CONCLUSIONS AND FUTURE SCOPE

7.1 Conclusions

On the basis of experimental modeling and optimization of quality characteristics for cutting of difficult-to-cut Al sheets by Nd:YAG laser reported in this thesis, following general conclusions have been drawn.

1. An experimental study of pulsed Nd:YAG laser cutting of difficult-to-cut aluminium alloy sheet has been carried out with the aim to improve the bottom kerf deviation. On the basis of optimization using a robust parameter design (Taguchi method) the optimum parameter levels suggested for present operating conditions are: at level 1 (4.0 kg/cm²) of oxygen pressure, level 2 (1.0 ms) of pulse width, level 3 (28 Hz) of pulse frequency, and level 3 (17.5 mm/min) of cutting speed, i.e. the optimum parameter setting for minimum bottom kerf deviation is $A_1B_2C_3D_3$. The empirical model developed for bottom kerf deviation shows that data is well fitted (see table 3.4). Pulse frequency and cutting speed have been two significant control factors for bottom kerf deviation in the present processing regime. The confirmation experiments conducted at optimum level shows that the bottom kerf deviation has been improved by 60%.

2. An experimental study of pulsed Nd:YAG laser cutting of difficult-to-cut aluminium alloy sheet has been carried out with the aim to improve the surface finish of cut edge. Parameter optimization has been done using the robust parameter design and optimum parameter levels are level 1 (4.0 kg/cm²) of oxygen pressure, level 3 (1.2 ms) of pulse width, level 2 (23 Hz) of pulse frequency, and level 1 (7.5 mm/min) of cutting speed. The pulse frequency and oxygen gas pressure have been found significant control factors for surface roughness. The confirmation experiment results show that surface finish has been improved by 42%.

3. The optimum values of control factors for minimum heat affected zone during laser cutting of duralumin sheet have been found as 7 kg/cm² of gas pressure, 1.8 ms of pulse
width, 6 Hz of pulse frequency and 25 mm/min of cutting speed. The gas pressure and pulse width have been found the most significant factor for heat affected zone in the laser cutting of duralumin sheet.

The quality of cut in the laser cutting of duralumin sheet has been considerably improved by reducing the heat affected zone as 30.01% at optimum level settings. The minimum values of heat affected zone have been obtained at lower value of the gas pressure and the medium value of pulse width.

4. Hybrid approach of Taguchi methodology and grey relational analysis with entropy measurement method has overcome the problem of uncertainty in assigning the weighting factor to quality characteristics. By using hybrid approach, the surface roughness and bottom kerf deviation have been simultaneously improved by 42% and 10%, respectively, during laser cutting of aluminium alloy sheet. The cutting speed has been found to be the most significant control factor for multiple quality improvement with a contribution of 45% followed by pulse width with a contribution 22%.

7.2 Future Scope

Recent researchers on laser beam cutting of thin sheets show that the pulsed Nd:YAG lasers are quite suitable due to their characteristics such as short pulse duration, low mean beam power, and high laser beam intensity. Only few researchers have used scientific methods under the umbrella of design of experiments (DOE) for a planned study of laser beam cutting process. Unplanned experimental study includes a lot of undesired factors which affect the performance variations and finally lead to unreliable results. Also, the quality laser cutting of highly reflective and thermally conductive materials like aluminium and its alloys have not been studied systematically to fulfill the demand of complex shape generation in these highly demanding materials. As complex shapes and profile require straight as well as curved cut profile of difficult-to-cut materials, aluminium rod it may be considered for future investigations. The experimental investigations may also be carried out for thick sheets of aluminium alloys. The newly developed difficult-to-cut advanced materials like ceramics, composites and superalloys, will be of high demand in industries but only few researchers have applied scientific approach to improve the laser cutting quality of these materials. Different hybrid approach methodologies applied in this research may be applied for modeling and optimization of other difficult-to-cut materials. Micromachining of difficult-to-cut material will also be an area of research in future.