10.0 CONCLUSIONS

Traditional optimization, statistical and econometric analysis approaches that are usually applied within the engineering context are often based on the assumption that the considered problem is well formulated and the DMs usually consider the existence of a single objective or evaluation criterion. In such a case, the solution of engineering problems is very easy to obtain. But in reality, the modelling of engineering problems is based on a different kind of logic taking into consideration the existence of multiple criteria, conflicting aims of the DM, subjective nature of the evaluation process and participation of several DMs. A ‘well formulated’ decision problem from a mathematical standpoint may not necessarily mean a ‘well structured’ problem. A ‘well structured’ problem can be easily understood and an appropriate solution procedure may be formulated. From a mathematical standpoint, a ‘well structured’ MADM process starts with identifying and constructing the problem, during which the problem to be solved is explored and available information are collected. The possible options (alternatives) are defined by eliminating alternatives that should not be worthy for further considerations. Recently operation researchers have started to embrace the complexity of decision-making process and foresee the innovative perspective, which overcomes the restrictive nature of the decision-making situation. Therefore, MADM contributes through the identification of the best alternatives according to the chosen problem, satisfactory solution of the conflicts between the criteria, determination of the relative importance of the criteria in the decision-making process, and revealing the preferences and system of values. It is already observed that various MADM methods have been successfully applied by the past researchers to solve complex decision-making problems in different manufacturing aspects. These MADM methods have been mainly employed to deal with different social, political, environmental and financial problems for long term strategic planning. Some of these methods are quite simple to understand and easy to implement, whereas, few are mathematically multifaceted and difficult to understand. In some of these methods, involvement of the DMs is required to determine the priority weight for different criteria. While applying these methods, the criteria values of the decision matrices need to be normalized to make them dimensionless and comparable.

In this present research work, eight most potential preference ranking-based methods are applied to solve some critical decision-making problems as taken from real time manufacturing environment. Based on the extensive analysis on the computational flexibility, accuracy, application viability and sensitivity analysis of these considered methods, the following conclusions can be drawn:
a) All the preference ranking-based methods are quite competent in solving the real time manufacturing decision-making problems and the rankings of the considered alternatives as obtained by these methods are almost in good congruence with those derived by the past researchers. The Kendall’s coefficient of concordance and Spearman’s rank correlation coefficient values are considered here to determine the overall rank correlation and pair-wise correlation between different methods. Their high values suggest that any of these preference ranking-based methods may be applied to solve any of the decision-making problems, as considered in this research work.

b) From the mathematical standpoint, COPRAS, COPRAS-G, ORESTE, OCRA, ARAS and PSI methods are quite simple to understand and easy to implement. On the other hand, EVAMIX and EXPROM2 methods are comparatively complex to apply due to their complicated mathematical formulations, and involvement of several preference functions and threshold values.

c) ORESTE method is mainly appropriate to support the conflicting decision-making situations in absence of crisp numerical criteria values and weights of the attributes. The main advantage of ORESTE method is that as it uses only the ordinal ranking of criteria which avoids the occurrence of lengthy discussions among the DMs while setting weight importance of the attributes. Since ORESTE method only takes into account the ordinal ranking of alternatives and criteria, it is mainly suited to problems with ordinal data, but it can also be used for problems with cardinal or mixed data, as illustrated through the real time problems considered.

d) The procedural steps as involved in PSI method for calculating the values of preference variation and overall preferences seem to be used for calculating the objective weights of the attributes. There is no scope in PSI method to see how the changes in the weights of importance of various attributes affect the decision-making process.

e) It is observed that the structure of a problem and the related decision matrix with respect to the number of alternatives, number of criteria, number of beneficial and non-beneficial criteria, and number of qualitative and quantitative criteria have no or very less effect on the solution accuracy of all the preference ranking-based methods.

f) With respect to the ranking performance as shown by the scatter diagrams and developed performance test tables, it is observed that although most of the considered preference ranking-based methods are almost comparable and have good ranking agreement among themselves, the performances of EVAMIX and EXPROM2 are comparatively poor. On
the other hand, the performances of ORESTE and COPRAS (also COPRAS-G) are relatively better than the other methods.

g) The results of non-proportional non-additive and additive weight sensitivity analyses, as adopted in the present research work, indicate that for most of the decision-making problems, EVAMIX and EXPROM2 show comparatively poor rank stability intervals. On the other hand, ORESTE and COPRAS (also COPRAS-G) are again observed to be the least sensitive methods to the fluctuations in the criteria weight values.

h) The high dimensional weight sensitivity analysis indicates that the highest weighted criterion may not be always the most critical criterion for any decision-making problem. Also, some criteria may be robust in nature, having no or very less impact on the performance of MADM methods. Therefore, it may be suggested not to select the most important criterion or any other criterion arbitrarily for weight sensitivity analysis. First, the DM should identify the ‘most critical criterion’ and then any weight sensitivity analysis may be performed to obtain better insights about the performance robustness of MADM methods.

i) During the comprehensive high dimensional weight sensitivity analysis, ORESTE and COPRAS (also COPRAS-G) are observed to be the least sensitive methods for a wider range of changing criteria weights for most of the decision-making problems, on the other hand, EVAMIX and EXPROM2 again show comparatively poor rank stability intervals.

j) It is found that although ORESTE and COPRAS (also COPRAS-G) perform well, any of the preference ranking methods can be successfully applied for any type of manufacturing decision-making problem. In few cases where strong disagreement between the preference ranking-based methods occurs, it is due to the presence of mixed ordinal-cardinal data in the decision matrix.

k) Overall, the main advantages that the preference ranking-based methods can generally provide, are summarized as below:

   i) the possibility to analyze complex decision-making problems,

   ii) the capability to aggregate both quantitative and qualitative criteria in the evaluation process,

   iii) the possibility of good evidence of proper decisions, and

   iv) the capability for the DMs to participate actively in the process and application of flexible scientific methods in the decision-making procedure.

   Although in the present research work, an attempt is made to apply eight preference ranking-based methods to solve complex decision-making problems in manufacturing
environment, the applicability of other new MADM methods along with fuzzy linguistic data can also be explored. In this research work, criteria weights are only considered for sensitivity analysis, however, this can be further extended to include other sensitivity analysis approaches for observing the effect of imprecise and changeable decision matrices on the final ranking of the alternatives. Additionally, the impact of different criteria weighting techniques and various normalization procedures on the final ranking of the alternatives can also be investigated. A bridge may be developed between the considered MADM approaches and linear programming-based models in order to reduce subjectivity in the decision-making problems.