PREFACE

Multi-criteria decision-making (MCDM) problems refer to making decisions in the presence of multiple, usually conflicting criteria or objectives. MCDM problems are common in everyday life. In personal context, a house or a car that one wants to buy may be characterized in terms of price, size, style, safety, comfort etc. In business context, MCDM problems are more complicated and usually of large scale. For example, many companies in Europe are conducting organizational self-assessment programs using hundreds of criteria and sub-criteria as set in the EFQM (European Foundation of Quality Management) business excellence model. Purchasing departments of large organizations often need to evaluate their suppliers/vendors using a range of criteria in different area, such as after-sale service, quality management, financial stability, delivery time, rejection percentage etc.

The application domain of MCDM problems are quite widespread, MCDM as a separate discipline has only a relatively very short history of about 30 years. The development of MCDM as a separate discipline is closely related to the advancement of the computer technology. In one hand, the rapid development of computer technology in recent years has made it possible to conduct systematic analysis of complex MCDM problems. On the other hand, the widespread use of computers and information technology can generate a huge amount of information and relevant data that makes MCDM increasingly important and useful in supporting business decision-making processes. Hence, there are calls in early 1970s to develop new methods that can produce consistent and rational results, capable of dealing with uncertainties and providing transparency to the analysis process.

In order to deal with these types of problems, the analytic hierarchy process (AHP) has been developed by Thomas L. Saaty in 1970 and since then, it is widely used to make such decisions. It involves breaking the problem down into finer and finer parts so that one is called upon to give a judgment comparing only a pair of issues at a time. This avoids mixing of too many aspects associated with the problem and not knowing what goes with what to obtain the final answer. However, it does call for one to structure the problem hierarchically with broad understanding of the people and their interests and of the issues involved. Once one has the structure, it becomes easier to convey to the others the influences driving the decision.

The AHP has a strong appeal to the managers and decision-makers at all levels of the decision-making process. It enables one to include both the strength of feelings as needed to express the judgment and logic and understanding relating to the issues involved in the decision. It combines the multiplicity of judgments in a systematic way so as to obtain the best outcome or mix of actions to be taken. Finally and more significantly, these outcomes are derived in an agreeable way that are in harmony with our intuition and understanding and not forced on us by
technical manipulations. There are easy to use software packages that can implement this approach and make decision-making task easier.

In sum, the AHP contributes to solving complex problems by structuring a hierarchy of criteria, sub-criteria and alternatives and by eliciting judgments to develop the priorities. It also leads to prediction of the most likely outcome according to these judgments. The outcome can be used to rank the alternatives, allocate resources, conduct cost-benefit comparisons, exercise control in the system, by evaluating the sensitivity of the outcome to changes in the judgment and carry out planning for the projected and desired features. A useful by-product is the measurement of how well the decision-maker understands the relations among various factors. Although people generally are not consistent, the main concern here is the degree of their inconsistencies.

The analytic hierarchy process (AHP), since its invention, has been a tool at the hands of the decision makers and researchers and it is one of the most widely used multiple criteria decision-making techniques. Many outstanding papers have been published based on the AHP, they include applications of AHP in different fields such as planning, selection of a best alternative, resource allocations, resolving conflicts, optimization etc. and numerical extensions of the AHP.

Vendor selection plays a very prominent and crucial role in modern day organizations and it may be the most important decision to select the best vendor, which will affect the subsequent business to success. The modern management theory and world-class manufacturing calls for a long term, almost a lifetime association with the vendors. This means that there will be fewer vendors, but those should be the dedicated ones – almost as a part of the organizational family. But, always an emphasis will be there for proper vendor selection and on monitoring the performance of the vendors through a suitable rating system. The organizational approaches towards vendor selection can be listed through the upper level management decision simply based on knowledge and experiences. In the present work, five important performance criteria like the technical capability of the vendor, price quoted for the required materials, quality of the supplied materials, delivery schedule for the materials and other factors affecting the performance of the vendors are selected so as to rate and rank the vendors engaged in a particular manufacturing organization. A real time case study is also cited to demonstrate the usefulness of the AHP based multi-criteria performance evaluation and vendor selection approach.

Modernization and pressing need for higher productivity have resulted in the increased sophistication of the equipment and machineries causing higher probability of failures and disruptions in production, resulting in loss of production or increased cost of production. These factors have made it imperative to ensure that the availability of the plant and equipment in the organization are to be maximized and at the same time, effective measures are to be taken to extend the useful life of the equipment and machineries in the plant. This clearly demands for the
need to apply the concept of selecting the optimal maintenance policy through the effective deployment of various management functionalities. Various dominant criteria and sub-criteria and their interrelationships within the developed hierarchy that will affect the selection of the optimal maintenance policy for a typical manufacturing organization, are identified. Three alternative maintenance policies, e.g. preventive maintenance (PM), corrective maintenance (CM) and condition-based maintenance (CBM) are considered, evaluated and compared with respect to maintainability, maintenance cost, quality and safety, and down time criteria by eliciting judgments for decision-making. The AHP technique is then used to measure the relative importance of each criteria and sub-criteria and finally, the overall score for each alternative is computed so as to select the optimal maintenance policy in order to fulfill the organizational requirements.

In any manufacturing organization, the traditional ABC analysis technique for selective inventory control represents the relationship between the volume and annual consumption value of the inventory items. The procedure of classifying inventory items into ‘A’, ‘B’ and ‘C’ categories needs to be constantly and carefully attentive to how well it will interpret the relevant data having multiple criteria and conflicting objectives. Perhaps the most creative and difficult task in making a decision is to choose the dominant criteria along with the other related sub-criteria and search out the fact that how those are important deciding factors in selecting the ‘A’, ‘B’ and ‘C’ class of inventory items. A distinct methodology is proposed to analyze the ‘A’, ‘B’ and ‘C’ class of items using the pairwise comparison matrices of the analytic hierarchy process (AHP) and it will ensure the consistency of the decision maker’s judgments regarding the importance of one criteria over another in order to find out the weight for each of the considered criteria and sub-criteria. The developed approach is illustrated using real time data and validated with the theoretical results.

The decision-making process regarding the selection of a material handling equipment is influenced by the ongoing development of new technology, practices and equipment with enhanced capabilities and complex characteristics. It can be emphasized that the specific problem of material handling equipment selection under constrained operating conditions is a complicated task due to the presence of many feasible alternatives and needs fulfilling various conflicting objectives. While choosing the optimal material handling equipment, the experts should constantly keep in mind the fact that the successful solution to most of the material handling equipment selection problems will involve the constraint of proper and suitable matching of the optimal solution against the existing or contemplated physical facilities and environment with the related cost trade-offs. Hence, under these constraints and conflicting circumstances, the application of the AHP technique is found to be a robust and flexible tool to aid the decision-making process. Systematic steps are developed for decision-making to solve the complex
problem of selecting the optimal material handling equipment under specific conditions so as to meet the organizational requirements.

Inventory control is observed to be an important function of an organization and the basic emphasis in inventory control is to determine the appropriate level of holding stocks, ordering sequence and also the quantity of materials to be ordered so that the total cost is minimum. The usual question often asked in inventory management is that how much of material is to be kept and when it is to be carried. Getting the right material at the right time can generate very significant results. Timely purchasing of materials is a very important factor, especially when the materials are independent. The demand and supply conditions also impose certain limitations within which the relevant costs are to be minimized. Hence, the selection of a suitable inventory control policy is a multi-criteria decision-making (MCDM) problem with diverse conflicting objectives and alternatives. The analytic hierarchy process (AHP) can be applied to this MCDM problem for evaluating performance measures of the alternative policies. Five most popularly used inventory control policies including perpetual review policy, periodic review policy, two bin policy, material requirement planning system and optional replenishment policy are considered and then subsequently ranked using the AHP under a multi-criteria environment. These considerations together with pairwise comparison matrices and evaluating methodology lead to prioritize the conflicting criteria for selecting the optimal policy. Sensitivity analysis is also performed to search out the most critical and robust criteria in the optimal inventory control policy selection problem.

Increased sophistication of equipment and machineries invite higher probability of failure and disruption in production. It is difficult for any organization to keep pace with the advanced technology without continuous renewal and upgradation of its existing production processes. If any piece of equipment fails to meet this challenge, it must be replaced, regardless of its age and wear out condition. A replacement policy that fails to give full recognition to obsolescence is bound to lead to poor manufacturing processes with rejection of parts/products. Replacement analysis is one of the most complex and ill-structured tasks often faced by the decision maker in an organization. Planning for replacement involves a large extend of unknown criteria with uncertain outcomes. Therefore, adopting the best course of action from a set of alternative policies to achieve the desired objective is the prime interest of replacement analysis. Three alternative policies, i.e. unit, block and group replacements are considered and compared with respect to technological, economical and social factors by eliciting judgments for decision-making. The AHP technique is then used to measure the relative importance of each criterion and finally, the preference value of each alternative is determined so as to select the optimal policy in order to meet the organizational requirements.
Selection of the optimal facility layout design is a multi-criteria decision-making problem where the decision maker has to choose the best layout amongst the given alternatives. It has a significant impact on the performance of any manufacturing or service organization. Generally, the algorithm-based techniques are used to solve the conventional layout design problems. A comprehensive approach using the analytic hierarchy process is proposed for solving the layout design problem considering interdependence among various criteria affecting the selection process. Activity relationships and closeness ratings among the departments of the layout are considered while solving the problem. Finally, a set of alternative layouts is evaluated using the proposed approach. The layout index values measure the priority of the alternatives to help in selecting the optimal facility layout design.

Measurement plays a vital role in every field of present day scientific and technological progress. The knowledge about anything remains incomplete if it cannot be expressed in terms of numbers. Measuring instruments are the devices that transform the measured quantity or a related quantity into a suitable numerical indication or information. The increasing automation in manufacturing processes requires the highest level of accuracy. The standard of accuracy and precision become so high that human being’s basic instinct and sense is inadequate to cope up with them. The simple verbal decisions are highly susceptible to bias. Hence, it is necessary to employ a multi-criteria decision-making (MCDM) tool to avoid such bias associated with the selection process. The analytic hierarchy process (AHP) is a very powerful MCDM tool that helps in selecting the measuring instruments as a means of reconciling the decision maker’s expression of preferences and identifying the consistency of his/her judgments. It provides the priority values for the alternative measuring instruments based on the initial information collected from the decision maker in the form of pairwise comparisons.

In the fast changing technology and globalization of market, the prime deciding factor for long-term successful business strategic planning is to select the best facility location. An appropriate facility location is an important link between the upstream suppliers and downstream customers in the supply chain. The basic objective of an organization is to maximize the portability that can only be achieved through the selection of a suitable facility as needed for transporting the raw materials, parts/products and finished goods with minimum cost. Four alternative facility locations are chosen and then ranked using the AHP technique so as to select the best alternative. It is observed that this technique is more conductive to multi-criteria decision-making problems for selecting the best alternative. It is also noticed that in the AHP, the decision makers develop senses of judgment eliciting expert opinions and thus, it facilitates their involvement at every level of the decision-making process. The AHP exercise begins with the competitive selection strategies for defining relative importance of the considered criteria like construction cost, transportation cost, technology, environment, government policy etc. for long
run profitability of the organization. These considerations, together with the evaluation methodology, lead to the proposed approach of prioritizing the conflicting criteria for choosing the optimal facility location.

A project is an organized venture to be undertaken to achieve a desired objective. Depending on the objectives, projects may be of various types, like research, development, welfare and industrial etc. A project is to be selected from the available alternatives that will best suit the entrepreneur’s capacity, competence and willingness. Thus, it seems to be a complex exercise involving balancing of various technological, financial and social considerations. The priorities of different factors affect the selection of the best project and the project that promises to satisfy the overall entrepreneurial objective ultimately has the highest chance of selection. The modern concept of management theory and globalization of market call for complex situations in selecting the best project, associated with multi-dimensional objectives. There should always be an emphasis for proper project selection and on monitoring the performance of the project with the adoption of effective control measures. A comprehensive list of objective measures is proposed using the analytic hierarchy process (AHP) technique considering various qualitative factors so as to evaluate the optimal project selection methodology. Sensitivity studies are also performed to check the consistency of judgments.

The present research work deals with various Industrial Engineering (IE) related multi-criteria decision-making (MCDM) problems where it is assumed that all the considered criteria, sub-criteria and alternative decision options are independent in nature. But in many practical situations, this assumption is violated. In these circumstances, a new and promising technique like the analytic network process (ANP) can be applied in the decision-making process to take into account the dependencies amongst the criteria, sub-criteria and alternatives. In all decision-making problems, the judgments provided by the decision-makers are considered to be distinct and deterministic in nature. But the concepts like fuzzy set theory and group decision-making can be incorporated to give the present research work a more practical dimension. Other mathematical programming techniques like goal programming and 0-1 integer programming methods, expert system (ES) and quality function deployment (QFD) can also be used to validate the results provided by the analytic hierarchy process (AHP) technique. Other Industrial Engineering related multi-criteria decision-making problems, like selection of the optimal forecasting technique, selection of optimal production schedule, selection of the best transportation route etc. can also be considered where the analytic hierarchy process (AHP) technique can be successfully adopted.