality products, which we could consider them in third phase of investigation phase. Talking with customers and suppliers could create new ideas for creativity phase, because we have to get all the required new ideas for better decisions of creativity phase.

5- Conclusion

In this paper, we have discussed implementation of value engineering technique into the agile manufacturing. A model was proposed for this purpose to be helpful for the industries to obtain maximum customer satisfaction, reduce unnecessary costs, eliminate waste, and also increase quality. Agile manufacturing is an effective process for today’s increasingly competitive market of fast changing customer requirements. The main requirements of AM are enrichment of the customers, considering view points of challengers, quick reaction to sudden changes, uncertainty and complexity, and leveraging people and information [G3]. Value Engineering is the systematic application of recognized techniques by multidiscipline team(s) that identifies the function of a product or service; establishes a worth for that function; generates alternatives through the use of creative thinking;
and provides the needed functions, reliably, at the lowest overall cost [G3]. Clearly, if we combine these two techniques, more productivity would be acquired. Also better decisions would be taken in brainstorming sessions too. Unpredicted changes could be then solved easily after implementing the new proposed model. This model contains eight different phases which could thoroughly analyze all the problems.

6- References


