**Preface**

Research on energy storage devices was getting priority because of the energy crisis. In this context many energy storage systems were explored to store electrical energy in large scale throughout the world.

One of the explored systems was Fe-Cr Redox flow battery; this will be operated by employing FeCl$_2$ and CrCl$_3$ as active materials in positive and negative sides respectively dissolved in 2N HCl solution. Due to slow reversibility of the Cr(III)/Cr(II) redox couple, performance of Fe-Cr redox flow battery significantly slow. The catalytic procedures applied on electrode material, which is carbon felt, enhances the reversibility of Cr(III)/Cr(II) redox couple.

Hence, the main objective of the work is to improvise the redox reaction and to achieve better coulombic and energy efficiencies for the battery.

The Pb and Bi electroplated samples were utilized to get maximum efficiencies. Catalysis and electroplating techniques developed are very suitable even for laboratory practices.

A further study was also carried out by replacing chloride electrolyte materials with sulphate materials. This lead to most efficient and cheaper redox flow cell was obtained compared with other RFB’s. A maximum of 100% chromium reduction, 98% coulombic efficiency and 78% energy efficiencies were recorded by implemented cell procedures.
An innovative catholyte regeneration method was developed without affecting the characteristics of Nafion-117 membrane which was used for cell operation.

**The present thesis is divided into 5 chapters:**

**Chapter-1** Describes the background of the work and gives a brief of technology of batteries, flow batteries and fuel cells. A brief history of Fe-Cr RFB and applications of the same were given. This chapter is also concerns about the technology limitations of ICB and requirements for the same. Solving technical obstacles mentioned as scope of work, the methodology followed to build an efficient Fe-Cr redox flow cell technology to overcome the complicated disadvantages than other systems.

**Chapter-2** Materials and methods, focus has been given to preparation of catalytic carbon felt electrodes and their characterization. This chapter also describes the various normalization treatment procedures for carbon felt electrodes. Nafion-117 membrane, which is a proton exchange membrane. This membrane will be pretreated and post treated for better results. The procedures followed for this purposes were given in this chapter. A novel method for regeneration of catholyte using formic acid solution was developed. Optimum procedures are evolved to get maximum results with this method. The chemicals and reagents required for preparation of electrolytes was also discussed in this
chapter. The materials, fixtures and other requirements for construction of cell were also given. The procedures followed to evaluate the cell performances and measuring the coulombic, chromium reduction and energy efficiency values were also mentioned in this chapter.

**Chapter-3** Consists of characterization of electroplated Pb and Bi carbon felts with SEM-EDS instrumental technique. The prepared electrodes holds good for the total content of the metal electroplated as well as physical properties of the metal on carbon felt. All the characterized samples showed uniform dispersion of metal content on felt mentioned per square unit area. Evaluation of cell for the prepared electrodes and electrolytes were measured using a setup which was constructed with a double head diaphragm pump and 2 flow meters and anolyte and catholyte tank connected with suitable piping. The cell performances are measured based on coulombic, chromium reduction and energy efficiency values of the cell. The Bi and Pb metals were electroplated individually and used as additives in anolyte respectively to each other. Further research was carried out to get maximum energy efficiency by replacing chloride active materials with sulphate material. This combination resulted maximum of 78% energy efficiency.

**Chapter-4** Consists of cost assessments for Fe-Cr RFB with a 5KWH pilot plant model. The cost estimations for the construction of required battery and materials and reagents costs were tabulated. The
effect of the individual item on total cost of the project was also estimated by comparing this project cost with individual components. Nafion 117 membrane and cell fixtures were occupied a 59% of the total cost of the project. This chapter also states that the necessity and urgency for the improvement of the technology for reducing costs in concern with membrane preparation technology and construction technology.

**Chapter-5** Presents the conclusions of the present work. Along with conclusions the recommendations of the developed catalytic techniques with Pb and Bi as additives in anolyte and as plated on felt as catalysts for the Cr(III)/Cr(II) redox reaction. Recommendations of the present work are also given to construct a redox flow battery by sophisticated software systems and practical implementations of the work.

A list of publications of articles, which are under revision/review and communications were mentioned as appendix.