Chapter 3
Problem Formulation

3.1 Research gaps identified from the literature

This chapter describes the research objectives of the proposed study. The methodology of experimental work is also presented to explain the steps involved to achieve the desired objectives. After exhaustive study of the literature survey, following research gaps have been identified:

1) The material removal rate and surface integrity of the tool and die steels and advanced materials machined by conventional machining processes are significantly improved by the non-conventional machining processes due to their better control over the machining parameters. The literature provides limited information about the mechanism of material removal during hybrid machining of advanced materials like ceramic based MMCs, advanced heat resistant alloys and hardened tool steels.

2) The earlier studies on electro-discharge grinding reveal that the limited work has been performed on EDSG of high carbon high chrome steels (HCHCr) and heat resistant alloys and composites. Most of the earlier studies involve the effect of input parameters like tool polarity, gap current, gap voltage, pulse on-time, pulse off-time and rotational speed on performance parameters like material removal rate, electrode wear rate and surface roughness. There are certain other parameters like APS, APC and tool polarity which remain constant in some studies, and there is urgent need to address the effect of composition of grinding wheel/composite tool electrode and the role of size of abrasives during electro-discharge surface grinding operation.

3) Little information is available on surface roughness and topography of the machined surface by hybrid machining processes.

4) There is a lack of information regarding optimization of machining parameters for optimum responses using design of experiments.

5) There are conflicting opinions of various researchers concerning the fact of different parameters on MRR, SR, EWR, which needs to be addressed urgently.

6) The other area of research which needs the attention is the effect of electrical and non-
electrical parameters on recast layer developed on machined specimens.

3.2 Statement of the problem

The present work “Investigations into Electrical Discharge Surface Grinding Process” has been undertaken keeping into consideration of the research gaps identified during the review of published work and following implications:

1. Inefficiencies during machining of advanced materials by a single interaction based non-conventional machining techniques.
2. Low material removal rates and inadequate surface finish in machining of advanced metal ceramic-based composites.
3. Incomplete information on the effect of non-electrical machining parameters during EDSG operation.
4. Optimized conditions for the combined electrical and non-electrical parameters to improve machining characteristics of the EDSG process.
5. To compare the machining mechanisms of EDSG of die steel and composite.
6. Predicted optimal solutions may not be achieved practically using optimal setting of machining parameters suggested by any optimization technique. So, all the predicted optimal solutions should be verified experimentally using suggested combination of machining parameters.
7. To study the effect of heat generated during EDSG in terms of temperature and thermal stress distribution are the primary considerations of the study.

3.3 Objectives of the Proposed Research Work

After an exhaustive literature survey, following objectives have been selected for the present research work:

1) To develop the experimental setup for the EDSG process in the laboratory. The experimental setup should be enabled to adapt the changes in different parameters and their levels.
2) To prepare metal matrix composite (MMC) tool electrode for the machining of die & mold steel. The electrodes would be processed through different compositions and sizes of abrasives.
3) To investigate the effect of various process parameters of EDSG like pulse on time,
off- time, peak current, voltage, electrode rotation, etc. on process performance. The process is measured in terms of MRR, SR, EWR.

4) To optimize the machining parameters of EDSG in order to obtain the optimum response characteristics (MRR, SR, EWR) using D.O.E.

5) To study the surface topography and surface integrity of machined workpieces by EDSG using scanning electron microscope (SEM), optical microscope, X-ray diffraction, etc.

6) To model the EDSG process in order to validate the results using FEM.

3.4 Different phases of research work

To accomplish the approved objectives, present work has been completed in six stages. Figure 3.1 shows phases of experimental work through flow chart.

Phase-1

- Development of the experimental set up for EDSG. The experimental set up should have controls and adaptations for selected input parameters.
- Processing of the composite tool electrodes

Phase-2

- Identification of the working ranges and the levels of the EDSG process parameters (pilot experiments) affecting the selected quality characteristics, by using one factor at a time approach.

Phase-3

- Design of experiments by Taguchi experimental design approach. Selection of the orthogonal array (OA) on the basis of a number of process parameters and their levels and interactions to be studied.
- Investigation of the effects of EDSG process parameters on quality characteristics viz. material removal rate, electrode wear rate and surface roughness while machining die steel and the composite workpiece.
Figure 3.1: Research design flow chart
Phase-4

- To determine optimized conditions for performance characteristics to plan new experiments.
- Experimental validation of results by performing confirmation experiments.

Phase-5

- Microstructure analysis of machined surfaces by scanning electron microscope to check surface integrity, topography and thickness of recast layer.
- XRD analysis of the machined surface to verify deposition of foreign materials and compound formation on the machined surface.

Phase-6

- Development of the thermal model for EDSG process using finite element analysis approach.
- Prediction of temperature distribution of the machined surface and thermal stresses to identify the failure regions on the machined surface due to excessive thermal stresses.
- Validation of the thermal model of EDSG.