DESIGN AND DEVELOPMENT OF POLYMER BASED CONDUCTIVE BI-POLAR PLATES FOR ELECTROCHEMICAL ENERGY STORAGE DEVICES

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College ***:*** *Jyothy Institute of Technology**,** Bengaluru*
Branch ***:*** *Department of Mechanical Engineering*
Guide(s) ***:*** *Dr. H B Muralidhara*
Mr. Jayatirtha M Patil
Student(S) ***:*** *Mr. Aditya R*

Introduction:

Energy crisis is a major problem the world is facing today and the focus of several researchers through out the world is towards development of an energy storage device that is very much efficient than the existing energy storage devices[1]. Iron Redox flow battery is one such energy storage device that stands out due to their unique properties such as high efficiency, long life cycle and non-flammable electrolytes. However, several components used in the system has to optimized in order to achieve better efficiency and low cost. Electrolyte, bi-polar plates, electrodes, ion exchange membranes are the few important components that draws major focus[2][3][4]. Several studies on new flow field designs and polymer based bi-polar plates may become an able replacement for existing much brittle graphite based bi-polar plates with conventional flow designs.

Optimization the flow field designs with uniform velocity distribution and least pressure drop in order to draw better efficiency and also find an alternative polymer-based material to replace the traditional graphite based bi-polar plate[5]. Also, several researchers focus towards the selection of an able materials for the development of bi-polar plates as it must possess good electrical conductivity which is a very important factor for its implementation is redox flow battery. Polymer-carbon based materials appear to be much promising materials that can be used to develop an affordable and efficient bi-polar plate[6].

Herein we have proposed an approach to design new flow field patterns using Solidworks and have carried our CFD analysis using Ansys fluent software. Also, the work involved synthesis of conductive polymer (polyaniline) which was utilized as a conductive filler to develop graphite based bi-polar plates[7].

Objectives:

1. To design and carry out CFD analysis of novel flow field designs
2. To synthesize conductive polymer for development of polymer based bi-polar plates
3. Development of carbon-polymer based bi-polar plates for iron based redox flow batteries.
4. Initially the newly proposed designs is modelled using a 3D modeling software and later CFD analysis was carried out using Ansys fluent. Initial trials for development were carried out.

The material (graphite, polypropylene, Polyaniline) used to develop bi-polar plates were blended uniformly using oil bath at 100 degrees Celsius. Compression molding machine was used to develop preliminary model of bi-polar plate.

Methodology:

3 D modeling of bipolar plates

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CFD Analysis of designed flow fields

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Synthesis of Polyaniline

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Compounding of graphite, polyaniline and polypropylene using screw extruder

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Development of bi-polar plates using compression molding

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Material characterization and testing

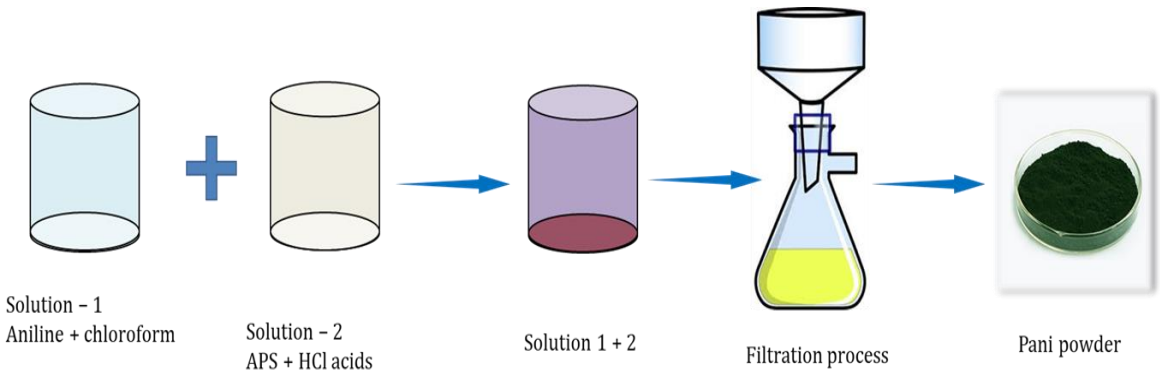

Fig.1 Process involved in synthesis of conductive polymer

Fig.2 Process involved in development of conductive bi-polar plate test samples

Conclusion:

The physical system considered in the study with a computational domain made of flow field and porous substrate with an active area of 132 cm2 was considered. Flow fields with different flow designs were modelled using Solidworks software

To study the hydrodynamics of the designed flow fields, CFD analysis were carried out using Ansys Fluent. The porous media considered in the study is placed below the flow domain and has a specific permeability of 7.518 e-11 m2 with a porosity of 0.8. The surface contact between the flow domain and porous media is considered as interface with no flow resistance to fluid. A uniform velocity is defined at inlet and the outlet is specified with gauge pressure. The wall surface is considered as no slip condition.

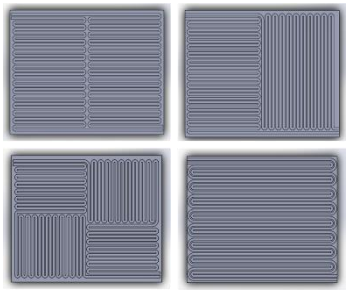

Fig. 3 Conceptual design and different 2 channel flow field

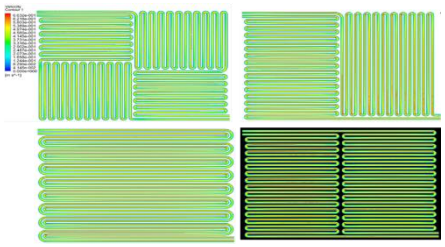

Fig. 4 Velocity contours of all different 2 channel flow field designs

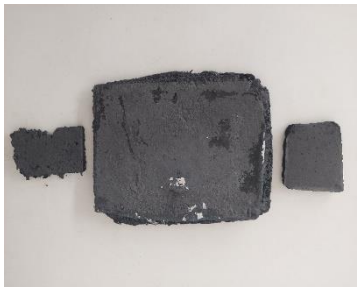

Fig.5 Preliminary test samples developed using compression molding

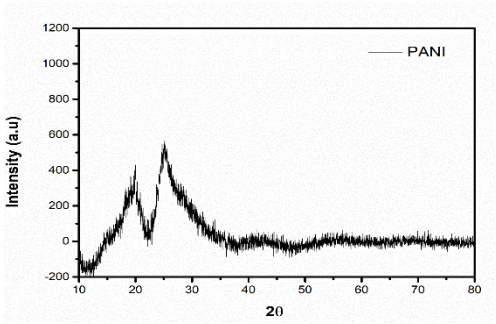

Fig.6 XRD spectrum of synthesized Polyaniline

To determine the crystallinity of the synthesized PANI materials XRD analysis was carried out. Major intense peaks for PANI were obtained at 2Ɵ 20.4 and 25.6 that corresponds to the reflections of pure PANI [8]

Scope for future work:

Design and development of cost effective and better efficient conductive polymer based bi-polar plates for iron based redox flow battery is proposed. Further studies can be carried out to optimize to material to make it even more cost effective and efficient. The electrical conductivity of the developed conductive bi-polar plates can be enhanced using a suitable conductive coating. The life cycle studies of iron based redox flow batteries on implication of developed conductive bi-polar plates can be carried out to study the enhancement in performance of iron based redox flow battery.

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