CHAPTER 6

CONCLUSION

This chapter presents the summary of the present research work and conclusion drawn from the present investigation. The salient features of the present research work are summarized in the first section and the major conclusions drawn from the results of the theoretical and experimental studies are given in the following section. The scope for future work is given in the final section.

6.1 SUMMARY OF THE PRESENT RESEARCH WORK

- AlSiC composite work material was fabricated by using indigenously designed and developed furnace with stirring facility.
- Friction drills were developed indigenously as they are not readily available.
- Thirty one experiments have been carried out for each tool based on the design matrix developed under RSM.
- Effectiveness of conventional tool materials like HSS, TiN coated HSS and Carbide tools in making holes in MMC, instead of expensive PCD or CBN tool material is emphasized.
The drilling performance of these friction tools were evaluated using the performance indicators such as reduced hole diameter error, surface roughness, torque and thrust force.

Twelve response surface regression models are developed for the prediction of all the four responses namely, thrust force, torque, circularity error of the hole and surface roughness for each of the three tool materials used viz. HSS, Carbide and TiN coated HSS.

Good predictability of all these models is evident from the fact that the co-efficient of determination \( (R^2) \) for all the models are more than 90%.

The order of most influential factors in drilling of AlSiC composite material is identified by using ANOVA as feed rate, thickness of the work piece, spindle speed followed by weight percentage of SiC.

Power and Energy analysis of the friction drilling process were carried out to provide the basic information for the machine requirements, such as the selection of the spindle speed and design of the fixture for work holding.

Process outcome were optimised using Grey relational grade to obtain best input parameters among the experimental values for all the three tool materials namely HSS, TiN coated HSS and Carbide for the benefit of mass production in Industries.

A comparative analysis of performance of all the tool materials was performed to bring out the merits of each tool material in the friction drilling of AlSiC composite.
6.2 MAJOR CONCLUSIONS

The major conclusions drawn from the present investigation on friction drilling of AlSiC composite material are:

1. In friction drilling, unwanted chips are not produced and the walls of the hole drilled are stronger in grain orientation in comparison with twist drill where holes are made by cutting the grains abruptly.

2. Extended tool life is observed in friction drilling process in comparison with conventional twist drilling process.

3. Only concern of friction drilling is the higher thrust force, clamping force and elevated temperature that were within tolerable level in this experimentation.

4. Peclet criterion is applied to ensure the strong contribution of thermal energy in the process of plastic deformation during friction drilling process.

5. Friction drilling process was rapid, taking a maximum of 12 seconds only.

6. The confirmation experimental results of optimised input parameters for the three tools have close proximity to the predicted values of models (RSM). It is observed that the error percentages of results are below ± 6.41 %.

7. Higher circularity error value of 317 µm is observed for HSS tool when the spindle speed is 3500 rpm, feed rate is 70 mm/min, wt % of SiC is 10% and thickness of work piece is 3.5 mm. Lower circularity error value of 100 µm is obtained when spindle speed is 2500 rpm, feed rate is 70 mm/min, and
wt % of SiC is 20% and thickness of work piece is 2.5 mm for coated HSS tool. Overall performance of the coated HSS tool in respect of minimal circularity error was better than HSS tool and Carbide tool too performed well. The TiN coating of the Coated HSS tool helps in sliding in comparison with other tools that reduces the circularity error values.

8 Higher surface roughness value of 3.43 µm is observed when the spindle speed is 3500 rpm, feed rate is 70 mm/min, wt % of SiC is 10 %, and thickness of work piece is 3.5 mm. for HSS tool. Lower surface roughness value of 0.89 µm is obtained for coated HSS tool when spindle speed is 4000 rpm, feed rate is 60 mm/min, wt % of SiC is 15% and thickness of work piece is 3 mm. Overall performance of the coated HSS tool in respect of surface roughness was better than HSS tool and Carbide tool too performed well.

9 Higher thrust force value of 485 N is observed when spindle speed is 3500 rpm, feed rate is 70 mm/min, wt % of SiC is 20% and thickness of work piece is 3.5 mm for Carbide tool. Lower thrust force value of 178 N is obtained for HSS tool when spindle speed is 2500 rpm, feed rate is 50 mm/min, wt % of SiC is 10% and thickness of work piece is 3.5 mm. Overall performance of the coated HSS tool in respect of thrust force was better than HSS and Carbide tool.

10 Higher torque value of 1.82 Nm is observed when spindle speed is 3500 rpm, feed rate is 70 mm/min, wt % of SiC is 10 %, and thickness of work piece is 3.5 mm for HSS tool. Lower torque value of 0.31 Nm is obtained for the Coated HSS tool when spindle speed is 3500 rpm, feed rate is 50 mm/min, wt % of
SiC is 20 %, and thickness of work piece is 2.5 mm. Overall performance of the coated HSS tool in respect of torque was better than HSS and Carbide tool.

11 Grey analysis was used to optimise the hole making by friction drilling conditions for the AlSiC composite material. The optimised hole making parameters evolved in this research work will help to achieve better hole making of these materials.

12 Among the three tools used, Coated HSS and Carbide tools were equally significant and performed better than the HSS tool.

13 The factors influencing the drilling of AlSiC composite material were predicted with the help of RSM with a confidence level of 95%. The main factors influence the machining of AlSiC composite materials are cutting speed followed by feed.

14 Maximum temperature recorded in friction drilling of AlSiC composite material is 313 °C for Coated HSS tool that is well below the recrystallization temperature of AlSiC composite.

6.3 SCOPE FOR THE FUTURE WORK

- The experiment can be replicated with work material preheated for easy plasticisation and modified properties of cutting tool materials with wider geometry.

- FEM modeling can be attempted to study the temperature and stress in the tool during friction drilling. This can be beneficial for the tool geometry design and tool material selection. A
better tool geometry can also help to reduce the thrust force and deflection.

- The tool wear of the friction drills used can be studied for determining the tool life.

- Corrosion studies on the friction drilled holes can be carried out.

- Thermal effect of the process on the tool material as well as the work material can be studied with the support of microstructures.

- Variation in the hardness of the work material before and after hole making by friction drilling can be studied.