CHAPTER 6

CONCLUSION

As the need for materials with different thermal properties, advanced materials and high strength materials grows in technologically sophisticated industries and supported by the advances in the field of material research, there has been an increase in the availability and use of difficult-to-cut alloys. This has made WEDM an important manufacturing process for machining of such alloys and novel materials.

In this experimental research studied the effect of Wire Electro Discharge Machining parameters such as Gap voltage, pulse-on time, pulse-off time and wire feed rate on the performance characteristics of three difficult-to-cut alloys, Incoloy 800 superalloy, Titanium alloy and AISI D3 Tool steel using of Grey-Taguchi method. Mathematical relations between the machining parameters and performance characteristics are established by the Non-linear regression analysis. Surface characteristics of machined surfaces have also been examined based on SEM micrographs. Summarizing the main features of the results, the following conclusions may be drawn:

6.1 MACHINING OF INCOLOY 800 SUPERALLOY

(i) The analysis of experimental data based on the Grey-Taguchi method revealed that the optimum levels of machining parameters for Incoloy 800 for material removal rate, surface roughness and kerf width were are: Gap voltage : 50 V, pulse-
on time : 10 μs, pulse-off time : 6 μs and wire feed rate : 8 mm/min. The corresponding material removal rate, surface roughness and Kerf width are 0.05765 g/min, 3.10 μm and 0.296 mm respectively.

(ii) The confirmation evaluation of the response of the optimized machining parameters showed an increase in MRR from of 0.05351 g/min to 0.05765 g/min, A surface roughness reduction from 3.31μm to 3.10 μm and a reduction in Kerf width from 0.324 to 0.296 mm, resulting in 7.74% increase of Material Removal Rate, 6.34% reduction in surface roughness and 8.64% reduction in Kerf width.

(iii) The results of ANOVA showed that Gap voltage as the major influencing factor contributing to 45.59%, pulse-on time contributing to 30.71%, pulse-off time contributing to 8.58% and Wire feed rate contributing to 15.12% towards maximization of MRR with a corresponding improvement in surface finish and reduction in Kerf width.

(iv) The evolved mathematical models have been validated and the results show that the deviations are well within the acceptable limits of the techniques employed.

(v) Thus the mathematical models can be used for predicting the results of combination any set of machining parameters.

(vi) The surfaces machined by WEDM were examined using Scanning Electron Microscope (SEM) to study the surface integrity and features. The study has revealed the elimination of surface defects such as large pockmarks, cracks, craters and recast layer.
6.2 MACHINING OF TITANIUM ALLOY

(i) The analysis of experimental data based on the Grey-Taguchi method revealed that the optimum levels of machining parameters for Titanium alloy for material removal rate, surface roughness and Kerf width were are: Gap voltage : 50 V, pulse-on time : 10 μs, pulse-off time : 8 μs and wire feed rate : 8 mm/min. The corresponding material removal rate, surface roughness and Kerf width are 0.02743 g/min, 3.02 μm and 0.278 mm respectively.

(ii) The confirmation evaluation of the response of the optimized machining parameters showed an increase in MRR from of 0.02512 g/min to 0.02743 g/min, A Surface Roughness reduction from 33.33 μm to 3.02 μm and a reduction in Kerf width from 0.296 to 0.278 mm, resulting in 9.20% increase of Material Removal Rate, 9.31% reduction in surface roughness and 6.08% reduction in Kerf width.

(iii) The results of ANOVA showed that pulse-on time as the major influencing factor contributing to 83.25%, gap voltage contributing to 12.07%, pulse-off time contributing to 2.93% and Wire feed rate contributing to 1.75% towards maximization of MRR with a corresponding improvement in surface finish and reduction in Kerf width.

(iv) The evolved mathematical models have been validated and the results show that the deviations are well within the acceptable limits of the techniques employed.

(v) Thus the mathematical models can be used for predicting the results of combination any set of machining parameters.
(vi) The surfaces machined by WEDM were examined using Scanning Electron Microscope (SEM) to study the surface integrity and features. The study has revealed the elimination of surface defects such as large pockmarks, cracks, craters and recast layer.

6.3 MACHINING OF AISI D3 TOOL STEEL

(i) The analysis of experimental data based on the Grey-Taguchi method revealed that the optimum levels of machining parameters for AISI D3 Tool steel for material removal rate, surface roughness and Kerf width were: Gap voltage : 50 V, pulse-on time : 10 μs, pulse-off time : 4 μs and wire feed rate : 8 mm/min. The corresponding material removal rate, surface roughness and Kerf width are 0.04014 g/min, 3.11 μm and 0.289 mm respectively.

(ii) The confirmation evaluation of the response of the optimized machining parameters showed an increase in MRR from of 0.037702 g/min to 0.04014 g/min, A surface roughness reduction from 3.42 μm to 3.11 μm and a reduction in Kerf width from 0.318 mm to 0.289 mm, resulting in 6.47% increase of Material Removal Rate, 9.06% reduction in surface roughness and 9.12% reduction in Kerf width.

(iii) The results of ANOVA showed that Gap voltage as the major influencing factor contributing to 47.24%, pulse-on time contributing to 40.27%, pulse-off time contributing to 3.35% and Wire Feed rate contributing to 9.14% towards maximization of MRR with a corresponding improvement in surface finish and reduction in Kerf width.
(iv) The evolved mathematical models have been validated and the results show that the deviations are well within the acceptable limits of the techniques employed.

(v) Thus the mathematical models can be used for predicting the results of combination any set of machining parameters.

(vi) The surfaces machined by WEDM were examined using Scanning Electron Microscope (SEM) to study the surface integrity and features. The study has revealed the elimination of surface defects such as large pockmarks, cracks, surface craters and recast layer.

Some of the observations and trends between the different materials used in the experiment are as follows:

- During the WEDM process, the thermal properties of the work materials were found to have significant influence on the quality and accuracy of the work materials. Moreover, the performance parameters were also found to be influenced greatly by the thermal and electrical properties of the materials like: thermal/ electrical conductivity, specific heat capacity, melting point, thermal expansion coefficient, and ductility.

- On comparison of MRR between Incoloy 800, Titanium alloy and AISI D3 Tool steel for their corresponding optimum machining parameters, the Incoloy 800 exhibits higher material removal due to its low melting point.

- AISI D3 Tool steel was found to be better capable of producing burr-free and less heat affected surfaces compared to other two work materials. At the same level of discharge
energy, the Titanium alloy was found to produce relatively broader craters on the machined surface, which makes the surface rougher.

- A comparative evaluation of effects of WEDM process parameters on the characteristics of machined surfaces as well as material removal rate and Kerf width is under way in order to achieve an improved surface quality and the optimum machining conditions.

- From the present analysis it is evident that the optimal parametric combination will be very beneficial to the manufacturing communities who are working in the WEDM process.

6.4 SCOPE FOR FUTURE WORK

The following recommendations could be fruitful for future works:

1. The research work could be further extended over a Variety of New advanced materials.

2. The number of combination of process parameters can be increased to create a data base through extensive experimentations.

3. The same materials can be analyzed using other optimization Techniques such as Neural network, fuzzy logic, genetic algorithm, particle swarm optimization etc., and their effectiveness can be compared.
4. Apart from experimental work, ample scope exists for theoretical modeling and process simulation (such as finite element analysis) in dry EDM.

5. The technique presented in this research can also be tried for other non traditional machining process such as electrochemical machining, electron beam machining, laser beam machining etc., for effective utilization of such machine tools.

6. Further research might attempt to consider the other performance criteria, such as surface waviness, form accuracy, surface flatness, over-cut, process repeatability, surface integrity, cutting speed, wire wear ratio and wire offset as output parameters.