CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The present global changes in manufacturing sector demand low cost and high quality products/services in order to retain the existing customers as well as to attract new customers. Cost reduction and quality are the main factors for the customers’ satisfaction, which cannot be achieved with a little effort as they require various analyses, evaluation, selection and optimization of process, equipment, material, system, etc. A multi-attribute decision making approach/method is required to solve the problems containing many attributes. There are numerous tools, methodologies, techniques and algorithms such as AHP, ANP, TOPSIS, FUZZY AHP, QFD, GA, SA, PSA, ANN, DOE, etc., that have been applied by various researchers for analysis, selection, and evaluation and optimization purposes.

The literature on the following major areas is reviewed in detail:

1. AHP and ANP in manufacturing.
2. TOPSIS in manufacturing
3. Fuzzy and other intelligent systems in equipment selection.
4. Intelligent systems in manufacturing process evaluation/selection
5. Intelligent systems in manufacturing systems evaluation/selection
7. Activity based costing approach in manufacturing
2.2 LITERATURE REVIEW ON MANUFACTURING SYSTEMS AND PROCESSES

2.2.1 AHP and ANP in manufacturing

The analytic hierarchy process and the analytic network process are the two general theories introduced by Thomas Saaty of relative measurement used to derive composite priority ratio scales from individual ratio scales that represent relative measurements of the influence of elements that interact with respect to control criteria. The ANP is a general form of the AHP whereas AHP models a decision making framework that assumes a unidirectional hierarchical relationship among decision levels, ANP allows for more complex interrelationships among the decision levels and attributes.

Hung-Tso Lin (2010) developed a decision support tool using an integrated analytic network process (ANP) and fuzzy data envelopment analysis (DEA) approach to effectively deal with the personnel selection problem drawn from an electric and machinery company in Taiwan. Also he demonstrated how this approach can avoid the main drawback of the current method, and more importantly, can deal with the personnel selection problem more convincingly and persuasively. Dilay Celebi et al (2010) presented an application of Analytical Network Process (ANP) for determination of best logistics partnership strategy of a small electronic appliances manufacturer operating in Turkey. He used ANP for three logistics management alternatives (In-house logistics, Third party arrangements, and Strategic alliance). Shankar Chakraborty (2006) focused on the application of the AHP technique in selecting the optimal material handling equipment under a specific handling environment. The AHP technique breaks down decision making problems into finer parts to allow for easier and more logical selections. Sensitivity analysis is performed to identify the most critical and robust criteria in the material handling equipment selection process. Mustafa Yurdakul (2004) used AHP
and ANP for justifying the machine tool selection. Hierarchical decision structures are formed in the application of the AHP and ANP approaches. Ranking scores which are used to rank the alternatives are obtained as outcomes of the applications.

**Literature Review on AHP and ANP reveals the following:**

- AHP requires hierarchical decomposition of the problem where as ANP requires decomposition of the problem but does not require any hierarchical arrangement.
- AHP and ANP consider the both qualitative and quantitative values of the attributes.
- AHP just prioritizes requirements; it does not draw your attention towards success-critical factors and their corresponding requirements.
- The quantification of inheritance and interactions is not possible by using AHP and ANP.
- ANP gives higher precision results than AHP. Moreover, it can be noted that while analyzing a problem with the dependence between criteria and alternatives, there is a risk of getting results which provide unrealistic rankings.
- It is found that these methods are mathematically correct, but they do not yield actual value observed in practices. Intuitively, it might appear that this poor correlation is because of the model’s ineffective representation of the real system.
- AHP does not consider the interdependence between the clusters where as ANP includes the interdependence between the clusters and elements within the cluster. Evaluation of an attribute in real MCDM problem probably depends upon the achievement level of other attributes.
- The fuzziness and vagueness existing in many decision-making problems may contribute to the imprecise judgment of decision makers.
• AHP is sometimes thought of as a ‘soft’ decision-support approach, which does not tackle the difficult estimation problems.

2.2.2 AHP with other intelligent systems in manufacturing

Thus, conventional AHP and ANP does not react natural human thinking. In order to avoid these risks on performance, AHP is integrated with other tools like fuzzy, TOPSIS, goal programming, QFD etc.

Cheng-Shiung Wu et al (2010) applied AHP and TOPSIS as a decision-making framework is essential for marketing strategists to determine the most appropriate marketing strategy in an efficient manner. They used AHP for evaluating the criteria of the strategies and TOPSIS for ranking the alternative strategies. Chia-Chi Sun (2010) developed an evaluation model based on the fuzzy AHP and fuzzy TOPSIS, to help the industrial practitioners for the performance evaluation in a fuzzy environment where the vagueness and subjectivity are handled with linguistic values parameterized by triangular fuzzy numbers. Jia-Wen Wang al (2009) simplified the complicated metric distance method and proposed fuzzy hierarchical TOPSIS, which not only is well suited for evaluating fuzziness and uncertainty problems, but also can provide more objective and accurate criterion weights. Emrah Cimren et al. (2006) proposed a decision support system for machine tool selection using an effective algorithm, the analytic hierarchy process. Main and sub-decision criteria are investigated to apply the proposed methodology. The major contribution of their study is combining the AHP-based selection methodology with reliability, precision, and cost analyses to evaluate several alternatives and make an accurate decision.

San Myint and Mario T. Tabucanon (1994) used both AHP and goal programming to select the machine for flexible manufacturing systems. The
first part is called the prescreening stage, which narrows down all possible configurations by using the analytic hierarchy process (AHP). The second part uses a goal programming (GP) model to find out the satisfactory candidate from the remaining shortlisted configuration. After applying the GP model, AHP is used again for sensitivity analysis. Zone-Ching Lin and Chu-Been Yang (1996) developed a model using the analytic hierarchy process for the selection of the most suitable machine, from a range of machines available for the manufacture of particular types of part. Akarte M.M., et al (1999) used AHP and Fuzzy approach for evaluating product-process compatibility, which is useful for casting process selection and product design improvement. Nagahanumaiah, Ket al (2008) proposed methodology comprises three major steps: (1) rapid tooling process selection, (2) manufacturability evaluation, and (3) mold cost estimation. For RT process selection, an integrated QFD-AHP method has been developed in which tooling requirements are prioritized using AHP based pairwise comparison, and rapid tooling process capabilities are mapped using QFD. The entire methodology has been implemented in a Visual C++ program running in Windows environment. Mustafa Yurdakul (2002) provides a multi-criteria performance measurement model to measure the profitability performance of a manufacturing system. In developing the model, analytic hierarchy process and its extension system-with-feedback (SWF) approaches are used. The SWF approach, an extension of the AHP method, is recommended when independence among different elements of a system assumption is violated. The performance evaluation model developed in this study includes the competitive strategy and interdependence between the system criteria in its hierarchical structure and achieves a more realistic and accurate representation of a manufacturing system.
Literature Review on AHP with other intelligent systems reveals the following:

- AHP is applied for evaluating the criteria of the strategies and TOPSIS and goal programming are used for the ranking.
- Fuzzy with AHP is used for evaluating the process-product compatibility, where as QFD is used with AHP in order to map the process capabilities.
- AHP produces relative results according to the analyzed alternatives. The introduction of a new alternative may lead to a change in the ranking of the other alternatives; i.e. Rank reversal problem.
- AHP with SWF achieves a more realistic and accurate representation of the system.

2.2.3 TOPSIS in manufacturing

TOPSIS- Technique for order preference by similarity to ideal- is also a multi-attribute decision making tool found wider applications. It is used for the selection of best alternative, such that best one should be as close to the ideal solution as possible and as far from the negative-ideal solution as possible.

Vijay Manikrao Athawale and Shankar Chakraborty (2010) presented a logical and systematic procedure to evaluate the computer numerical control (CNC) machines in terms of system specifications and cost by using the technique for order preference by similarity to ideal (TOPSIS) method, which is observed to be quite capable of solving such type of multi-criteria decision-making (MCDM) problems. The priority weights for different criteria are determined using analytic hierarchy process (AHP) method and subsequently, these weights are used for arriving at the best decision regarding selection of the proper CNC machine using TOPSIS method. Fatih Emre Boran et al (2009) proposed TOPSIS method combined with fuzzy set to
select appropriate supplier in group decision making environment. Intuitionist fuzzy weighted averaging (IFWA) operator is utilized to aggregate individual opinions of decision makers for rating the importance of criteria and alternatives. Jadidi .O (2008), established for supplier selection problem and they proposed single objective model to calculate the optimum order quantities among the selected suppliers. An integration of TOPSIS method and Fuzzy multi-objective mixed integer linear programming (Fuzzy MOMILP) is proposed to consider both quantitative and qualitative factors for choosing the best suppliers and define the optimum quantities among the selected suppliers under conditions of price breaks and multiple sourcing where buyer wants to buy multiple products.

Kavita Devi et al (2009) proposed TOPSIS method for the evaluation of alternatives based on weighted attributes play an important role in the best the alternative selection. TOPSIS has been extended for vague sets and a approach to determine the most preferable choice among all possible choices, when data is vague is presented. Thus an extension of TOPSIS to the fuzzy environment is a natural generalization of TOPSIS models. Chu T.C. and Lin Y.-C ((2003) proposed a fuzzy TOPSIS method for robot selection, where the ratings of various alternatives versus various subjective criteria and the weights of all criteria are assessed in linguistic terms represented by fuzzy numbers.

**Literature Review on TOPSIS reveals the following:**

- TOPSIS alone cannot provide better result; hence it is integrated with other tools. Thus, TOPSIS is combined with AHP or FUZZY to get better results.
- TOPSIS method does not include the interaction between the attributes.
- There are rank reversals during evaluation using TOPSIS
2.2.4 **Fuzzy and other intelligent systems in equipment selection**

Fuzzy logic (FL) was developed by Lotfi A. Zadeh in the 1960s in order to provide mathematical rules and functions. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. It associates a weighting with each of the inputs that are processed, define functional overlap between inputs, and ultimately determines an output response. The rules use the input membership values as weighting factors to determine their influence on the fuzzy output sets of the final output conclusion. Once the functions are inferred, scaled, and combined, they are defuzzified into a crisp output which drives the system. There are different membership functions associated with each input and output response.

Abdi M.R (2008) proposed Fuzzy multi-criteria decision model for evaluating reconfigurable machines. He investigated reconfigurable machining system characteristics in order to identify the crucial factors influencing the machine selection and the machine (re)configuration. He also considered changeover cost and changeover time while switching from one product to the other which is taken into account. In particular, a fuzzy analytical hierarchical process model is proposed to integrate the decisive factors for the equipment selection process under uncertainty. Shuo-Yan Chou and Yao-Hui Chang (2008) presented a strategy-aligned fuzzy simple multi-attribute rating technique (SMART) approach for solving the supplier/vendor selection problem from the perspective of strategic management of the supply chain (SC). A fuzzy SMART is applied to evaluate the alternative suppliers, and deals with the ratings of both qualitative and quantitative criteria. Alecos Kelemenis and Dimitrios Askounis (2010), considered fuzzy Technique for Order Preference by Similarity to an Ideal Solution concept for the ranking of the alternatives. Chan F. T. S., et al (2001) described the development of an
intelligent material handling equipment selection system called material handling equipment selection advisor (MHESA). The MHESA is composed of three modules: (1) a database to store equipment types with their specifications; (2) a knowledge-based expert system for assisting material handling equipment selection; and (3) an analytic hierarchy process (AHP) model to choose the most favorable equipment type. The concept proposed in this paper can automate the design of a material handling equipment selection system, and provides artificial intelligence in the decision-making process.

Yang-Byung Park (1999) presented an intelligent knowledge-based expert system called ICMESE for selection and evaluation of material handling equipment suitable for movement and storage of materials in a manufacturing facility. ICMESE consists of four modules: (1) a knowledge base to select an appropriate equipment type, (2) a multi-criteria decision-making procedure to choose the most favorable commercial model of the selected equipment type, (3) a database to store the list of commercial models of equipment types with their specifications, and (4) simulators to evaluate the performance of the equipment model.

Kusiak.A and Heragu S. S. (1998) proposed a knowledge-based system KBSES for the selection of production equipment, i.e. machine tools and material handling carriers in an automated manufacturing system, is presented. Existing expert systems which have been applied to the selection of material handling carriers are briefly reviewed. Chulho Chung and Qingjin Peng (2004) discussed the selection of tools and machines on Web-based manufacturing environments. It helps existing CAPP systems to generate realistic and economical process plans, and lets designers efficiently undertake manufacturability evaluation. In particular, the machine selection incorporated with tool selection can generate extended strategies for economical production.
Literature Review on Fuzzy and other intelligent systems in Equipment selection reveals the following:

- Data base is created to store the specifications and characteristics of the equipment.
- An expert system is created for assisting the equipment selection process.

2.2.5 Intelligent systems in manufacturing process evaluation

Madan J. et al (2007) developed system for automated manufacturability analysis for die-cast parts. Purpose of this system is to assist designers in their effort to come up with manufacturable die-cast parts economizing in terms of cost and time without compromising with quality and functional requirements. Hernandez-Matias J. C. et al (2006) have developed methodologies and software tools for evaluating and analyzing the manufacturing process and tested their tools through examples. Jyh- Milind Akarte, and Ravi. B (2002) presented a web-based system for casting process or producer evaluation using a common set of decision criteria. The criteria assess the compatibility between product requirements and process or producer capability, and help identifying design parameters that could be modified to improve manufacturability. The system allows a team of product, tooling and manufacturing engineers to work on a casting project simultaneously by accessing information (from any computer worldwide), analyzing the product and process and updating the information to the web server.

modeling framework covering all aspects related to the shop-floor. The main methodologies and software tools have been identified for the evaluation of industrial problems. An expert system described by Jyh-Cheng Yu et al. (1992) helps designers to select a manufacturing process in the early stage of product design. They focus on net-shape manufacturing processes and identify the major factors that affect the selection of an appropriate process. This methodology considers all the factors like shape, production volume, and material simultaneously in assessing the suitability of the candidate processes. The proposed system uses the concept of design compatibility analysis to represent the suitability of candidate processes with respect to the given product specifications. They used an expert system to eliminate incompatible candidates and rank the compatible set of processes. Xuan F Zha and H Du (2003) presented an intensive approach and system for selecting suitable manufacturing processes and materials for microelectromechanical systems (MEMS) devices in concurrent collaborative design environment. They addressed the fundamental issues on MEMS manufacturing process and material selection such as concurrent design framework, manufacturing process and material hierarchies, and selection strategy. Then, a fuzzy decision support scheme for a multi-criteria decision-making problem is proposed for estimating, ranking and selecting possible manufacturing processes, materials and their combinations. They developed a web-based prototype advisory system for the MEMS manufacturing process and material selection, (WebMEMS-MASS) to find good processes and materials for MEMS devices.

A system has been described by Sabah U. Randhawa and Thomas M. West (1994) that integrated product design specifications with material and process databases, and a simulation-based analysis module. The system allows product design specifications to be evaluated in terms of economic and technical criteria. It allows designing better products through integration of
design and manufacturing, and to explore trade-offs between design and manufacturing. Ronald E. Giachetti (1998) described a prototype material and manufacturing process selection system called MAMPS that integrates a formal multi-attribute decision model with a relational database. The decision model enables the representation of the designer’s preferences over the decision factors. MAMPS allows the decision maker to specify product profile requirement values, their level of precision, and an importance weight. A compatibility rating between the product profile requirements and the alternatives stored in the database for each decision criteria is generated using possibility theory. A ranked set of compatible material and manufacturing process alternatives is output of the system. Raviwongse R et al. (2000) presented an intelligent self-organizing map (SOM)/fuzzy-based model to aid designers in the selection of an appropriate plastic manufacturing process. They classified plastic part attributes into three main categories: part characteristics, material type, and production requirements. A fuzzy membership function is generated for each of the attributes using the self-organizing map paradigm. Fuzzy associative memories are used to perform reasoning on these input fuzzy sets to derive the output fuzzy sets. The output fuzzy sets are then defuzzified to determine the process compatibility scores.

Cheng-Min Feng et al (2010) presented a hybrid fuzzy integral decision-making model that integrates factor analysis, interpretive structural modeling, Markov chain, fuzzy integral and the simple additive weighted method for selecting locations of high-tech manufacturing centers in China. The analytical results of this case study demonstrate the feasibility of the proposed model for solving fuzzy multiple attribute decision-making problems, especially when criteria are interdependent.
Literature Review on Intelligent systems in manufacturing process evaluation reveals the following:

- Various intelligent systems are generated for the selection of suitable manufacturing process.
- Database is generated to store the process capabilities of various processes and to store the material specifications.
- Very few authors carried out the manufacturability analysis to select the suitable process.

2.2.6 Intelligent systems in manufacturing systems evaluation/selection

Ming-Lang Tseng (2008) proposed Fuzzy analytic hierarchy process, to discuss and tackle the different decision criteria like effective leadership, people management, customer focus, strategic plan and process management, which are involved in identifying the TQM strategic critical success factors with uncertainty. Albert Penarroya et al. (2007) addressed the application and comparison of spreadsheet analysis (LOTUS 123), rapid modeling (MANUPLAN II) and simulation (STARCELL) for the design and evaluation of manufacturing systems. The objective is to evaluate the quantity and quality of the required inputs, generated outputs, and the amount of time required for each of these analytical tools compared to the amount of knowledge gained. A best machine/cell configuration was emphasized to simplify the system and increase its efficiency. David S. Cochran et al. (2001) presented an evaluation of the manufacturing system design of two automotive manufacturing plants, located in North America. The manufacturing system designs are evaluated in terms of the achievement of design requirements stated by the Manufacturing System Design Decomposition (MSDD). The evaluation was based on a set of performance
measures that were related to the Manufacturing System Design Decomposition. Oliver Houseman et al (2004) presented a technology selection methodology to quantify both tangible and intangible benefits of certain technological alternatives within a fuzzy environment. Specifically, it describes an application of the theory of fuzzy sets to hierarchical structural analysis and economic evaluations for utilization in the industry. By using this methodology, the ambiguities involved in the assessment data can be effectively represented and processed to assure a more convincing and effective decision-making process. The basic principles of the fuzzy set theory were described by Iphar M.and Goktan R.M (2006) and the fuzzy set theory was applied to one of the conventional classification systems by following the Mamdani fuzzy algorithm. It was shown that the fuzzy set theory could effectively overcome the uncertainties encountered in the practical applications of conventional classification systems, and also provides more information on the obtained final ratings.

Osman Kulak, M., et al (2005) proposed the information axiom for the selection of the proper alternative that has minimum information. Selection of the convenient equipment under determined criteria (such as costs and technical characteristics) using the information axiom will be realized in this study. The unweighted and weighted multi-attribute axiomatic design (AD) approaches developed in this research work include both crisp and fuzzy criteria. These approaches were applied to the selection among punching machines while investing in a manufacturing system. The selection process has been accomplished by aiding a software program called MAXD.

Ching-Chow Yang and Bai-Sheng (2004) proposed an evaluation model that integrates triangular fuzzy numbers and the analytical hierarchy process to develop a fuzzy multiple-attribute decision-making (FMADM)
model for key quality-performance evaluation. Using the proposed model, decision-makers can determine, in advance, critical quality elements that might significantly affect quality performance.

Ertugrul Karsak. E.and Onur Kuzgunkaya (2000) presented a fuzzy multiple objective programming approach to facilitate decision making in the selection of a flexible manufacturing system (FMS). The proposed model determines the most appropriate FMS alternative through maximization of objectives such as reduction in labor cost, reduction in setup cost, reduction in work-in-process (WIP), increase in market response and improvement in quality, and minimization of capital and maintenance cost and floor space used.

**Literature Review on Intelligent systems in manufacturing systems reveals the following:**

Mostly, all researchers used fuzzy set to analyze and evaluate the manufacturing systems.

Fuzzy set theory could effectively overcome the uncertainties encountered in the practical applications.

**2.2.7 Petri nets in manufacturing**

Ozgur Armaneri (2006) presented Petri nets for modeling, simulation and analysis of simple one machine-two product systems. Ramaswamy S. et al (1992) proposed Extended Petri Nets (EPNs) for modeling, analyzing, and simulate potential failures which may occur in a materials handling system. Potential system failures have been modeled and accommodated with EPN subnets. The described approach proposes an efficient methodology to generate an overall EPN design to model and analyze
potential system failures at different levels of detail. Behera T.K. et al (1994) have used deterministic and stochastic methods for modeling and analyzing the performance of the Real-Time system. Since the operational times of an FMS, such as machine times and part transfer times are deterministic, they used Deterministic Timed Petri Nets (DTPNs) for obtaining the performance of the system. For analyzing tool breakage and machine failure, they used Generalized Stochastic Petri Nets, because such failures are random in nature.

2.2.8 Activity based costing approach in manufacturing

Derya Eren Akyol et al. (2005) also applied Activity-Based Costing (ABC) in a manufacturing system to evaluate the effectiveness of the system. ABC models the causal relationships between products and the resources used in their production and traces the cost of products according to the activities through the use of appropriate cost drivers. Frank Chen Frank (1996) focused on an activity-based costing approach to the equipment selection problem for flexible manufacturing systems. The technique helps decision-makers to select the appropriate set of equipment or machines to be used in the system based on the objective to minimize total operating cost subject to the availability of machines in the system. The equipment selection algorithms were formulated to minimize the total production cost. Two methods to approach the equipment selection problem were presented in their research. The first one is the equipment selection with no expansion into new products (ES1). The second method to the equipment selection problem is the equipment selection with expansions into new products (ES2). In addition, computer programs were developed for both methods to facilitate the planning of larger systems.
Literature Review on Activity based casting approach in manufacturing reveals the following:

Cost of each activity was considered and the total cost was arrived. Based on the total cost, manufacturing process and equipments are selected.

2.2.9 Other tools in manufacturing

Peter Leung (2005) presented an advanced application of Failure Modes and Effect and Analysis (FMEA) to facilitate globally distributed projects. Global FMEA (GFMEA) is an attempt to coordinate the planning activities of globally distributed projects and to provide a leading indicator in addressing delays and quality problems. Using risk as a quantifiable metric, GFMEA assesses potential global work distribution failure modes with project complexity and proposes mitigation plans according to the selected distributed scenario. GFMEA synchronizes the visions within the planning team to ensure the company’s objectives to strategically align with the project goals.

Quality, Reliability-Co-Effect of product/part and manufacturing-system component reliability are investigated in an assembly fixture system by Jin, J. and Chen, Y (2001). The interdependency between part quality and fixture-system reliability is investigated. As an example, fixture design and its reliability analysis was studied by integrating information of pin failure, pin wear and their interdependency with part quality. The proposed integrated manufacturing system reliability model is validated by using Monte Carlo simulation results. Therefore, based on the proposed integrated fixture-system reliability model, a comprehensive analysis and system-level optimization could be conducted to achieve an optimized manufacturing system—in terms of both product quality and process productivity. Chowdary. B V (2001) described the notion of an integrated manufacturing performance measure for evaluation and selection of a manufacturing system which proposed with
flexibility and related issues as one of the main focus. Ozgur Samuel h. Huang et al. (2003) presented a systematic methodology for productivity measurement and analysis at the factory level. Metrics of Overall Equipment Effectiveness (OEE) and Overall Throughput Effectiveness (OTE) are introduced and developed respectively for rigorous and quantitative measurement of equipment and system productivity. Sethia, P.C., et al. (2008) considered a Continuous Manufacturing System (CMS), usually employed for mass production, which has a serial line arrangement of different machines. They are arranged in sequence of operations to produce a specified product. In such CMS, over a long period of usage, the production rate comes down, due to failures of machines in the line. Thus, reliability i.e. probability that such a CMS will give rated production over a year reduces considerably. To compensate for such loss of production, introduction of redundant parallel standby machines approach has been hypothesized and is in use irrespective of the cost involved. A new approach of introducing buffers of Work-In-Progress (WIP) at various stages in the line, in place of standby redundant machines, has been proposed and its effect on the reliability of CMS to give rated production is analyzed. Suk-Tae Bae et al. (2007) determined the performance capability of manufacturing system based on the system reliability, availability, and maintainability (RAM) and its system cost. For the systems performance improvement, they developed a system availability model subject to multi-state failures where a component or subsystem may fail completely or may continue to operate at a level below the original design specification. In addition, a quantitative model of system availability, system costing, and its software development were included.

Following the pioneering work of Taylor in 1907 and his famous tool life equation, different analytical and experimental approaches for the optimization of machining parameters have been investigated. Gilbert (1950)
studied the optimization of machining parameters in turning with respect to maximum production rate and minimum production cost as criteria. Armarego & Brown (1969) investigated unconstrained machine-parameter optimization using differential calculus. Brewer and Rueda (1963) carried out simplified optimum analysis for non-ferrous materials. For cast iron (CI) and steels, they employed the criterion of reducing the machining cost to a minimum. A number of monograms were worked out to facilitate the practical determination of the most economic machining conditions. They pointed out that the more difficult-to-machine materials have a restricted range of parameters over which machining can be carried out and thus any attempt at optimizing their costs are artificial.

Bhattacharya et al. (1970) optimized the unit cost for turning, subject to the constraints of surface roughness and cutting power by the use of Lagrange’s method. Walvekar and Lambert (1970) discussed the use of geometric programming for the selection of machining variables. They optimized cutting speed and feed rate to yield minimum production cost. Wang and Jawahir (2004) used this technique for optimization of milling machine parameters.

Torben Lenau (2001) suggested a different procedure for selecting materials and processes within the product development work. The procedure includes product examples in order to increase the number of alternative materials and processes that are considered. Product examples can communicate information about materials and processes in a very concentrated and effective way. The product examples represent desired material properties but also include information that cannot be associated directly to the material, e.g. functional or perceived attributes. A database that supports the selection procedure has been compiled. It contains uniform
descriptions of a wide range of materials and processes. Product examples matching the requirements can be found using a search engine, and through hyperlinks can relevant materials and processes be explored.

2.3 LIMITATIONS AND SHORT COMINGS OF THE EXISTING APPROACHES IN MANUFACTURING

Based on what is being revealed in the literature reviews on various major relevant areas and the limitations and short comings of the existing research works, the following research gaps have been identified:

- Most of the researches used one or two factors as contributing factors and omit some factors. The reason behind the omission is poor capability of the method considered.
- Difficulties may arise when a user has to deal with a large number of factors which can lead to inconsistency in providing the estimation of the importance among the factors.
- In some cases, the ranking of the alternatives can be reversed when a new alternative is introduced (Rank reversal problem).
- The fuzziness and vagueness existing in many decision-making problems may contribute to the imprecise judgement of decision makers.
- Activity based costing method (ABC) considers the cost for different operations for a product which can be machined by different machines. Based on the total cost, a machine can be selected. In this method, other attributes like surface finish are not considered.
- An integrated manufacturing performance measure described by Chowdary (2001) considers only flexibility related issues and omits other factors for the selection of manufacturing system.
• Metrics of Overall Equipment Effectiveness (OEE) and Overall Throughput Effectiveness (OTE) are used for rigorous and quantitative measurement of equipment and system productivity. Here, other qualitative factors and relative importance between the factors are neglected.

• Performance capability of manufacturing system is analyzed based on the system reliability, availability, and maintainability (RAM) and its system cost. Here, the researcher does not consider the interdependency between these factors.

• Manufacturing System Design Decomposition (MSDD) is used for analyzing the various configurations of the system. This method is mostly applicable to arrange the machines to get the maximum output. It relates the functional requirements to the design parameters. This method does not consider the interdependency between the design parameters.

• Most of analyses related to manufacturing processes are based on the unit cost techniques. Here, cost alone is considered to optimize the process parameters and other factors are neglected.

• Net shape manufacturing includes shape, production volume, and material as factors where as many contributing factors like cost, skill of the operator, etc. are neglected.

• Most of the computer integrated analyses require data base which are created earlier and modeling and simulation packages are required. The result entirely depends on the software packages and the skill of the programmer which is suitable to large manufacturing sectors.

• Quality of the software developed purely depends on the skill of the programmer.

• Each specific problem requires separate package, as it consumes more time.
• An obvious drawback of fuzzy logic is that it is not always accurate. The results are perceived as a guess, so it may not be widely a trusted result from classical logic, though, some chances need to be taken.

• In a highly complex system, use of fuzzy logic may become an obstacle to the verification of system reliability. Also, fuzzy reasoning mechanisms cannot learn from their mistakes.

Motivation:

The above said research gaps have motivated the author to carry out the research work and substantiate the existing works so that all the limitations and short comings of the existing research works are over come.