CHAPTER 7

CONCLUSION, LIMITATIONS AND SCOPE FOR FUTURE WORK

7.1 SUMMARY AND CONTRIBUTIONS

In this work, various classical heuristics have been analyzed to solve the permutation flow shop scheduling problems (PFSP) with the objective of makespan optimization. As the PFSPs are NP-complete, heuristics are preferable where the time criterion and cost are important for a specific level of accuracy. The heuristic procedures are approximate methods, and hence, there always exist a possibility of improvement. For smaller problems, they are still popular and the schedule can be prepared in less time. One simple heuristic has been developed based on Pascal’s triangle for \( nC_r \) and the performance analyzed. It is concluded that the performance is not excellent, but, comparable to that of Gupta’s heuristic.

The solutions vary in quality, if the parameter based on which the procedure to compute the solution differs. Nine heuristic procedures with different starting sequences have been studied using benchmark problems. It was found that in spite of the less number of enumerations, the procedure of scheduling the jobs based on the Ratio of the machine idle time to the total processing time (IT/PT), in the ascending order is also a better choice, comparable with the CDS algorithm. This was verified using 120 numbers of Taillard benchmark problems.

Though the indicator values and sorting sequences are unlimited, the important ones were covered by Framinan et al. In this work, twenty three starting sequences have been considered, combining the total processing time and total Machine Idle Time. In all the cases, the insertion technique is used. However, unlike the original NEH which selects the first two jobs as the initial sequence, the first and last jobs, middle two jobs, and the last two jobs are also considered for the analysis. These four options of selecting the first two jobs (original NEH), the first and last
The NEH, as an individual, is one of the best Heuristics.

The NEH family completely dominates.

The starting sequence of selecting the first two jobs is the best option.

It may be noted that considering the middle two jobs is also a good option for obtaining the solutions.

The descending order is once again proved to be the best sorting one.

It is proposed that the best solution obtained, using all four NEH family members, can be used as the initial solution for the next level meta heuristics, to improve the solution.

Except a few heuristics, most of the procedures are a bit complicated and require some level of expertise to understand and implement. Also, the number of sequences obtained using a single algorithm is one or at the most a few. A simple concept of the dummy machine is proposed to find more than one sequence having optimal/near optimal make spans in a single algorithm. A dummy machine with zero processing times for all the jobs is introduced in the beginning, and is moved towards the right to make more iterations and thus many new sequences. Four classical heuristics, namely, the Palmer slope index, RA, CDS and Gupta’s algorithms are coded in MATLAB and the results are analyzed for the Taillard problems. A majority of problems show significant improvement and the average is reasonably good. It is shown that many more sequences with optimal/near optimal make spans are obtained. A few sequences have better make spans than the ones obtained using Parent Algorithms. The main advantages are that this can be effectively used even by the shop floor supervisors with minimum effort, and alternate sequences having even better make spans are in hand, which can be used in case of any constraints. As the classical algorithms, the procedure is very simple and for smaller problems, manual
computations are possible with no errors. The ANOVA was also carried out for deviations among the heuristics.

Two models are developed with constraints, and analyzed for assessing their performance. In the first model, the processing times are classified under three categories: (i) the processes that require power supply and do not permit pre-emption (ii) The processes that require power supply and permit pre-emption. That is, the processing could be resumed when the power supply returns (iii) The processes that do not require power supply and can be continued during the break down time also. The makespan is optimized in a situation where the un-availability of the machine time span is known in advance.

In the second model, a specific case of three machines and ‘n’ jobs with a transportation time in between has been analyzed. If all the jobs have equal importance of processing, then it is not required to check for the structural conditions and select an alternative, to combine the processing/ transportation times as proposed by a few researchers. Instead, the transportation times can be considered as independent processing times, and any efficient simple algorithm can be effectively used to find the optimal sequence. When used with the Taillard problems and the CDS algorithm, it was observed that the solutions are optimal in most of the cases.

7.2 LIMITATIONS

The major findings and conclusions have been reported above; however, some of the limitations of the present work are mentioned below:

1) This work has been restricted to only one performance measure, namely, “makespan” of flow shop scheduling.
2) Multi-objective optimization which reflects shop floor situations has not been considered in the present work.
3) The optimization of makespan has been tried using only simple heuristics. The concept and the models are not concerned with either meta or hybrid heuristics.
7.3 SCOPE FOR FUTURE WORK AND CONCLUSION

Further research may be carried out to investigate the feasibility of using the dummy machine concept in other heuristics, with the objective of makespan optimization, and also other performance parameters. Additionally, the complete effect of the improvement in makespan and new sequences has to be studied, when the outputs from this are used as the candidate solutions for meta heuristics or hybrid heuristics. The impact of solutions from the NEH family of heuristics with different initial sequences for other performance parameters, can also be studied in detail. Also, when used with meta heuristics for refining the solutions, the number and time taken for the iterations need attention. An exhaustive additional study is also needed, to figure out how efficient the developed models are, using more number of benchmark problems, and to address the other possible shop floor applications. Different shop environments, including parallel machines flow shop, no idle flow shop, job shop, and open shop problems with other performance measures, such as minimum due dates, maximum lateness, and multi-criteria measures could also be studied with the latest optimization techniques. Future research should be directed to improve the quality of solutions in specific cases of multi-objective flow shop scheduling problems with constraints, as they only represent the real shop floors.