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Flexible Manufacturing System and its feasibility in context of Manufacturing Industries

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ABSTRACT: Highly automated machine cell which is based on the principle of Group technology, comprising a group of processing work station for the production is refer as Flexible Manufacturing System (FMS), where different processes like material handling, storage system, operation, inspection etc., are interconnected by automatic control unit. The concept of FMS (system 24) was first introduced in the mid-1960s to form a system which can operate 16 hours a day without any human attendant. The reason behind selecting this area for research is that there are problems like more lead time, inefficient utilization of machine, more space requirement in machine shop and high inventory level in current manufacturing industry. All these problems can be solved by introducing automation in manufacturing system, which can be done through FMS. FMS provides better resources utilization, high quality control, low cost product, high rate of production, reduced direct labour requirement and high labour productivity. Operational issues related to FMS faced by industries are machine loading, scheduling and dispatching, part routing, tool management, and part grouping so there is much scope of future development of FMS if all these issues are resolved..

Keywords: FMS, Production Industries, FMS Benefit, Operational Issue, Future Scope.

1. INTRODUCTION

A Flexible Manufacturing System is a method where multipurpose machines are fit for preparing a wide scope of parts.This involves planning procedures to use the systems efficiently. In this system we use Automatic Material Handling system, Computer Numeric Control machine tools, Automated Storage, and Retrieval System (AS/RS) to perform the different types of operation. The 1991 crisis in Indian economy heralded an era of LPG (Liberalization, Privatization, Globalization) which ushered many advance technologies in India. During this period FMS technique has been implemented in many manufacturing industries of India.[1] Earlier it was seen that Indian industries depended on conventional machines for the manufacturing of the parts but the issues associated with it were many: low productivity, high manufacturing lead time, more material wastage, high manufacturing cost, and low quality product which encouraged Indian industries to switch to FMS. By implementing FMS, following benefits are achieved such as high utilization of machine, less space requirement, less inventory requirement, and less manufacturing lead time. The objective of this paper is to determine the

feasibility index with the help of different methods such as GTA (Graph Theoritical Approach)[2], ISM (Interpretive Structural Modelling)[5], TOPSIS (Technique for Order Preference by Similairity to the Ideal Solution)[8][9][12], and Petri net. Different process parameters related to manufacturing system (attributes) are defined by experts' opinion, and based on their inter-dependency and priority, feasibility index is evaluated. With the help of this index the feasibility to implement FMS in existing as well as new establised industries is found.

II PARAMETER WHICH AFFECT THE FEASIBILTY OF FMS SYSTEM [2][3][4]

2.1 Behavioural: This refers to the behaviour of people who are involved with the implementation of FMS. This includes clear vision in the top management, efficient planning methodology, creating friendly environment, team work and motivation.

2.2 Non-behavioural: This refers to the equipments, machines, structural building and other systems in an organizations that are essential for the production processes, material handling, assembly, and inspection. This includes availability of resources, adequate space, and reliable supplyer.

2.3 Financial: This refers that the organization should be economically strong to adapt FMS because heavy investment is need to implement FMS. This includes expansion of plant, Credit from different agencies, monetary assistance from the government etc.

2.4 Methodologies: The proper methods should be effectively applied for the better utilization of resources. Various methods can be used such as Group Technology, Supply Chain Management, Material Requirement Planning, Concurrent Engineering, Just In Time, Information Technology.

2.5 Operational: This majorly relates to the operational/control techniques that are used in FMS. This depends upon the design, flow of information, and control. This includes advance system, automated manufacturing systems, latest sensor technology, suitable tool management etc.

2.6 Human and cultural: It involves human participation for the successful adoption of FMS. Human involvement in the FMS improves the degree of automation. Humans basically supervise the ongoing processes, load/unload parts, remove unwanted parts and tools.

III METHODOLOGY

In this paper we use different methods to find the feasibility of the industries so that owner, investor or any stake holder is able to decide if it's better to go for FMS or use the conventional system. The methods are given below:

3.1 GTA (Graph theoretical approach) [2]

GTA shows the correlation between several attributes that provide certain value for the system. It depicts the directional properties and inter related links among the variables. Feasibility of an organization in FMS environment can be evaluated through GTA method. In this method graph represents the inter relationship between different factors by forming a network, which is known as graph representation. Feasibility Index of Transition (FIT) is used to evalute the probability of changing over a conventional production system into FMS environment. It is based on the survey of certain number of experts. This method consists of three representation i.e. digraph form, matrix form, and permanent function representation. The steps used in this method are given below:

I. Recognize the various component of an organization that affect the transformation of conventional manufacturing system into FMS. These elements are also known as factors or enablers.
II. Represent these enablers in digraph form, which shows interdependence among these enablers.

III. Convert this digraph into matrix form which is known as matrix representation. Diagonal element is enabler (E_i) and off-diagonal element is interdependence of this enabler (e_{ij}). The values of interaction (off-diagonal element) are decided by expert on the basis of their experience. Its values lies in the range of 1-5.

IV. Using equation (1) now find the FMS enabler's matrix's permanent function:-

$$\text{Per F} = \prod_{i=1}^{n} E_i + \sum_{i,j,o,p,m,n}(e_{ij}e_{ji})E_oE_pE_mE_n + \sum_{i,j,o,p,m,n}(e_{ij}e_{jo}e_{oi} + e_{io}e_{oj}e_{ji})\, E_pE_mE_n +$$
$$(\sum_{i,j,o,p,m,n}(e_{ij}e_{ji})(e_{op}e_{po})E_mE_n + \sum_{i,j,o,p,m,n}(e_{ij}e_{jo}e_{op}e_{pi} + e_{ip}e_{po}e_{oj}e_{ji})E_mE_n) +$$
$$\{\sum_{i,j,o,p,m,n}(e_{ij}e_{ji})(e_{op}e_{pm}e_{mo} + e_{om}e_{mp}e_{po})E_n + \sum_{i,j,o,p,m,n}(e_{ij}e_{jo}e_{op}e_{pm}e_{mi} + e_{im}e_{mp}e_{po}e_{oj}e_{ji})E_n\} +$$
$$[\sum_{i,j,o,p,m,n}(e_{ij}e_{ji})(e_{op}e_{pm}e_{mn}e_{no} + e_{on}e_{nm}e_{mp}e_{po}) + \sum_{i,j,o,p,m,n}(e_{ij}e_{jo}e_{oi})e_{pm}e_{mn}e_{np}) +$$
$$\sum_{i,j,o,p,n,m}(e_{ij}e_{ji})(e_{op}e_{po})(e_{mn}e_{nm}) + \sum_{i,j,o,p,m,n}(e_{ij}e_{jo}e_{op}e_{pm}e_{mn}e_{ni} + e_{in}e_{nm}e_{mp}e_{po}e_{oj}e_{ji})] \qquad (1)$$

This value shows the feasibility of industries to adopt FMS.

V. List different industries according to their FIT values. Those industries which have highest values of FIT have good chances to adopt FMS.

3.2 ISM (Interpretive Structural Modelling) [5][7][10][11]

This method was introduced by Warfield in year 1974 for modelling of different elements of a complex system into simplified structured form. A decision is taken by adopting hierarchical approach among different items of an issue. A systematic structure is generated to transform ambiguous, unclear model of a system into well-defined model by using designed graphical pattern and set of words.

I. In ISM, first we identify different relevant attributes related to the problem in the industry and then develop a contextual relationship among these attributes. Experts' (industry or academia) opinion and management techniques like brainstorming, nominal group technique etc. are used to develop relationship among these attributes.

II. SSIM (Structural Self Interaction Matrix) of attributes are recognized which show the inter relationship among different attributes related to a problem. To reach a unanimous decision, SSIM is further discussed among the experts.

III. A reachability matrix is created from SSIM. Further it is divided into different levels.

IV. This reachability matrix is transformed into conical form.

V. Digraph is drawn on the basis of relationship among attributes in reachability matrix. Digraph is a depiction of the attributes and their inter-dependencies through nodes and edges. Transitivity link from digraph is removed.

VI. Obtained ISM model is evaluated for inconsistencies present and further required modifications are incorporated.

VII. This ISM model is analysed using MICMAC analysis to find the utility of Flexible Manufacturing System.

3.3 TOPSIS (Technique for Order Preference by Simulation to the Ideal Solution) [5][8][9][10][12]

TOPSIS was created by Hwang and Yoon (1981) and was later utilized by Lai et al. (1994) and Yoon and Hwang (1995). In this method we identify most feasible solution from defined set of alternatives by minimizing the distance from the ideal point and maximizing the distance from the nadir point. This helps us to find the feasibility of an industry for FMS adaptation. Steps to select the most desirable attribute from the given set of attributes are given below:

I. Determine the objectives and its related attributes which are required for FMS.

II. From this information a matrix is developed which is known as Decision matrix. Each row and column consists of one attribute and one criteria respectively. Hence for n attributes with m criteria n*m (n cross m) ordered matrix is obtained. Each value of criteria is obtained from a survey where certain number of

experts are represented as X_{ij}. This value is converted into standardised measures S_{ij} using the equation (2).

$$S_{ij} = X_{ij}/((\sum_{i=1,j=1}^{n,m}(X_{ij})^2)^{1/2}) \qquad (2)$$

III. Weightage w_k (k = 1,2,3,4….n) for each of criteria is developed using the formula:-

$$\text{Normalised weight of each importance} = \frac{Total\ of\ Each\ Importance}{Grand\ Total\ of\ All\ Importance} \qquad (3)$$

IV. Weighted normalised matrix W_{ij} is a product of multiplication of each element in S_{ij} with its corresponding normalised weight W_k. Hence, the weighted normalised matrix W_{ij} is expressed as:

$$W_{ij} = W_k S_{ij} \qquad (4)$$

I.

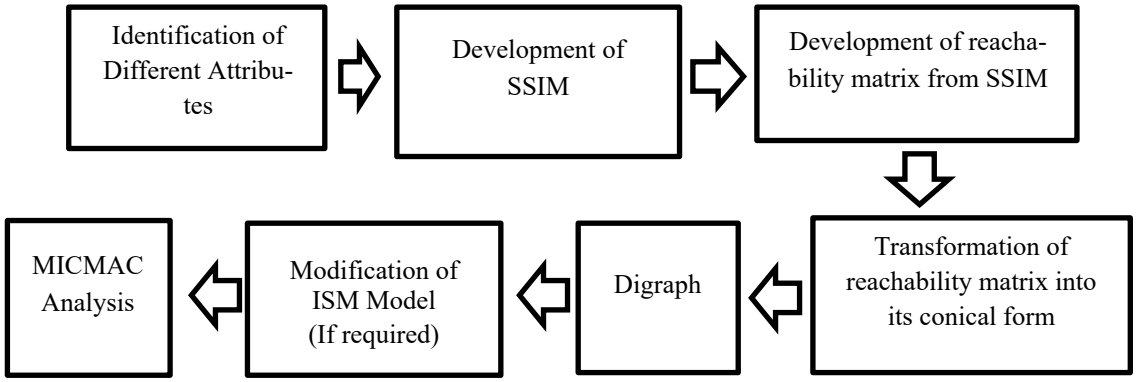

Fig.1. Development of ISM Model

V. Now we have to determine the ideal attribute which is the most suitable one among each criterion. It is the hightest obtain value of the each rating column of the weighted matrix. It is denoted by S^+.

VI. Similarly we have to identify the nadir attribute, which is the least desirable attribute on each criterion. It is the least obtain value of each rated column of weighted matrix. It is denoted by S^-.

VII. A distance measure is developed for both ideal (D_t^+) and nadir (D_t^-) criterion. This can be measure by following formula:-

$$D_t^+ = \{\sum_{j=1}^{m}(W_{ij} - S_j^+)^2\}^{1/2} \qquad i=1, 2, 3, 4…n \qquad (5)$$

$$D_t^- = \{\sum_{j=1}^{m}(W_{ij} - S_j^-)^2\}^{1/2} \qquad i= 1, 2, 3, 4…n \qquad (6)$$

VIII. By using following formula we find how close an attribute is with its ideal solutions.

$$R_i = D_i^-/(D_i^- + D_i^+) \qquad i = 1, 2, 3, 4….n \qquad (7)$$

By using the value of the R_i (the overall or composite performance), we get to know the least and most preferred attributes and feasibility is predicted.

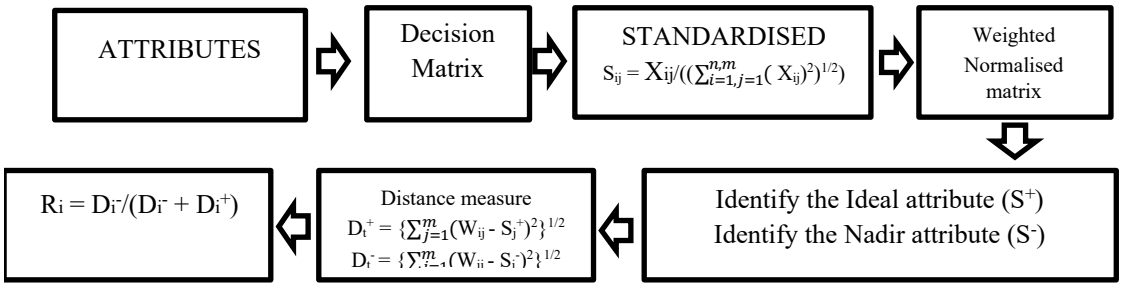

Fig.2. Development of TOPSIS Model

3.4 PETRI NET [6]

This method is developed by Carl Adam Petri in the year 1939.This is modeling tool which enable the visual communication among researchers who are worked for modeling the system. It includes three main elements:- places, transitions, and arcs. Possible conditions of a system are represented by circles, while transitions are represented by bars or boxes. A set of arcs denotes the relationship between the places and transition in either direction. Tokens are represented as black dots in places which show the dynamic behavior of system.

IV DISCUSSION

This paper describes the feasibility of FMS in industry by using different methods such as ISM, GTA, TOPSIS, PETRI NET, taking into account different attributes. Potential attributes are prioritized based on survey. In these entire methods, feasibility index is found on the basis of attributes. For Small and Medium ventures hierarchical approach is followed in ISM method to adopt FMS. A power matrix is formed which gives relative importance and inter-dependencies within these attributes. In Interpretive Structural Model, the attributes at lower level have high potential power and impact one another. In micro, small and medium ventures, government support has been a crucial factor for the implementation of FMS. In TOPSIS, a solution is identified from a definite set of possibilities which is based upon simultaneous minimizing of distance from ideal point and maximizing of distance from nadir point. Hierarchical model of TOPSIS is similar to ISM. TOPSIS analyses implies that support from government is important for the growth and development of small and medium scale ventures. Next method, GTA is based on the inter-relationship among factors such as behavioural, financial, non-behavioural, human resource and operational. A permanent function is calculated to find an index known as FIT (Feasible Index of Transition), which shows up to what extent an organization is flexible for FMS environment. The last one, Petri net method is a mathematical tool which emphasises on the behavioural and structural properties to find out the feasibility in application domain. Behavioural properties are dependent on initial state while structural don't.

V CONCLUSİON

A Flexible Manufacturing System is an automated system that can rapidly configured to produce wide range of products. Different attributes (process parameters) are accounted to determine feasibility of an industry to adopt FMS. These attributes include fund, technology, resources, will power, government support, and the market condition. Feasibility index is obtained from interrelationship among these attributes. Industry experts and academia interpret this index for acceptance of FMS by a conventional industry. In this paper we have discussed four methods- Petrinet, GTA, ISM, and TOPSIS. In all these methods subjective approach is followed to model FMS based system in which attributes that influences the feasibility are prioritised based on experts opinion.

The feasibility index enables, us to observe the weakest and strongest attributes influencing the feasibility of FMS environment so that we can spot the weak areas or loop holes present in system and use the strong factors as a driving potential for implementation of FMS. Further we can improve the existing FMS oriented industry to

enhance its performance. For the development of FMS in existing and new industry, feasibility index is an important criterion.

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