IMPROVED AND OPTIMISED WAY OF DEVELOPMENT OF RECONFIGURABLE MANUFAACTURING SYSTEM

Vimal Sewal[1], Nishant Sharma[2*]

[1]PG Student, School of Mechanical Engineering, Bahra University Shimla Hills, Waknaghat, Himachal Pradesh, India
[2]Assistant Professor, School of Mechanical Engineering, Bahra University Shimla Hills, Waknaghat, Himachal Pradesh, India

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ABSTRACT: *Ideal reconfigurable producing systems possess six core RMS characteristics: modularity, integrality, made-to-order flexibility, measurability, customizability, interchangeability. A typical RMS can have many of those characteristics, though not essentially all. Once possessing these characteristics, RMS will increase the speed of responsiveness of producing systems to unexpected events, like unexpected market demand changes or surprising machine failures. The best reconfigurable system provides precisely the practicality and production capability required, and might be economically adjusted precisely once required. The graph theory approach (GTA) and matrix method have been used to determine the barrier index of various obstacles. In this study, the imperative structure modelling (ISM) method has been used to determine the barrier index of the various obstacles. This study discusses the conceptual framework of several obstacles and variables related with RMSs along with their interdependencies. Analytical Hierarchy Process (AHP) approach has been used in this present study for determining a consistency ratio and an adequacy index factor of the best production system. AHP is used to structure the decision-making process for the selection of a production system among viable options, including RMS. In this frame work, the GTA method propose an index of the factors in RMS. The value of this index is measured using a permanent function derived in the diagram. The study demonstrates current state of the study on the RMS implementation, with use of graph theory approach and matrix method, it has been emphasized the significance of various obstacles, so that feasibility of the RMS transition may be assessed. The diagram theory has been used to determine the index factor for the transition to RMS. Two ISM frameworks for obstacles and considerations have been established that demonstrate their administrative consequences for RMS adoption.*

Keywords: Reconfigurable Manufacturing System, RMS characteristics, Graph Theory Approach, Imperative Structure Modelling, Analytical Hierarchy Process, RMS Index Factor, Diagram Theory.

1. INTRODUCTION

Global rivalry has led business to constantly enhance business so that they can offer the appropriate goods to consumers in the right amount and in right time. Numerous difficulties and developments define the contemporary industrial environment. Traditional manufacturing methods are widely acknowledged as not suitable for current market competitiveness and a change is required. A considerable deal of study has been done in the quest for innovative production methods. Many of these innovative methods, however, do not have a unified global production viewpoint and target just certain production views. Product design needs in the 21st century offer a growing difficulty. Consumers are increasingly demanding goods that meet their particular but constantly changing requirements. The added feature of the product does not ensure that the client receives precisely what he wants. Changes in client needs generate the need for new production system designs. Manufacturer organizations should be flexible enough to manufacture a range of goods on the same system to maintain competitiveness in changing marketplaces. In this manner, modern production system must correctly evaluate both economic and technical factors: in order to justify their investment. They cannot acquire a fair proportion of the competitive market.

The producers must look for this kind of production technology to address the problems, which may provide the manufacturing system flexibility and reconfiguration. The ideal solution to such problems is a customizable production system. Reconfigurable Manufacturing System (RMS) is a production paradigm that seeks to create a wide range of goods and successfully react to market changes. In order to rapidly modify production capacity, RMS may be described as the production system built from the start for fast changes in hardware and software components.

It has many unique features such as modularity, integrability, adaptability, and convertibility. RMS are intended to quickly create several product families without compromising quality in quickest time and at the lowest cost. Furthermore, the production reconfigurability soon became a new economic goal alongside traditional objectives like low cost and good quality. In other words, the reconfiguration process is to change the existing configuration into a new configuration that may change the process.

In order to rapidly modify manufacturing capacity and functionality within a component family, the RMS is intended for structural changes. The production method where a number of goods that consumers need are categorized into families, each of which is a series of comparable products that corresponds to new conditions and change them so they may be used not just to produce a range of goods, but also to introduce new products within each families. Reconfigurable systems are intended to keep performance at ahigh level by altering their design to satisfy many functional needs or changes in operating circumstances.

RMS is a specialized flexible manufacturing system. A characteristic aspect of RMS is that its configuration changes over time to offer the required functionality and capacity. When modifications are required, it is preferable to modify the configuration to reduce underutilized capacity and functionality. Furthermore, there should be a high degree of reconfiguration smoothness between both successive configurations so that the cost, time and effort of reconfiguring the system is minimized.

RMS is generally the system used by manufacturers that reiterate the importance of being able to change and evolve rapidly in order to adjust the productivity capacity and functionality.

TABLE 1.1. Strategic Benefits of RMS

S. No	Description
1.	Increased Product Quality
2.	Reduced Time Required for Product Changeover
3.	Enhanced Ease of Prototype Development
4.	Reduction of Lead-Time for Launching a New Manufacturing System
5.	Rapid Upgrading of System
6.	Quick Integration of New Process Technology

TABLE 1.2. Tactical Benefits of RMS

S. No'	Description
1	Improved Process Technology
2	Customized Manufacturing Policy
3	Improved Gap Level Between Manufacturing System and Demand Variation
4	Adjustable Machine Structure
5	High Scalability
6	High Flexibility
7	Improved Quality
8	Improved Working Condition
9	Improved Manufacturing Control

10	Good Monitoring of Machine and Tools
11	Greater Accuracy with Reduced Set ups
12	Adjustable System Structure
13	Improved Control of Parts
14	Improved Data Management
15	Improved Control of Operations of Simultaneous Tools
16	Increasing frequency of New Product Introductions Due to Shorter Product Life Cycles

1.3 Research Methodology

The research technique used in this research are as follow:

I. Questionnaire Based the Survey Approach

It is proven approach to know the respondent's perception related to different issues of a research problem. This has been used to gain a broad insight of RMS implementation in India.

II. Analytic Hierarchy Process (AHP) Technique

The technique was used to access the optimum system. The technology has become a significant option for efficient data analysis, particularly for decision making process. AHP is a structural technology that helps individuals handle difficult choices. AHP is a technique which created for supporting multicriteria choices where implies that the issue is divided into the component parameters and hierarchy suggest that the primary objective is a hierarchy of the component parameters. AHP is a multicriteria decision making technique using a hierarchical framework to handle complex, unstructured choice issues, in a particular in circumstances where significant qualitative elements need to be addressed in combination with variables. In the current study, AHP was utilized to determine the index factor for appropriateness.

III. Graph Theory Approach:

Graph theory approach is a power technique, which can be applied in various fields for example advanced manufacturing system etc. In the present work, it has been for finding the barriers index and factor index in transition to feasibility of RMS.

IV. ISM Approach:

ISM is frequently used to comprehend circumstances as well as to develop a plan of action to solve an issue. This method structures a series of diverse components. Directly and indirectly, into a compressive system model. It was utilized to determine the driving and dependent power of the RMS factors and obstacles.

2. METHODOLOGY

2.1 Graph Theoretic Approach

"A diagram may be undirected, such that the two vertices that are associated with each edge have no distinction. Drawing a dot at each vertex and drawing an arc between the two vertices visually depicted. Diagraph models are based on the system structure but are sufficiently flexible for the analysis of changes. Conventional representations, such block diagrams and flowcharts, do not show the relationship between components and not appropriate for further study. The theory of graph is a system approach that describes the components and their connections. The GTA has certain special characteristics that allows for the modelling of the interdependency of the variables. It is a systematic approach of the translation of qualitative values, and the suggested strategy is based on mathematical modelling. It includes three components like diagraph representation, and persistent representation of the function. The matrix transforms the diagraph to math.

2.2 Diagraph Representation

In terms of nodes and borders, a diagraph depicts the components and their interdependence. No direction is assigned to the edges of the graph in an undirected graph or diagraph have directional edges. A diagraph of RMS factors is ready to express RMS factors in terms of nodes and edges. It depicts factors (Bi) by its nodes and dependency of factors (bij's) by its borders. Bi shows the heritage of the factors and bij indicates the extent to which the factor is dependent. Figure 2.1 describes schematically five types of factors, such as technological factors (B1), behavior factors (B2), non-compliance factors (B3), strategic factors (B4) and financial factors(B5) and the matching RMS factors digraph in figure 2.2. The technical component (B1) influences the compartmental variable.

The behavior component (B2) is presented which affects all other variables, i.e. the B2 to B1, B3, B4 and B5 direct edge. A strategic factor (B4) and financial factors (B5) are affected by non-conduct (B3), strategic factor (B4) impacts everyone else factors, i.e. a direct edge from B4to B1, B2, B3 and B5. Financial factors (B5) affects behavioral (B2) and technical factor (B1).

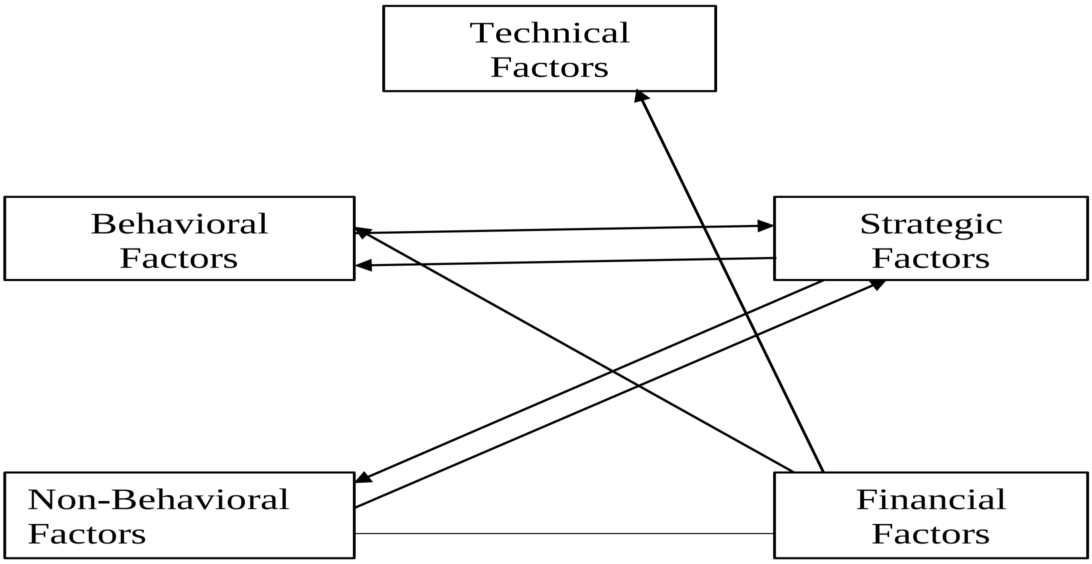

Fig.2.1 Schematic Representation of RMS Factors

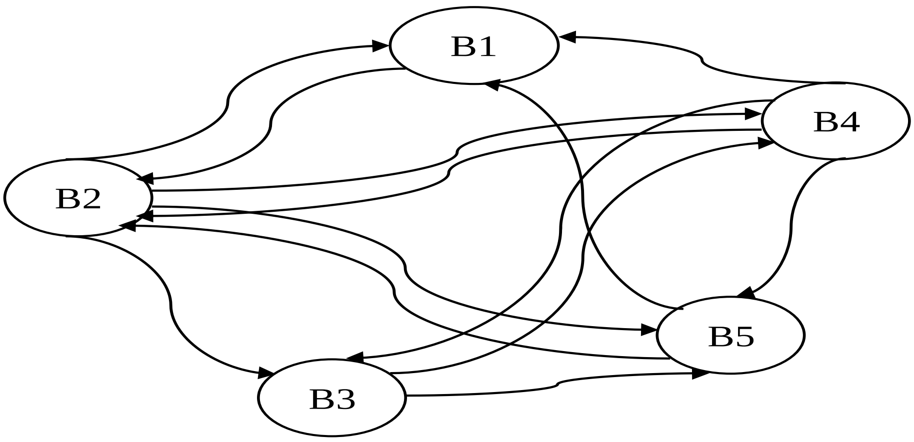

Fig.2.2 RMS Factor Digraph

2.3 The Matrix Representation

A diagraph is a representation so it helps in analysis to a limited extent only. To establish the expression for RMS factors, the diagraph is represented in matrix form. Consider a diagraph of a n factors leading to a n-th order symmetric (0,1) matrix A=[bij]. The rows and columns in the matrix represent interactions among factors, i.e. bij represents the interactions of the i-th factor with j-th factor;

Bij = 1; if factor I is connected with factor j;

Bij = 0, if factor I is not connected with factor j

Generally, bij: *p* bji as RMS factor are directional and bii = 0, as a factor, is not interacting with itself. The RMS factor matrix representing the diagraph shown in figure is written as:

$$A = \left|\begin{array}{ccccc} \boldsymbol{B1} & \boldsymbol{B2} & \boldsymbol{B3} & \boldsymbol{B4} & \boldsymbol{B5} \\ 0 & 0 & 0 & 0 & \\ & & 0 & & \\ & 0 & 0 & 0 & \\ & & 1 & 0 & \\ 1 & 0 & 0 & 0 & 0 \end{array}\right| \begin{array}{c} \boldsymbol{factors} \\ \boldsymbol{B1} \\ \boldsymbol{B2} \\ \boldsymbol{B3} \\ \boldsymbol{B4} \\ \boldsymbol{B5} \end{array}$$

The interdependency of RMS factors is shown by off diagonal elements with value 0 or 1. the elements are 0 since the effect of RMS factors is not taken into consideration.

2.4 Variable Permanent Matrix of RMS Factors (VPRMS)

By assuming all factors VPRMS is defined as matrix B

$$B = \left|\begin{array}{ccccc} \boldsymbol{B1} & \boldsymbol{B2} & \boldsymbol{B3} & \boldsymbol{B4} & \boldsymbol{B5} \\ \boldsymbol{B1} & \boldsymbol{b12} & \boldsymbol{bn} & \boldsymbol{b14} & \boldsymbol{b15} \\ \boldsymbol{b21} & \boldsymbol{B2} & \boldsymbol{b23} & \boldsymbol{b24} & \boldsymbol{b25} \\ \boldsymbol{b31} & \boldsymbol{b32} & \boldsymbol{B3} & \boldsymbol{b34} & \boldsymbol{b35} \\ \boldsymbol{b41} & \boldsymbol{b42} & \boldsymbol{b43} & \boldsymbol{B4} & \boldsymbol{b45} \\ \boldsymbol{b51} & \boldsymbol{b52} & \boldsymbol{b53} & \boldsymbol{b54} & \boldsymbol{B5} \end{array}\right| \begin{array}{c} \boldsymbol{factors} \\ \boldsymbol{B1} \\ \boldsymbol{B2} \\ \boldsymbol{B3} \\ \boldsymbol{B4} \\ \boldsymbol{B5} \end{array}$$

Thus, VPRMS corresponding to five factors RMS diagraph (figure 2.2) is shown in matrix B*.

VPRMS B^* =

$$\left|\begin{array}{ccccc} \boldsymbol{B1} & \boldsymbol{B2} & \boldsymbol{B3} & \boldsymbol{B4} & \boldsymbol{B5} \\ \boldsymbol{B1} & \boldsymbol{b12} & 0 & 0 & 0 \\ \boldsymbol{b21} & \boldsymbol{B2} & \boldsymbol{b23} & \boldsymbol{b24} & \boldsymbol{b25} \\ 0 & 0 & \boldsymbol{B3} & \boldsymbol{b34} & \boldsymbol{b35} \\ \boldsymbol{b41} & \boldsymbol{b42} & 0 & \boldsymbol{B4} & \boldsymbol{b45} \\ \boldsymbol{b51} & 0 & 0 & 0 & \boldsymbol{B5} \end{array}\right| \begin{array}{c} \boldsymbol{factors} \\ \boldsymbol{B1} \\ \boldsymbol{B2} \\ \boldsymbol{B3} \\ \boldsymbol{B4} \\ \boldsymbol{B5} \end{array}$$

The diagonal elements B1, B2, B3, B4, and B5 represents the effect of the five factors and the off-diagonal elements represents interdependencies of each elements in the matrix.

2.5 Permanent Representation:

The permanent representation is a standard matrix function. Application of permanent concept will lead to a better appreciation of RMS factors. Moreover, using this negative sign will appear in the expression (unlike determinant of the matrix in which a negative sign can appear) and hence no information will be lost. The permanent function is nothing but the determinant of a matrix but considering all the determinant terms as positive terms. The RMS factors function for matrix expression is written as:

$$VPM_{RMS} = per\ B^* = \prod_{i=1}^{5} Bi + \sum_{i,j,k,l,m} (b_{ij}b_{ji})\, B_k B_l B_m + (b_{ij}b_{jk}b_{ki} + b_{ik}b_{kj}b_{ji}) B_l B_m$$
$$+ \left(\sum_{i,j,k,l,m} (b_{ij}\ b_{ji})(\ b_{kl}b_{lk}) B_m + \sum_{i,j,k,l,m} (b_{ij}b_{jk}b_{kl}b_{li} + b_{il}b_{lk}b_{kj}b_{ji)} B_m \right)$$
$$+ \left\{ \sum_{i,j,k,l,m} (b_{ij}b_{ji})(b_{kl}b_{lm}b_{mk} + b_{km}b_{ml}b_{lk}) + \sum_{i,j,k,l,m} (b_{ij}b_{jk}b_{kl}b_{lm}b_{mi} + b_{im}b_{ml}b_{lk}b_{kj}b_{ji}) \right\}$$
$$+ \left[\begin{array}{l} \sum_{i,j,k,l,m} (b_{ij}b_{ji})(b_{kl}b_{lm}b_{jk} + b_{kn}b_{ml}b_{lk}) + \sum_{i,j,k,l,m} (b_{ij}b_{jk}b_{ki}) b_{lm}b_{lk}) \\ + \sum_{i,j,k,l,m} (b_{ij}b_{ji})(b_{kl}b_{lk})(b_{ml}b_{mk}) + \sum_{i,j,k,l,m} (b_{ij}b_{jk}b_{kl}b_{lm}b_{ml}b_{mk} + b_{ml}b_{lk}b_{kj}b_{ji}) \end{array} \right]$$

The $\boldsymbol{VPF_{RMS}}$ is a mathematical expression in symbolic form and it ensure an estimate of the RMS factors existing in an organization. It is a complete expression for RMS factors as it considers the presence of all factors and their interdependencies.

2.6 Quantification of Bi's and bij's

The RMS factors (I.e. Bi's) are quantified using above equation. The subsystem is designated as each group of factors is assessed for a permanent function taking into account different variables influencing the subsystem. Dependence of factors at the subsystem level is shown in digits. These digits lead to the legacy if system level factors via matrix and each permanent variable matrix function is assessed. The permanent function of these matrices leads to RMS factors being inherited. GTA may thus be used at all levels. In order to get the whole value of the multinomial, some numerical value should be given to diagonal and off diagonal components in VPMRMS. As previously said diagonal components are distinct factors while off diagonal elements are interdependent between RMS factors. because the impact of all variables may not be equal and the reliance on factors cannot be directly assessed at system level, these values are only given via a team of specialists after appropriate interpretation.

2.7 RMS Factor Index (RMSFI)

The RMS implementation in an organization is a function of these five factors and their interdependencies:

RMS factor index = f (factors)

Although it is very difficult to talk about RMS factors in quantitative terms, VPRMF is a useful tool and estimates the RMS implementation in terms of factors. It is a function of various RMS factors, their interdependencies and complexities. Hence, the RMS factors index is given as:

RMSFI = per $\boldsymbol{B}^*$ = permanent value of VPMRMS of this index are as follow:

This index is a means to evaluates the content of factors existing in an organization.

RMS factors existing in an organization are represented by a single numerical value. A higher value of index indicates that an organization has to improve the weak links in implanting RMS.

2.8 Methodology

GTA evaluates the impacts of factors in an organization in terms of a single numerical index. This takes into consideration the individual effects of the various factors are as follow:

Step 1

Identify the various factors affecting the RMS. Different industries may have a different set of factors affecting the RMS, depending on the size of the industries.

Step 2

Broadly group these factors into different categories.

Step 3

Foe each category of factors, logically develop a diagraph among the sub factors based on the interactions among them. This is the digraph at each subsystem level.

Step 4

Develop a subfactor matrix. This will be of size M*M, with diagonal elements representing factors and the off-diagonal elements representing interactions among them.

Step 5

At the subsystem level, get numerical values for inheritance of factors and their interactions.

Step 6

Find the value of permanent function

Step 7

Repeat the step 3-6 for each category of factors.

Step 8

Develop the digraph between major categories of factors depending on their interdependencies. The number of nodes should be equal to number of major factors categories and the magnitude and direction of edges should correspond to their interdependencies.

Step 9

At the system level the permanent value of each category factor provides inheritance of factors in RMS implementation. The quantitative value of interaction among factors is obtained through proper interpretation by experts.

Step 10

Find the value of the permanent function for the system.

Step 11

Record the results of this study and document for the future analysis. Based on the methodology discussed above, the organization can evaluate the extent of factors of RMS.

3. The Effect of Factors in the Design and Implementation of RMS

3.1 Technical Factors

This category includes the following technical factors

- Convertibility
- Scalability
- Flexibility
- Customization
- Modularity

Convertibility may be a metric of system performance of any system type, but it is particularly essential for RMS application. This is because of the personalization of RMSs. If RMS is tailored for the parts family, then batches of one component are manufactured for a limited duration, followed by a reconfiguration, following which batches of the next part begin production within the family. These reconfigurations, or conversions, should be performed in a very short period of the time to provide a system with high convertibility thus achieving maximum performance at multiple levels.

Scalability is the ability to correctly change the volume of a system with minimum costs and across a variety of capacities in minimum time. Convertibility and scalability measures are essential when it comes system responsiveness. The investment allows the business to expand its production scale quickly in the case of better than anticipated market circumstances and increases demand. Current CNC based machining systems may be scalable since CNC machines be added to the production capacity progressively. However, the RPS will not only be able to parallel the addition of entire machines, but also includes modular scalable machine tools. This implies machine modules may be added to each machine so that capacity can be changed more quickly.

The capacity to alter and adapt to a variety of states may be characterized as flexibility. The term flexibility originates from the Latin language, which means 'to mix'. Flexibility is a key element in understanding reconfigurable system design conceptually. The capacity to be modified in terms of flexibility and control may be defined.

The customizable flexibility implies that machines are constructed around the family of products. The integration of control modules with open architecture technology ensures customized control for the RMT, giving the precise control functions required to operate the non-orthogonal machine.

The modularity may be described as production functions and operating unit needs which can be changed between alternative production systems in order to obtain the optimum arrangements

3.2 Behavioral Factors

The behavioral factors are as follows:

- Training of staff
- Team spirit
- Clear vision
- Top management commitment
- Long term planning

The function of training is to understand how the system will change manufacturing processes. It is true that training is very important for every staff member to increase the efficiency of industry. For designing of advanced systems i.e. RMS, education from start of the project should be focus.

When developing sophisticated manufacturing systems, system users must be taught.

Team spirit is an important element in the design of the RPS. The team should include a mixture os consultants and internal employees to build the technical skills required for design. It is extremely essential that the team member be allocated full time throughout the design process. The team should be co-located as far as feasible at a designated location to promote cooperation. It is important that the team knows the functions and products of company so that they know what is required to support key business operations. The management should have clear vision of RMS implementation and should create a long-term strategy for it. To succeed, every company must have a significant commitment in the part of the senior management. The goal must be conveyed clearly and constantly to all staff. Both the corporate philosophy and personal philosophy of the senior management work together to create the operational parameters of the company.

3.3 Non-Behavioral Factors

Non behavioral factors play a key role in implementation of RMS. this category of factors includes the following:

- Availability of resources
- Software and hardware enhancement
- Operational and control technique
- Availability of spaces

The availability of resources such as man, machine, material, etc. is necessary in order to carry out tasks. Therefore, cautious and intelligent resource allocation must be made to ensure the required output is developed with minimal resource usage.

Software is tangible whereas hardware is intangible and requires upgrading. These criteria are essential for RMS implementation. Operating technology covers all the actions establishing a task and authority framework for operations. Feedback devices are conducted in line with the control methods to verify whether the work is completed according to schedule or not. These methods are extremely useful when RMS is used.

Good workplace, employment security, a fair and free workplace provide an employee with pleasure. Failure to do so may also be discontent.

3.4 Strategic Factors

Strategies factors are as follows:

- Technical knowledge
- Social implications
- Vendor development
- Market share
- Innovation strategies

Vendor development may be described as any action a purchasing company does out to enhance the performance and ability of a supplier to fulfil the supply requirement of the purchasing companies. The development factors thus play an essential part in the conception of reconfigurable production. The word social refers to a feature of human beings and social implications implies that a relationship which holds two proposals or classes of proposals under which one is logically deducted from others. The technical knowledge element helps to develop an RPS.

If employees with many and superior working methods and abilities are accessible, significant RMS design challenges will be addressed. Market share shall be determined as the percentage of the total sales of the particular product or service type that is attributable to a particular company. In other words, a market share will be the percentage of a particular market achieved and sold by the particular product, advertising or agency.

Innovation is a crucial part of the strategic planning cycle of companies. Innovation plays a well overall strategic role for the business. In many instances, the future prosperity of the business may rely on the efforts of innovations.

3.5. Financial Factors

Financial factors include the following factors

- Manufacturing and design cost
- Overhead cost
- Warranty claims
- Availability of funds
- Maintenance cost

Cost is crucial issue in implementing an RPS. To build a system whose design factors vary during operation lead to higher costs. Design engineers do components engineering analyses and may construct a prototype for product testing.

Overhead costs are all non-employment expenditure. These are either fixed or variable costs. Foxed expansion includes the depreciation of hypothecary payments and variations in sales and other variables between month and month.

Warranty claims include claims field in person or by telephone for alleged sales representation of the product or service, high-pressure sales tactics, failure to disclose essential conditions of the offer and verbal representation net, consistent with the written contractual requirements.

Money are accessible for drawing or other purposes to an account holder. This may include overdraft money or credit lines and may be categorized as the balance available.

Maintenance is a term for retrofitting, rework, replacement and periodic examination of the equipment. Maintenance expenses are frequently used to assess the performance of maintenance across business.

4. RESULTS AND DISCUSSION

The methodology presented in this paper, helps in the calculation of intensity of different factors affecting the RMS. Hence, with knowledge of the intensity of various factors, some precautions and good decision may be taken by the managers to handle these factors. It was observed in the considered example that technical factors have the maximum intensity. At the subsystem level, convertibility, scalability, flexibility, customization, modularity factors play a significant role in the implementation of RMS. To overcome these factors the management should formulate and follow some standards.

The next major category is the behavioral factor and the factors comes under the category of behavioral factors are training of staff, team spirit, clear vision, top management commitment, long term planning. These factors are essential factors for implementations of reconfigurable manufacturing system. The next category is non behavioral factors. The factors come under this category are availability of resources, software and hardware enhancement, operational and control technique, availability of space.

The management should pay more attention on these factors to implement RMS in the organizations. The next category is strategic factors. These are related to objectives, policies and strategies of the organization. To handle these factors, a strategy must be developed and properly communicated to the lower level by the management. The next category are financial factors. To overcome the financial factors, management should give more attention to hidden and intangible factors such as warranty claims, availability of funds, maintenance cast to successfully implementations of RMS, managers should formulate and follow some standards for materials, tools and equipment.

5. CONCLUSIONS

Due to globalization, manufacturers are facing more challenges than ever before. Market has become highly volatile due to large fluctuation in product demand. To remain competitive, companies must design manufacturing systems that not only produce high quality products at low cost but also respond to market changes in an economical way. These changes include increasing the frequency of the introduction of new product, modification in the existing product, changes in product demand, changes in process technology for better quality and productivity, changes in government policy regarding safety and environment issues. Companies must be able to respond to these changes rapidly and cost effectively. Design of manufacturing system should be such that it must be capable to fulfil the strategic objectives of the company.

When demand fluctuates, the strategic objectives is to meet demand. These drawbacks have been discussed below. The challenges with copying with large fluctuations in product demand cannot be solved with dedicated lines that are not scalable. So that quite often opportunities to supply a large demand of a product are ignored even though the available production capacity for another product remains largely underutilized. The reason for this low average utilization is that some products, in the early stages of introduction or at the end of their life cycle, are required, but in lower than optimal volumes. Even products in the phase o not always reach the production volumes forecast when the dedicated manufacturing lines was designed.

Conversely, DMLs also fails when demand goes above the design capacity. If a product's popularity exceeds all markets expectations, or when new users are found for existing products, the DML is powerless to respond. When the concept of FMS was introduced, it attracted the attention of many researchers. Many industries have started to use FMS. But a survey on FMS was conducted and it was presented by Hytler et al. during 1997 in Engineering research center for Reconfigurable

Manufacturing System. The details of survey have been discussed in report describes that many industries are not adapting FMS because FMS is too expensive and complex. According to the survey report, two third of the responded said that FMS is not living up to its full potential, over half reported that they purchased FMS of excess capacity and features, the problems identified with FMS was training, reliability, maintenance, software, cost and reconfigurability. This study discussed the conceptual framework of several obstacles and variables related with RMSs along with their interdependencies. Analytical Hierarchy Process (AHP) approach had been used in this present study for determining a consistency ratio and an adequacy index factor of the best production system. AHP was used to structure the decision-making process for the selection of a production system among viable options, including RMS. In this frame work, the GTA method proposed an index of the factors in RMS. The value of this index measured used a permanent function derived in the diagram. The study demonstrated the state of the study on the RMS implementation, with use of graph theory approach and matrix method, it had been emphasized the significance of various obstacles, so that feasibility of the RMS transition might be assessed. The diagram theory used to determine the index factor for the transition to RMS. Two ISM frameworks for obstacles and considerations had been established that demonstrated their administrative consequences for RMS adoption.

6. REFERENCES

[1] J. Browne, D. Dubois, K. Rathmill, S. P. Sethi et al., "Classification of Flexible Manufacturing Systems", The FMS magazine, vol.2, no.2, pp. 114-117, 1984.

[2] D. S. Cochran, J. F. Arinez, W. Duda and J. Linck, "A Decomposition Approach for Manufacturing System Design", Journal of Manufacturing Systems, vol.20, no.6, pp. 371-389, 2002.

[3] Y. Koren, "General RMS characteristics, Comparison with Dedicated and Flexible Systems in RMS and Transformable Factories", pp. 27-45, Berlin, Heidelberg: Springer Berlin Heidelberg, 2006.

[4] R. Galan, J. Racero, I. Eguia, D. Canca "A Methodology for Facilitating Reconfiguration in Manufacturing: The Move Towards Reconfigurable Manufacturing System" International Journal of Advanced Manufacturing Technology, 33: 345-353, 2007.

[5] Raj T., Arora A. and Malhotra V. "Reconfigurable Manufacturing System: An Overview" International journal of Machine Intelligence, Vol. 1, Issue 2, pp-38-46 2009.

[6] D. A. Vera, A West and R. Harrison "Innovative Virtual Prototype Environment for Reconfigurable Manufacturing System" Journal of Engineering Manufacture, Vol. 223, Part B, 2009.

[7] Rakesh K., P. K. Jain and Mehta N. K., "A framework for Simultaneous Reconfiguration of Part Families and Operation Groups for Driving A Reconfigurable Manufacturing System" Advances in Production Engineering and Management Journal 5, 45-58, 2010.

[8] A. O. Oke "The Design and Development of a Reconfigurable Manufacturing System" South African Journal of Industrial Engineering, Vol. 22(2), 121-132, 2011.

[9] Yaram Koren and Moshe Shpitalni, "Design of Reconfigurable Manufacturing System", Journal of Manufacturing Systems, DOI: 10.1016/j.jmsy.2011.01.001, 2011.

[10] Wencai Wang and Yaram Koren, "Scalability Planning for Reconfigurable Manufacturing Systems" Journal Manufacturing Systems, Vol. 31, No. 2, pp. 83-91, 2012.

[11] Lokesh Kumar Saxena and Pramod Kumar Jain, "A Model and Optimization Approach for Reconfigurable Manufacturing System Configuration Design", International Journal of Production Research 50 (12), 3359-3381, 2012.

[12] K. K. Mittal and P. K. Jain, "An Overview of Performance Measures in Reconfigurable Manufacturing System", Elsevier, ScienceDirect, Procedia Engineering 69,1125-1129, 2013.

[13] Abhinav Singh, Pranay Kumar and Sunil Singh, "Vision, Principle and Impact of Reconfigurable Manufacturing System", International Journal of Engineering and Advanced Technology, Vol. 3, Issue-1,2013.

[14] K. K. Goyal, P. K. Jain and Madhu Jain, "A Novel Methodology to Measure the Responsiveness of Reconfigurable Machine Tools in Reconfigurable Manufacturing System", Journal of Manufacturing System 32, 724-730, 2013.

[15] A Subhash Babu, "Reconfigurations of Manufacturing Systems-An Empirical Study on Concepts, Research, and Applications", The International Journal of Advanced Manufacturing Technology 66 (1-4), 107-124, 2013.

[16] K. K. Mittal and P. K. Jain, "Impact of Reconfiguration Effort on Reconfigurable Manufacturing System", 5th International and 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014), IIT Guwahati, Assam, India, Dec 12th-14th, 2014.

[17] Ibrahim H. Garbie, "Performance Analysis and Measurement of Reconfigurable Manufacturing System", Emerald Insight, Journal of Manufacturing Technology Management, Vol. 25, Issue-7, pp. 934-957, 2014.

[18] M. Groover, Fundamentals of Modern Manufacturing: Materials, Process and Systems, Wiley, 2015.

[19] M. Groover, Automation, Production System and Computer Integrated Manufacturing Pearson India, 2016.

[20] Ann-Louise Andersen, Kjed Nielsen and Thomas Ditlev Brunoe, "Prerequisites and Barriers for the Development of Reconfigurable Manufacturing System for High Speed Ramp-up", Elsevier B.V. ScienceDirect Procedia CIRP 51, 7-12, 2016.

[21] Rameshwar Dubey, Angappa Gunasekaran, Petri Helo, Thanos Papadopoulos, Stephen J. Childe and B. S. Sahay, "Explaining the Impact of Reconfigurable Manufacturing System on Environmental Performance: The Role of Top Management and Organizational Culture", Journal of Cleaner Production, DOI: 10.1016/j.jclepro.2016.09.035.,2016.

[22] Stefano Borgo. Amedeo Cesta and Andrea Orlandini, "A Planning Based Architecture for a Reconfigurable Manufacturing System", 26th International Conference on Automated Planning and Scheduling (ICAPS 2016), 2016.

[23] Guo-xin Wang, Si-han Huang, Xi-wen Shang, Y. Yan and Jing-jun Du, "Formation of Part Family for Reconfigurable Manufacturing Systems Considering Bypassing Moves and Idle Machines", Journal of Manufacturing Systems 41, 120-129, 2016.

[24] Durga Prasad and S. C. Jayswal, "Design of Reconfigurable Manufacturing System", National Conference on Futuristic in Mechanical Engineering (FME-2016), Gorakhpur, UP, India, 2017.

[25] Andreas Hees, Corne SL Schuttle and Gunther Reinhart, "A Production Planning System to Continuously Integrate the Characteristics of Reconfigurable Manufacturing Systems", Production Engineering 11(4), 511-521, 2017.

[26] H. Haddou Bendral, M. Dahane, and L. Benyoucef, "Flexibility-Based Multi-Objective Approach for Machines Selection in Reconfigurable Manufacturing System Design Under Unavailability Constraint," International Journal of Production Research, vol.55, no.20, pp.6033-6041,2017.

[27] Y. Koren and W. Wang, "Value Creation Through Design for Scalability of Reconfigurable Manufacturing Systems," International Journal of Production Research, vol.55, no.5, pp. 1227-1242,2017.

[28] K. K. Mittal, P. K. Jain and D. Kumar, "Configuration Selection in Reconfigurable Manufacturing Systems Based on Reconfigurability", International Journal of Logistics Systems and Management, vol.27, no.3, pp. 363-379, 2017.

[29] S. Lee, K. Ryu and M. Shin, "The Development of Simulation Model for Self-Reconfigurable Manufacturing System Considering Sustainability Factors," Procedia Manufacturing, vol.11, pp. 1085-1092, 2017.

[30] Y. Koren, Xi GU and Weihong GUO, "Reconfigurable Manufacturing System: Principles, design and future trends", Frontiers of Mechanical Engineering, 2017.

[31] S. Huang, G. Wang, X. Shang, and Y. Yan, "Reconfiguration Point Decision Method Based on Dynamic Complexity for Reconfigurable Manufacturing System", Journal of Intelligent Manufacturing, vol.29, no.5, pp. 1031-1043, 2018.

[32] H. H. Benderbal, M. Dahane and L. Benyoucef, "Modularity Assessment in Reconfigurable Manufacturing System Design: An Archived Multi-Objective Simulated Annealing-Based Approach", the Journal of Advanced Manufacturing Technology, vol.94, no. 1-4, pp. 729-749, 2018.

[33] Durga Prasad and S. C. Jayswal, "Assessment of Reconfigurable Manufacturing System", Emerald Insight, Benchmarking: An International Journal, BIJ-06-2018-0147,2018.

[34] K. K. Mittal, Dinesh Kumar and P. K. Jain, "A Systematic Approach for Optimum Configuration Selection in Reconfigurable Manufacturing System, Journal of The Institution of Engineers (India): Series C 99 (6), 629-635, 2018.

[35] Sihan Huang, Guoxin Wang, Xiwen Shang and Y. Yan, "Reconfiguration Point Decision Method Based on Dynamic Complexity for Reconfigurable Manufacturing System", Journal of Intelligent Manufacturing 29 (5), 1031-1040, 2018.

[36] Shokraneh K. Moghaddam, Mahmoud Houshmand and Omid Fatahi Valilai, "Configuration Design in Scalable Reconfigurable Manufacturing Systems, A case of Single Product Flow Line (SPFL)", International Journal of Production Research 56 (11), 3932-3954,2018.

[37] Sihan Huang, Guoxin Wang, Y. Yan and Jia Hao, "Similarity Coefficient of Reconfigurable Manufacturing System Part Family Grouping Considering Reconfiguration Efforts", IEEE Access 6, 71871-71883, 2018.

[38] M. Hojati, W. Stevenson and J. Cao, "Operation Management, McGraw Hill Education, 2018.

[39] Durga Prasad and S. C. Jayswal, "Reconfigurable Manufacturing System – A New Class of Manufacturing System", Management and Production Engineering Review, Vol. 10, Number 4, pp. 37-47, 2019.

[40] Arkadiusz Gola, "Reliability Analysis of Reconfigurable Manufacturing System Structures Using Computer Simulation Methods", Eskaploatacja Niezawodnosc – Maintenance and Reliability, Vol. 21, No. 1, 2019.

[41] M. Bortolini, Francesco Gabriele Galizia and Cristina Mora, "Dynamic Design and Management of Reconfigurable Manufacturing Systems", Elsevier, ScienceDirect, Procedia Manufacturing 33, 67-74, 2019.

[42] Sihan Huang and Y. Yan, "Part Family Grouping Method for Reconfigurable Manufacturing System Considering Process Time and Capacity Demand", Flexible Services and Manufacturing Journal 31 (2), 424-445, 2019.

[43] Sihan Huang, Guoxin Wang and Y. Yan, "Delayed Reconfigurable Manufacturing System", International Journal of Production Research 57(8), 2372-2391, 2019.

[44] Sihan Huang, Zhaoyi Xu, Guoxin Wang, Cong Zeng and Y. Yan, "RMT Design Philosophy for Multi-Part Families with New Design Principles Based on Reconfigurability", The International Journal of Advanced Manufacturing Technology 105 (1), 813-829, 2019.

[45] A. Khezri, H. H. Bendarbal and L. Benyoucef, "Towards Sustainable Reconfigurable Manufacturing System (SRMS): Multi-Objective based approaches for process plan generation problem", International Journal of Production Research,10.1080, 2020.

[46] Abdelkrim R., Yelles-Chaouche, Evgeny Gurevsky, Nadjib Brahimi and Alexander Dolgui, "Reconfigurable Manufacturing System from An Optimization Perspective: A Focused Review of Literature", International Journal of Production Research, doi.org/10.1080/00207543.2020.1813913, 2020.

[47] P. P. Singh, Jatinder Madan and Harvinder Singh, "Composite Performance Metric for Product Flow Configuration Selection of Reconfigurable Manufacturing System", International Journal of Production Research, DOI: 10.1080/00207543.2020.1756511,2020.

[48] Sihan Huang and Y. Yan, "Design of Delayed Reconfigurable Manufacturing System Based on Part Family Grouping and Machine Selection", International Journal of Production Research 58 (14), 4471-4488, 2020.