CoE Review Meeting, New Delhi, 5th June 2014

Center of Excellence (CoE)

Action Plan Presentation about Center of Excellence (CoE)
on

"Challenges of Nanotechnology for 21st Century Generation – Indian Perspective in Global Scenario"

Prof.Ch.V.R. Murthy, Principal, AUCE(A), AU

Prof.K.Ramji, Dept. of Mech. Engg., AUCE(A), AU, Visakhapatnam, A.P.
Coordinator, CoE

Prof. S.V.Naidu, Dept. of Chem. Engg., AUCE(A), AU, Visakhapatnam, A.P.
Principal Investigator, CoE

Under the Scheme of
TEQIP Phase II, CoE
Sub Component 1.2.1
MHRD, New Delhi

TEQIP PHASE - II, AUCE(A), ANDHRA UNIVERSITY

SPFUAP-TEQIP-II 1st Review Meeting on CoE's Activities 5th June 2014

Name of Institution: AU College of Engineering (A), AU, Vizag

Title of the Project: **"Challenges of Nanotechnology for 21st Century Generation – Indian Perspective in Global Scenario"**

Principal : Prof. Ch.V.R. Murthy
Coordinator: Prof. K. Ramji
Principal investigator: Prof. S.V.Naidu

Number and Name of Departments Involved: 05

- Center for Nanotechnology
- Department of Mechanical Engineering
- Department of Chemical Engineering
- Department of Metallurgical Engineering
- Department of Instrument Technology

Developments of CoE

- Project Proposal is Submitted: 10th Dec. 2012
- Sanction letter Received: 12th July 2013
- Sanction of Amount letter Received: 15th Sep 2013
- Amount received from SPFU, March 14: Rs.2.50 Cr
- Advanced amount from AUCE(A), Oct. 14: Rs. 1.00 Cr

Technical Teams

Center of Excellence (CoE)

•Multiscale Composites
•Nanocomposites
•Nanolubricants & Machining

- Prof. K. Ramji, Dept. of Mechanical Engineering, Coordinator
- Prof. A. Rama Krishna, Dept. of Mechanical Engineering, Investigator
- Prof. N.B.R. Mohana Rao, Dept. of Metallurgical Engineering, Investigator
- Prof. G.M.J. Raju, Dept. of Chemical Engineering, Investigator

•PEM Fuel Cell

- Prof. S.V.Naidu, Dept. of Chemical Engineering, Principal Investigator
- Prof. T.Subrahmanyam, Dept. Of Mechanical Engineering, Investigator
- Prof. G.M.J. Raju, Dept. of Chemical Engineering, Investigator
- Prof. D.V.R. Koti Reddy, Dept. of Instrument Technology, Investigator
- Prof. N.Chitti Babu, Dept. of Chemical Engineering, Investigator

Action plan for CoE

- Advisor committee consisting of experts constituted
- Technical committee consisting of subject experts constituted
- Retired Professor of IITs - identified as Research Advisor
- Procurement Plan of the equipments finalized & It is approved by BoG (12-12-2013)
- Discussions in progress for the collaboration with Industries
- Networking of Academic and Research Institutions are started

Action plan for CoE

- Active involvement of CoE team in the discussion with the Advisory committee comprising experts from R&D labs like and faculty from IITs and IISc.
- Awarded 05 MTech students for Assistantship
- Going for add to recruit 06 PhD students for Research Assistantship.
- Specifications for purchasing the equipment finalized & Initiated 4 NCBs, 18 NSs and 01 DC packages worth of Rs. 2.83 Crores in PMSS S/W.

Action plan for CoE

- Discussions are in progress for the collaboration with Institutions (Like NUS Singapore, NCSU, University of Illinois, UC Berkley, Stanford University USA etc.).
- Discussions are in progress for the collaboration with Institutions in India (Like IISc Bangalore, IIT Bombay, IIT Delhi, IIT Madras, IIT Hyderabad, UOH Hyderabad etc.).
- Discussions are in progress for the collaboration with R & D Institutions in India (Like DRDO Labs: DMRL, NSTL, NMRL, IICT, CECRI-Fuel Cell Division etc.).

Action plan for CoE

- Micro action plan Meetings and over all activities of the CoE have been completed.
- Laboratory space, office space and other related logistics are finalized.
- Team will meet once in every week to discuss the progress of management issues and research activities of the COE
- Procurement Plan uploaded in the PMSS - detailed specifications for the individual equipment finalized.

Action plan for CoE

- Support to Faculty members for Paper presentation – 06
- 04 Research articles of faculty/students working in CoE accepted for presentation in conference
- Support to Faculty members for Organising Workshops – 03
- Support to Faculty members for Organising Int. Conferences – 02
- Support to Faculty members for attending Training Programmes – 12 (Within India : 09 & Abroad: 03)

Advisory Committee

Center of Excellence (CoE)

- **Principal, A.U. College of Engineering (A), AU, Visakhapatnam – Chairman**
- **Vice Principal, A.U. C.E (A), AU, Visakhapatnam - Member**
- **Prof. K. Ramji, Dept. of Mechanical Engineering, Coordinator**
- **Prof. S.V.Naidu, Dept. of Chemical Engineering, Principal Investigator**
- **Prof. A. Rama Krishna, Dept. of Mechanical Engineering, Investigator**
- **Prof. T.Subrahmanyam, Dept. of Mechanical Engineering, Investigator**
- **Prof. N.B.R. Mohana Rao, Dept. of Metallurgical Engineering, Investigator**
- **Prof. G.M.J. Raju, Dept. of Chemical Engineering, Investigator**
- **Prof. N.Chitti Babu, Dept. of Chemical Engineering, Investigator**
- **Dean Academic & Research, A.U. C.E (A), AU, Visakhapatnam - Member**

Technical Committee

- **Dr.Tata Narasinga Rao**, Scientist – F,
  Team Leader - Centre for Nano Technology, ARCI, Balapur, Hyderabad.
- **Dr.-Ing. Vadali. V. S. S. Srikanth,** School of Engineering Sciences & Technology , University of Hyderabad, Hyderabad
- **Dr. G. Madhusudan Reddy,** DMRL, Kanchanbagh, Hyderabad
- **Prof. D. Ravi Kumar,** Dept. of Mechanical Engineering, IIT-D, New Delhi.

Technical Committee

1. **Dr. P Sridhar,** Chief Scientist
   CSIR – Central Electrochemical Research Institute
   CECRI – Chennai Unit, CSIR, Madras Complex
   IIT Taramani, Chennai -600 113
2. **Dr. A. Srinivas Kumar**
   Associate Director, Batteries Division
   Naval Science & Technological Laboratory (NSTL), Visakhapatnam
3. **Dr. Vasu Gollangi ,** Senior Engineer, Fuel cells & Renewable Energy Group, BHEL Corporate Research & Development Division
   Viakasnagar, Hyderbad – 500093
4. **Dr.G.A .Pathanjali**, General Manager(Operational)
   High Energy Batteries, Pakkudi Road ,Mathur
   Pudukottai District, Tamilanadu, INDIA -622515
5. **Dr. K.S. Dhathathreyan**, ARCI,-CFCT, Fuel Cell Division – Chennai
6. **Prof. Arun K Thangirala,** IIT Madras

Nano Materials – Areas of Research

- **Nano adsorbents/Lubricants**
  - Molybdenum Disulphide (MoS2) and Graphite Nano Particles as Lubricants
  - Turning and Milling Operations
- **Nano composites**
  - Polymer Nano composites and Multi Scale Composites with superior electrical (maximize breakdown strength & resistivity, minimize loss factor & discharge), mechanical (maximize tensile) & thermal properties (maximize thermal conductivity) Research Goal: Current transformers, potential transformers & related products with miniaturized dimensions
  - Polymer- Nano composites with high abrasion and impact resistance
- **Nano catalyst**
  - Fuel cells (PEM)
- **Multiscale Composites**

Industry Academia Collaboration

- **Research Collaborations with**
  - **DRDO Labs (NSTL, GTRE, ADA, DMRL, NMRL, ARCI etc.)**
  - **IITs (IIT Kanpur, IIT Bombay, IIT Chennai, IIT Hyderabad and IISc Bangalore) and**
  - **CSIR Labs (CECRI, NAL etc)**
- **Industry Collaborations with**
  - **BHEL**
  - **High Energy Batteries and**
  - **Chem Pal Industries**
- **M Tech students for work on their thesis in the above said labs and Industries for 6 months to 1 year on live projects**
- **PhD scholars (Faculty & Students) do collaborative work in our labs & sister labs to carry out research**

R & D Projects & Consultancy

- External Interactions:
  - ❖ DRDO Labs (NRB, NSTL, GTRE etc.)
  - ❖ ARCI, Chennai
  - ❖ ARCI, Hyderabad
  - ❖ DST, New Delhi CEN
  - ❖ AICTE, New Delhi
  - ❖ UGC, New Delhi
  - ❖ RINL Visakhapatnam
  - ❖ HPCL Visakhapatnam

R & D Projects & Consultancy

1.Synthesis, Characterization and Evaluation of Hybrid Nanocomposite Radar Absorbing Structure for Naval Applications.	**NRB Project, New Delhi, 2013-2015**	**2 years**	**39.675 Lakhs**	**Prof. K. Ramji**
2. Performance evaluation of Nano crystalline solid lubrication in the machining of the steel	**AICTE, 2011-2013**	**2 year**	**16.00 Lakhs**	**Prof. K. Ramji**

Experimental Infrastructure and Time line

The integrated infrastructure of CoE would be established on the ground floor of the new building

- Simulation Lab: Dedicated for device simulation activity both for teaching and research.
  Area : 2000 sq. ft. ; Time line: June 30, 2014.

- Materials Synthesis Lab: Synthesis infrastructure-wet benches, compacting press and Arc Discharge Method etc.
  Area : 1000 sq.ft; Time line: August 2014.

- Materials characterization lab: basic materials and structural characterization tools-AFM, PEM Fuel Cell, SEM etc.
  Area : 1000 sq.ft; Time line: September 2014.

Out put from fuel cell lab

Ph.D Awarded

•Experimental and theoretical studies on different operating conditions and flow geometries in a PEM fuel cell – B. Srinivasulu

M.Tech. Awarded

S.No	Name	Title of the dissertation
1	A. Leela Manohar	Sensitivity analysis of a 500 W Proton Exchange Membrane Fuel cell stack by design of experiments
2	Mohan Kumar Yadav	Parameter analysis of a Single PEM fuel cell by using design of experiments
3	K. Veerabhadra Rao	Effect of operating parameters on the performance of A PEM fuel cell with various flow field geometries – A theoretical study

Workshops/Conferences to be organised

S.No	Title of the Workshops/Seminars	Duration	Organising Secretary
1.	Two Day Workshop on "Fuel Cell" Resource persons: 1. Dr. K.S. Dhathatreyan, Associate Director, CFT, Chennai 2. Dr. M. Shaneeth, Vikram Sarabhai Space Center, Tiruvanathapuram 3. Sri M. R. Pawar, BHEL R & D, Hyderabad	20th – 21st , August, 2014	Prof. S.V. Naidu Prof. GMJ Raju Prof. N. Chitti Babu
2.	Two Day Conference on "PEM Fuel Cell" & Followed by one day Workshop on "Advances in PEM Fuel Cell"	21st - 23rd October, 2014	Prof. S.V. Naidu Prof. GMJ Raju Prof. N. Chitti Babu
3.	Three day International workshop on "Challenges in Nano Manufacturing: Indian Perspective in the Global Scenario (CNM – 2014)"	6th – 7th November, 2014	Prof. K. Ramji
4.	Two day International Conference on "Challenges in Nanotechnology: Indian Perspective in the Global Scenario (CNT – 2014)"	12th – 13th December, 2014	Prof. K. Ramji Prof. NRMR Bharghava

Workshops/Conferences/Trainings Attended & Guest Lectures Delivered

1. DST Sponsored Two Day National Seminar on "Futuristic trends of Nano Composites and their fabrication (FTNCF - 2013)" – **Prof. K. Ramji**	RVR & JC College of Engineering (Dist.) Guntur	6th & 7st September 2013.	As a Resource person (Delivered Guest Lecture on "Overview of Multiscale Modelling and Analysis of Fuzzy Cabon Fiber Reinforced Nanocomposites for 21st century generation Indian perspectives in global scenario").
2. AICTE Sponsored Two Day National Workshop on "Nanotechnology – A fuel for Chemical Industry" (NTFC-2013)" – **Prof. K. Ramji**	RVR & JC College of Engineering (Dist.) Guntur	20th & 21st September 2013	As a Resource person (Delivered Guest Lecture on Overview of Advanced materials in Nanotechonology with reference to Chemical Industry).
3 "International workshop on Hydrogen and Fuel Cell" - **Prof. S.V. Naidu** - **Prof. G.M.J Raju**	Cidade de Goa, India	1st – 3rd December 2013	Interacted with various eminent personalities in the field of fuel cell and participated in panel discussion.

Workshops/Conferences Attended & Guest Lectures Delivered

4. "National Workshop on Nano-Science and Technology – 2013 (NW NST – 2013)" I also enclosed copy of Invitation letter with this letter for your reference – **Prof. K. Ramji**	"Mangalore Institute of Technology & Engineering (MITE) of Rajalakshmi Education Trust", Badaga Mijar, Moodabidi-574225, Mangalore Taluk, D.K. Dist., Karnataka.	October 18 and 19, 2013.	Participated and Interacted with Resource persons and also participated in panel discussion.
5. National Workshop on Advanced Materials and Machining (AMM))" – **Prof. K. Ramji**	National Institute of Technology, Warangal, Andhra Pradesh	October 31 to 2nd November, 2013	Participated and interacted with persons and also participated in panel discussion.
6. International Conference on Recent Advances in Mathematical Sciences and Applications (RAMSA – 2013) – **Prof. K. Ramji**	GVP College of Engineering (A) Visakhapatnam	19th – 22nd December 2013	As a Resource person (Delivered Guest Lecture on "Overview of Nanocomposites and also chaired one technical session) Presented paper and participant and discussed issues and made some suggestions.

Workshops/Conferences Attended & Guest Lectures Delivered

7.Visited CSIR-Central Electrochemical Research Institute, Fuel Cell Division, Chennai Unit, Madras Prof. S.V. Naidu Prof. GMJ Raju Prof. N. Chitti Babu	Chennai	6th-7th January, 2014	Interacted with Senior scientists and collected the information regarding equipment and other information
8. Going to attend "European Technical School on Hydrogen and Fuel cells"	Crete, Greece	23rd -27th June, 2014	It is an opportunity to Interacted with various eminent personalities who are working in the field of fuel cells. The workshop will include details on research methods and instrumentation related to the state-of-the-art experimental facilities offering access within the H2FC project

Workshops/Conferences Attended & Guest Lectures Delivered

9. One day FDP Programme on "Applications of Nanotechnology" – **Prof. K. Ramji**	"VR Siddhrtha College of Engg, Vijayawada.	21st April, 2014.	As a Resource person (Delivered Guest Lecture on "Overview of Nanotechnology and its Emerging Applications").
10. AICTE Sponsored National seminar on "Advances in biomaterials for medical applications (ABMA – 2014)" – **Prof. K. Ramji**	RVR & JC College of Engineering (Dist.) Guntur	14th – 15th , March 2014	As a Resource person (Delivered Guest Lecture on "Overview of Overview of MICRO and NANO Systems and its Biomedical Applications").
11. Two day Workshop on "Advances in Composite Materials"– **Prof. NBR Mohan Rao**	JNTU College of Engineering (A) Vizianagaram	14th – 15th , March 2014	As a Resource person (Delivered Guest Lecture on "Overview of Metal matrix composites and and its Emerging Applications)".
12. Two day Workshop on "Advances in Composite Materials"– **Prof. K. Ramji**	JNTU College of Engineering (A) Vizianagaram	14th – 15th , March 2014	As a Resource person (Delivered Guest Lecture on "Overview of Nanocomposites and and its Emerging Applications)".

Workshops/Conferences Attended & Guest Lectures Delivered

13. Two day National Seminar on "Advances in Mechanical Engineering" – **Prof. K. Ramji**	"Govt. Polytechnic, Vizianagaram.	14th – 15th , March 2014	As a Resource person (Delivered Guest Lecture on " Emerging Applications Nanotechnology").
14. Two day Workshop on "Advances in Composite materials (ACM – 2014)" – **Prof. K. Ramji**	JNTU College of Engineering (A) Kakinada	15th – 16th , March 2014	As a Resource person (Delivered Guest Lecture on "Overview of Multi Scale Composites and its Emerging Applications").
15. Two day Workshop on "Advances in Composite Materials"– **Prof. NBR Mohan Rao**	JNTU College of Engineering (A) Kakinada	15th – 16th , March 2014	As a Resource person (Delivered Guest Lecture on "Overview of Metal matrix nanocomposites and and its Emerging Applications)".

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Specific areas of Excellence Under CoE

- Multiscale Composites
- Nanocomposites
- Nanolubricants & Machining
- PEM Fuel Cells

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SIMULATION STUDIES OF CARBON NANOTUBE BASED MULTISCALE COMPOSITES

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Outline of the Presentation

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Introduction to Nanocomposites and Multiscale Composites

Modeling of Nanocomposites and Multiscale Composites

Effect of Fiber Orientation on Elastic Properties of Multiscale Composites

Analysis of Stress Concentration

Free Vibration Analysis of Multiscale Composite Panels

Non-linear Structural Response of Multiscale Composite Panels

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CNT's are proven to be the

Stiffest

Strongest

Toughest fiber

High fracture strain 30-40%

High aspect ratio

Low density and high resilience

Superior electrical and thermal properties

Properties of carbon nanotubes in comparison with other common fiber reinforcements

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Fiber	Diameter (µm)	Density (gm/cm^3)	Tensile Strength (GPa)	Modulus (GPa)
Carbon	7	1.66	2.4-3.1	120-170
S-glass	7	2.5	3.4-4.6	90
Aramid	12	1.44	2.8	70-170
Boron	100-140	2.5	3.5	400
Quartz	9	2.2	3.4	70
SiC fibers	10-20	2.3	2.8	190
SWNTs	**0.001-0.002**	**1.3-1.4**	**13-200**	**1000**
MWNTs	**0.002-0.025**	**1.8**	**11-150**	**1280**

Nanocomposites

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Nanocomposites are made by introducing a nanoparticles into a composite matrix

Common nano particles are nanotubes, nanofibers, nanoclays, etc.

Improvement in composite properties with the addition of small amount of nanoinclusions.

The percentage weight of nanoparticles in the composite matrix is in the range of 0.1% to 5%

One of the nanoinclusions receiving much attention from the past two decades are CNTs

Multiscale Composites

Center for *Nanotechnology*

The properties of conventional composites can be increased by incorporating nanoscale reinforcement.

Multiscale composites are produced by combining traditional fiber reinforced composites with CNT's.

The concept is to use traditional reinforcements for in-plane load carrying

Nanoscale reinforcement for improving

-through-thickness performance,

-resin-dominated properties of resultant composites.

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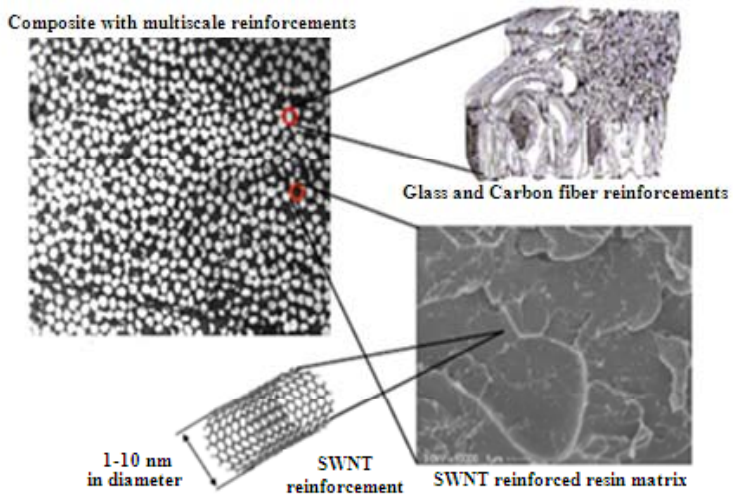

Concept of multiscale reinforcement composites

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Computational approach can play a significant role in the development of the CNT based composites.

Experiment-based research can ideally be used.

It require the use of sophisticated processing methods and testing equipment, which are expensive.

Computational modeling techniques are used to determine the mechanical properties.

Computation approach can be divided into two methods:

a. Molecular Dynamics(MD)

b.Continuum mechanics(CM) based methods.

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The MD approach can provide abundant information about the mechanical behaviour of nanocomposites.

But currently they are limited to small size due to computational expense.

CM approach is only the feasible approach at present for characterizing nano and multi-scale composites.

Modeling of materials at the nanoscale using CM approach models is a new and challenging task.

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The Objectives of this Research are

Develop, 3-D representative volume element (RVE) based on the continuum mechanics

Evaluate the elastic properties of nanocomposites using finite element method (FEM)

Study the integration effect of CNT's in polymer composites.

Develop numerical models for predicting the elastic properties of multiscale composites .

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Investigate the effect of fiber orientation on elastic properties of CNT based multiscale composites.

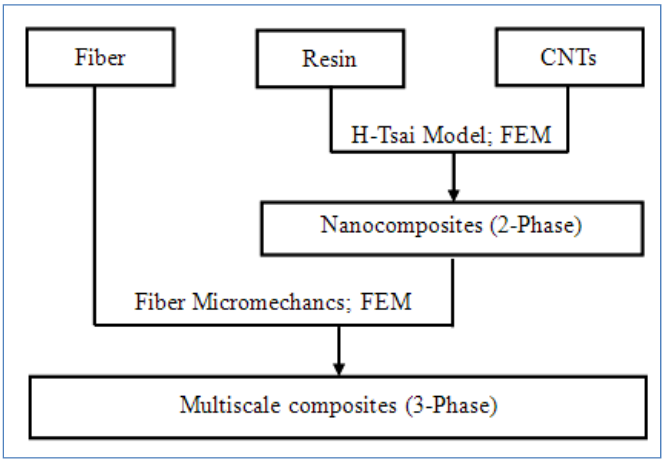
Study the effect of CNT reinforcement on the stress concentration of multiscale composites

Perform Free vibration analysis for three types of CNT based composite panels.

Find the non-linear response of CNT based composites subjected to air blast loading.

Modeling of Nano and Multi scale Composites

Methodology



Schematic of modeling for nano and multiscale composites

The following assumptions are made for the simulation of nano and multiscale composites

- It is assumed that perfect bonding between CNT and matrix
- CNT dispersion in the matrix is uniform
- Each CNT had the same mechanical properties and aspect ratio
- All CNT's were straight tubes
- There is no void in the matrix
- Fiber-matrix bonding was assumed to be perfect

Representative Volume Element (RVE)

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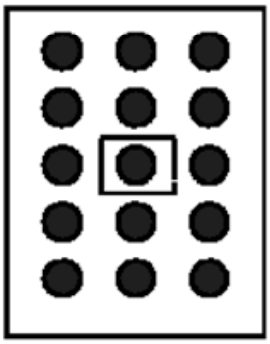
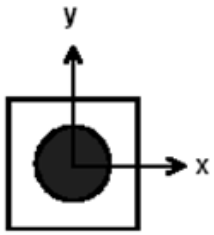
RVE - A single fiber with surrounding matrix material



Structure



RVE

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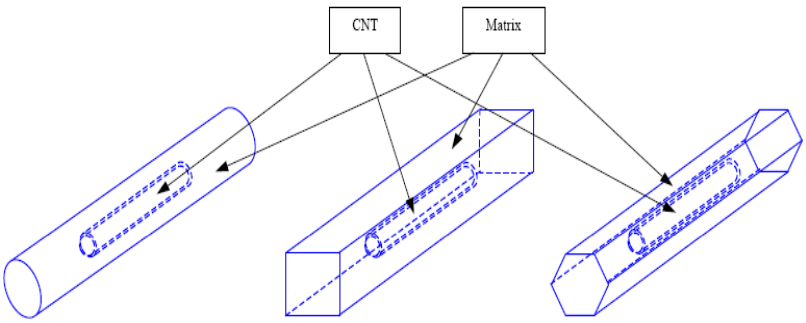
Three possible 3-D nanoscale representative volume elements



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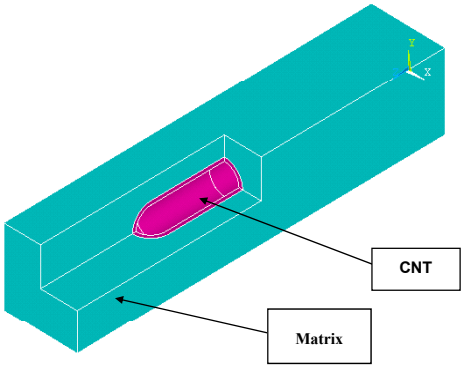
In the homogenization method, a RVE shown in Fig.



Assumed that the average elastic properties of a RVE are equal to the average properties of the particular composite.

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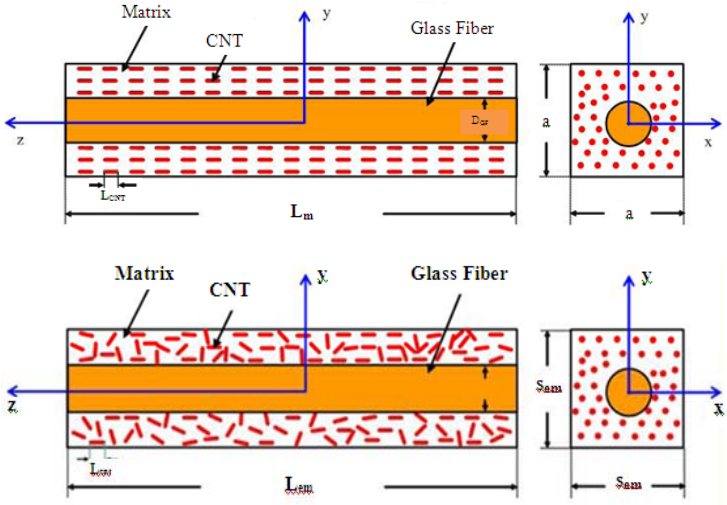
Multiscale Composites(Glass/CNT/Matrix)



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Effect of Fiber Orientation on Elastic Properties of Multiscale Composites

For a homogeneous material, properties do not depend on the location.

For an isotropic material properties do not depend on the orientation.

On the other hand fiber reinforced composites are microscopically inhomogeneous and non isotropic.

The mechanics of fiber reinforced composites is more complex than that of conventional materials.

The properties of fiber reinforced composites depends on the orientation of fibers.

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Finite Element Analysis for Stress Concentration in Multiscale Composites

- Rectangular orthotropic plate with central hole has found widespread applications
  Ex: aerospace, marine , automobile etc.
- Stress concentration arises from any abrupt change in geometry of plate under loading.
- Stress distribution is not uniform throughout the cross section.
- Failures such as fatigue cracking and plastic deformation occur at points of stress concentration.

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Non-linear Structural Response of Multiscale Composite Panels

Under, time-dependent pressure loading composite structural components undergo large deflections

Geometrically non-linear dynamic analysis for investigation of their response.

Dynamic response of CNT reinforced composite flat, concave and convex panels subjected to blast loading have been studied.

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Nanolubricants & Machining

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Machining- a complex phenomena

- **Turning** is one of the most fundamental and indispensable process of metal removal in industry.
- **Dry machining**
  - Low surface finish, Higher heat generation, Increased tool wear and Reduced tool life
- **Wet machining**
  - Increased pollution and Cost
- Machining with **Minimum Quantity Lubrication (MQL)**
- The desirable **properties of solid lubricant**
  - provide low, constant and controlled friction between two bearing surfaces
  - chemically stable over the required temperature range,
  - non-toxic and economical.
- **Solid lubricants:** Graphite, MoS_2, Boric acid, WS_2, etc.,
- **How to apply solid lubricants: 1. Powder form and**

  2. Emulsions
- **Mixed with liquid lubricants such as SAE 40 oil or Canola oil.**

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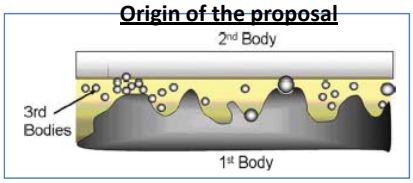
Origin of the proposal



- ***Particle size*** of the *solid lubricant* is the matter of importance in the tribological performance of the solid lubricant used
- By ***reducing*** **the** ***particle size*** in the microns level the performance of the boric acid has enhanced.
- It was investigated that there was an **inverse relationship between particle size and coefficient of friction when boric acid particle size was reduced from 350 microns to 0 microns** in tribological tests.

Definition of the problem

- Aims to study the influence of variation of solid lubricant particle size by varying it in the nano level in the machining of hardened steel.
- It also aims to investigate the influence of variation solid volume fraction on the proposed lubricant performance in machining of hardened steel.

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Importance of the proposed model

- Effect of solid lubricant particle size in the nano level can be uncovered.
- Difference between role of nano layered sputtered coatings and solid lubricant powder emulsions can be evaluated under real machining conditions.

Objectives

- To test the effect of variation of particle size in its nano level while machining hardened steel.
- To test the effect of variation of weight percentage of boric acid in canola oil.
- To differentiate the role of sputtered and solid lubricant emulsions used in machining applications.
- To validate with finite element model.
- To fit an equation using regression analysis.
- To develop a fuzzy model to generalize the particle size phenomena.

Technical details

- Range of particle sizes under study: 10-100 nm and 100-500 µm.
- Machining tests are proposed to evaluate the effect of boric acid particle size
- Evaluation parameters: Cutting forces, tool temperature and Surface roughness

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Equipment available with PI's Department

- All geared lathe- Kirlosker Turn Master
- Thermocouple module
- Toolmakers microscope.
- Metallurgical image analyser.

Major Equipment to be Purchased

- DC Magnetron Sputtering Unit.
- Lathe tool dynamometer
- Surface roughness tester

Consumables Required

- Cutting Tool Material: HSS and WC-Co
- Work piece material: Hardened steel
- Sputtering targets.

Methodology

- To synthesize the solid lubricant nano particles.
- To develop an experimental setup
- To conduct experiments to test the effect of variation of particle size.
- To coat the solid lubricant using sputtering process.
- To conduct the experiments to compare the results with that of I phase.
- Analysis of data.
- To validate the experimental results with FEA model
- To develop a fuzzy model

29 August 2014

Work Plan

Months	Activity
1-3	Problem specification and survey of literature
4-6	Procurement of Quotations Consumables and Boric acid Geometric tests on M/c tool
7-9	Procurement of Quotations Consumables and Boric acid Geometric tests on M/c tool
10-12	Characterization of raw boric acid Synthesis of Nano boric acid powders
13-15	Characterization of raw boric acid Synthesis of Nano boric acid powders
16-18	Fabrication of an Emulsification system Development of Experimental setup Procurement and calibration of dynamometer and Roughness tester

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Center for Nanotechnology

Work Plan

Months	Activity
19-21	Procurement and calibration of dynamometer and Roughness tester Conduct of experiments under various conditions To coat the solid lub. And to conduct the experiments
22-24	To coat the solid lub. And to conduct the experiments Analysis of experimental data Conduct of experiments under various conditions To coat the solid lub.
25-27	Conduct of machining experiments Analysis of experimental data Regression analysis and fuzzy model development
28-30	Analysis of experimental data Regression analysis and fuzzy model development
31-33	Verification and validation of the project results by using analysis packages Testing of the project module in real time environment
34-36	Documentation and report writing

29 August 2014

Center for Nanotechnology

DEVELOPMENT OF A PROTON EXCHANGE MEMBRANE (PEM) FUEL CELL

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Prof. N.Chitti Babu

SCOPE OF THE WORK

- An important part in PEM fuel cell is the catalyst layer, which is made by applying a thin layer of catalyst material on a carbon paper or polymeric membrane.
- Catalysts will be prepared in the proposed project by using different materials and alloys. Catalyst layers will be made.
- Fuel cells will be fabricated by using these catalyst layers indigenously and experiments will be conducted with these fuel cells to test their performances.
- Different catalyst loadings with supporting nano-materials will also be made and the performances will be tested in fuel cells.

- Gas diffusion layer (GDL) is another important part of the PEM fuel cell. A specialized porous carbon wafer is used as GDL. The thickness of the GDL is an important parameter of study in view of compactness, durability and efficiency of the fuel cell. Different thicknesses of GDLs will be used in making the fuel cells and their performances will be obtained quantitatively.

- Since the power obtained by a single fuel cell is low, stacks are made with many fuel cells to obtain the required amount of power. To get the maximum utilization of fuel and Oxidant it is essential to improve the flow fields flow pattern. Experiments will be conducted by using plates of different types of flow fields such as parallel, serpentine and other special types. The effect of each type of flow field on performance of the fuel cell will be obtained.

DEVELOPMENT OF 1 KW PROTON EXCHANGE MEMBRANE FUEL CELL

- In the stack single cell thickness:
- Membrane thickness 175 µm (N-117)
- GDL thickness 300 µm (250 – 400 µm)
- Catalyst layer thickness 20 µm (10 -30 µm)
- MEA thickness = 800 µm
- Bipolar plates thickness 6 mm
- Total single cell thickness in the stack 7 mm
- **1 KW stack thickness**
- No of cells 45 no
- 1 KW stack thickness = 45x7 +Thickness of End plates +collectors = 320 mm

DIFFERENT CATALYSTS AND SUPPORTING MATERIALS

The following are different catalysts and supporting materials that will be used in the proposed study.

Pt based catalysts

Pt/C, Pt-Ru/C, Pt-Mo/C, Au-Pd/C , Pt-Ru-Mo/C

- With different % of catalyst-carbon supports (5% - 20% of Pt)
- with different loadings (<0.4 mg Pt/cm^2)

Supporting materials

- Carbon black (Vulcan XC – 72, black pearls)
- Active carbon and graphite
- Multi-walled carbon nano tubes, carbon nano particles

MEA PERFORMANCE

Membrane Electrode Assembly (MEA):

The membrane, catalyst layer and gas diffusion layer together are called MEA.

The performance of MEA depends on :

MEA preparation

Catalyst loading and preparation.

Electrode structure

Gas diffusion layer.

CATALYST APPLICATION METHODS

The catalyst ink is applied by using the following methods.

- Conventional method
- Modified thin film method
- Electro deposition method

MAJOR EQUIPMENT TO BE PROCURED

- Fuel Cell Test station with mass flow controllers, Real time power PC controller and Fuel cell monitoring software
- 25 cm^2 and 100 cm^2 Single cell with all accessories

Consumables to be procured

:

- Catalysts & alloys (Pt, Ru, Mo, Pd, Fe, Co-Ni etc)
- Different Membranes (Nafion group)
- carbon nano powded, Carbon nano tubes
- carbon cloth/ carbon paper
- Nafion Solution
- Teflon solution
- Flow field plates/bipolar plates
- End plates, Gaskets etc
- Hydrogen, Oxygen & Nitrogen gases for experimentation

EQUIPMENT AVAILABE IN THE DEPARTMENT

Equipment available with	Generic Name of Equipment	Model, Make & year of purchase	Remarks
PI	6 KW Fuel cell test station	K-Pass . 2008	TEST STATION NOT WORKING DUE TO SOFTWARE AND HUMIDIFIER PROBLEM
	Fuel cell Stack: 1000 W & 500 W	Gas Hub, Singapore	
	Single Cell	Indigenous	
	Hydrogen cylinders-3 Oxygen cylinder – 1 Air cylinder – 1 Nirogen cylinder -1	BOC India LTD	
	Hydrozen gas leak detector	DRAGER-X-AM 2000 EX	M.Tech. – 3 Ph.D. – 1

PROGRESS OF THE WORK

- Conducted experiments to analyze the influence - flow rate of hydrogen, oxygen and the effect of anode humidification temperature on fuel cell performance.
- The experiments are also carried out the effect of percent excess oxygen flow rate on the performance of the fuel cell.
- Experiments are also carried out to analyze the effect of newly developed flow field plates viz., 4-Serpentine, interdigitated and dual inlet single outlet channels on polarization curve.
- Comparison of these channels also presented under identical operating conditions.
- The effects of backpressures on the performance of fuel cell are studied experimentally.
- The performances of these channels are also compared at different fixed backpressures. The hysteresis study presented.

PROGRESS OF THE WORK (cont..)

Experimental data obtained on a 500W PEM fuel cell stack containing 20 PEM fuel cells at different values of flow rates and pressures of hydrogen and oxygen. The experimental data are subjected to the 'design of experiments' analysis with an objective of identifying the most significant parameters. Both factorial and fractional factorial methods are used to analyze the experimental data.

The effect of various operating and physical parameters is studied theoretically on the performance of fuel cell. In the theoretical study the governing equations are solved by using the FLUENT. The parameters viz, temperature, pressure, humidity, GDL thickness and CL thickness are studied for the 4-Serpentine channel on the performance of fuel cell. Pressure drop calculations for both anode and cathode side are also studied.

Effect of Different parameters like

Theoretical vs experimental data

Temperature

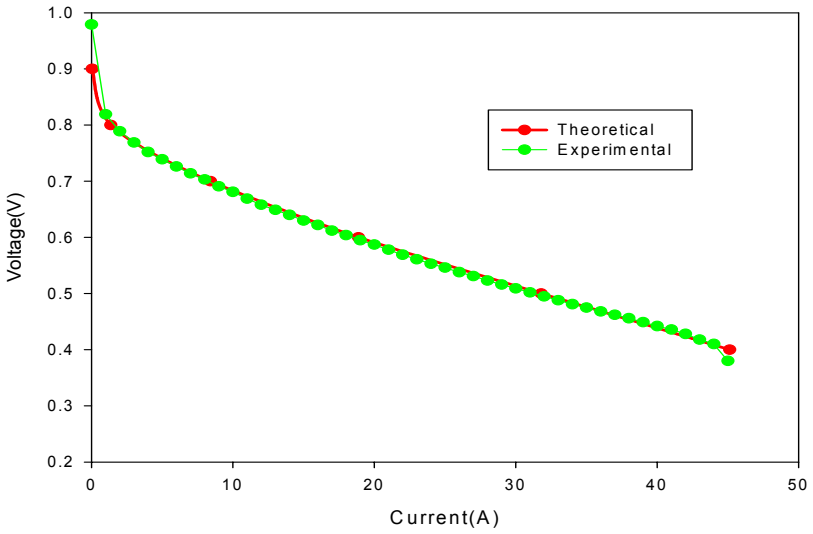
Pressure

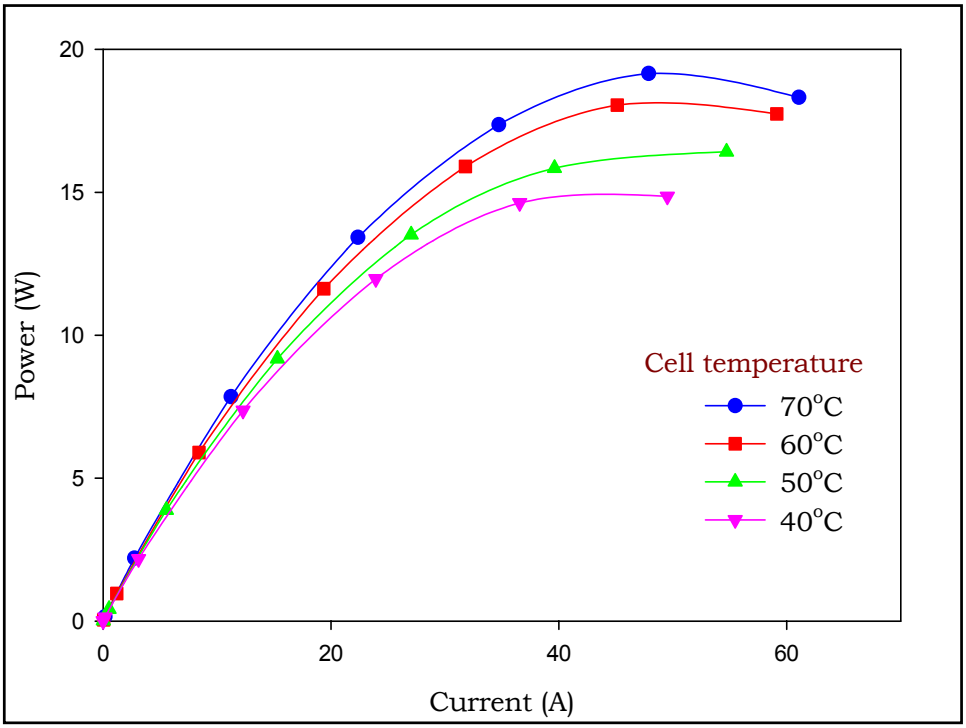
GDL porosity

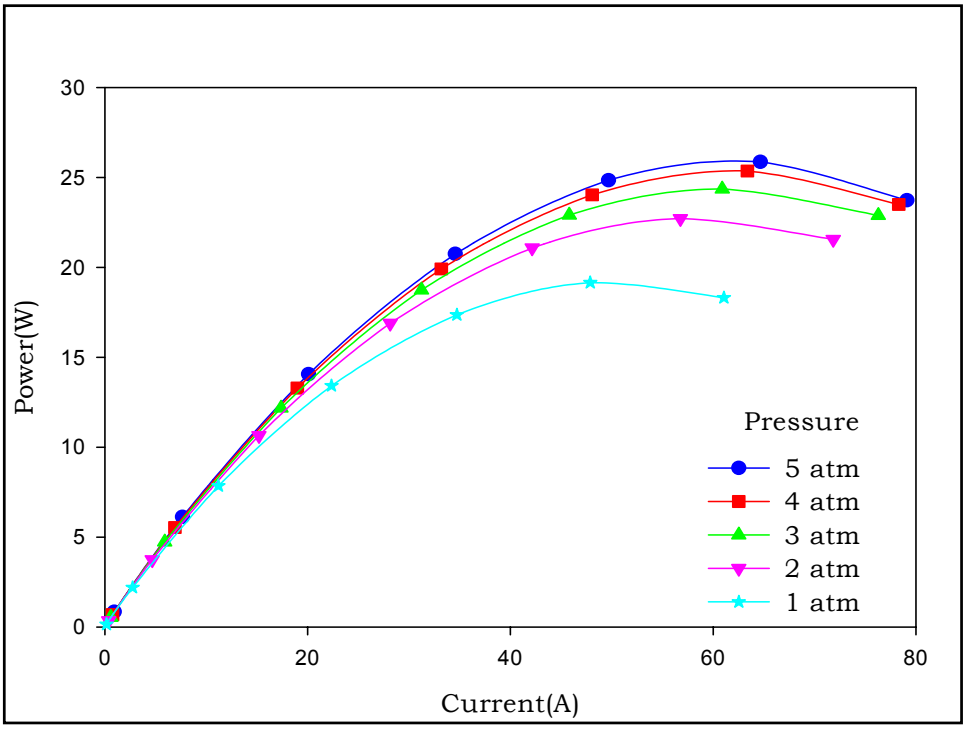
humidity

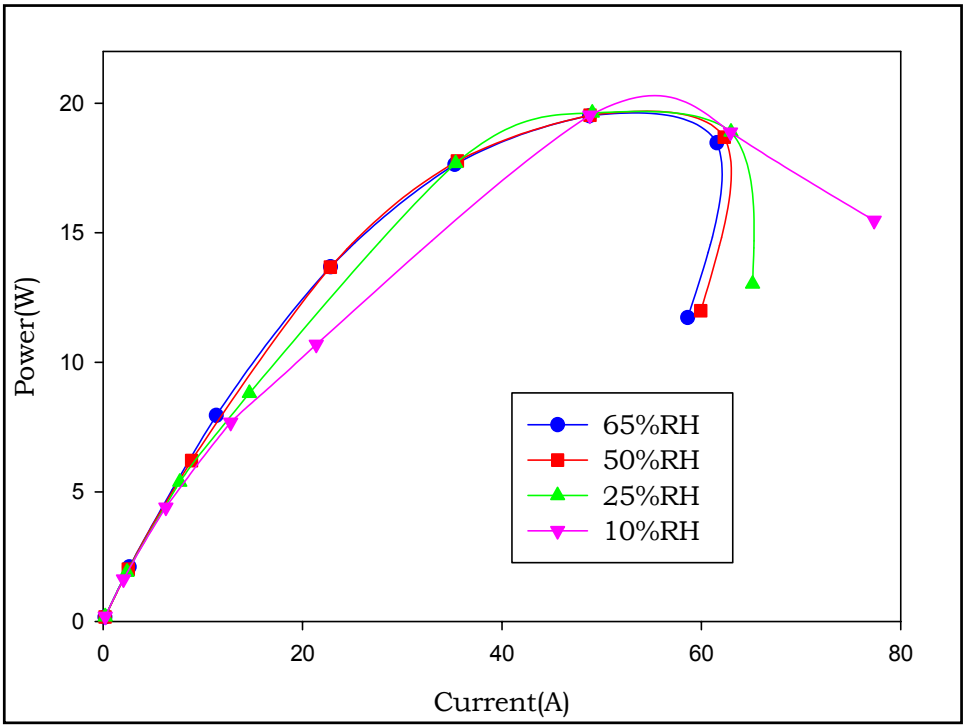
thickness of membrane

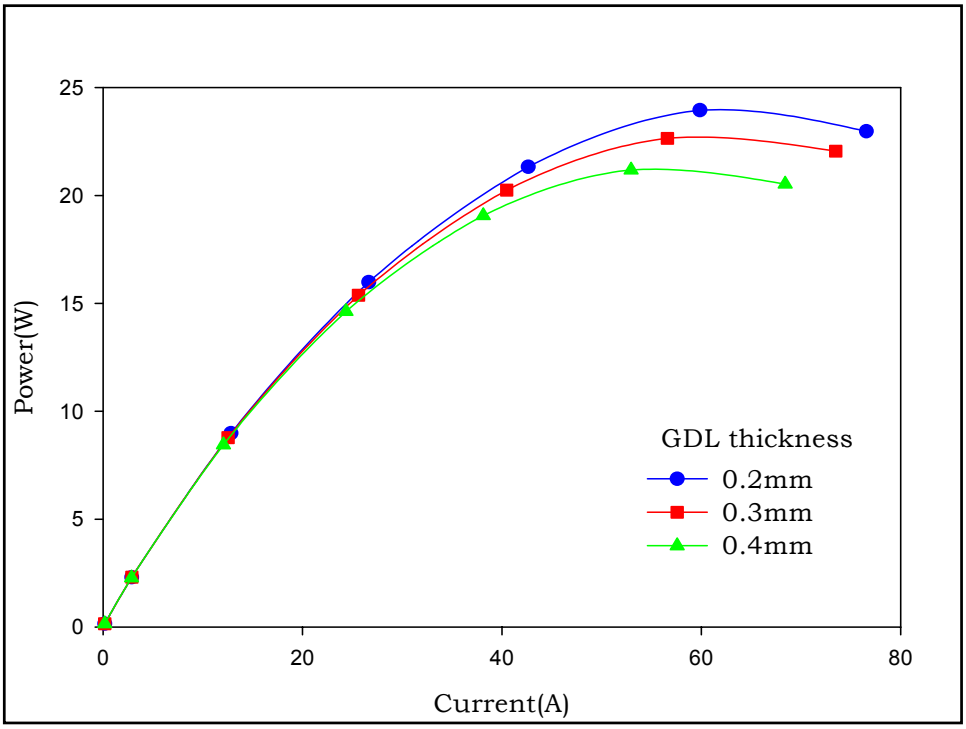
are studied theoretically using FLUENT

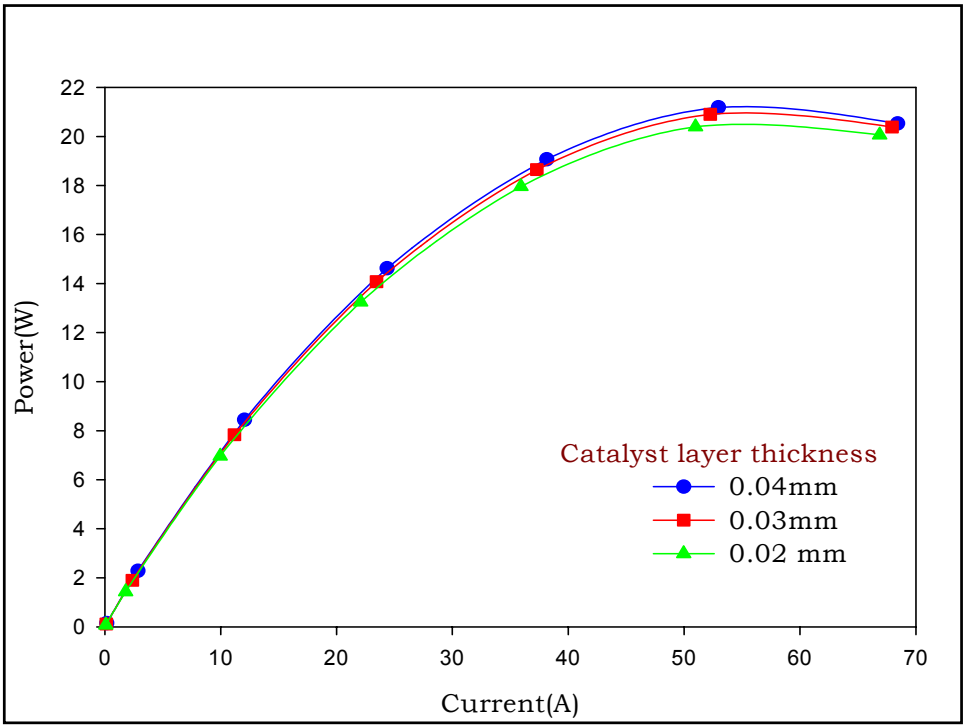



Power (W)
Current (A)
0
5
10
15
20
0
20
40
60
Cell temperature
70°C
60°C
50°C
40°C


Power(W)
Current(A)
0
5
10
15
20
25
30
0
20
40
60
80
Pressure
5 atm
4 atm
3 atm
2 atm
1 atm


Power(W)
Current(A)
0
5
10
15
20
0
20
40
60
80
65%RH
50%RH
25%RH
10%RH


Power(W)
Current(A)
0
5
10
15
20
25
0
20
40
60
80
GDL thickness
0.2mm
0.3mm
0.4mm



Conclusions

Experimental and theoretical studies have been carried out and presented on single PEM fuel cell and on stack of PEM fuel cells.

1. The performance increases steadily as H_2 flow rate increases. One can increase the limiting current and power by increasing the flow rate of hydrogen. At 0.25 lpm of H_2 flow rate the power obtained is 14.5W from the cell. When the flow rate is increased to 0.4 lpm, a 40% increased is obtained in power (20W).
2. The voltage decreases as the humidification temperature increases due to an increase in the saturation humidity of hydrogen gas.
3. As the oxygen flow rate is increased, there is an increase in the cell voltage due to maintaining sufficient oxygen is maintained on the cathode catalyst layer and carryover of water by oxygen. When the flow rate is doubled (0.2 to 0.4 lpm) a 10% increase is found in power production (17.7 to 19.4W).

4. Under identical operating conditions, at 25A current the fuel cell gives the highest voltage with 4-serpentine flow field plates (0.6V). The interdigitated and dual-inlet-single-outlet flow geometries occupy the second and third positions (0.48 and 0.4V) respectively in the performance.
5. The 4-serpentine and dual inlet and single outlet flow channels show improvement in overall performance and power with an increase in back pressure. However if water is formed in the channel it can supersede the advantage gained by increasing the back pressure.
6. It can be concluded from the hysteresis that 100% excess flow rate gives the better performance at lower currents and 150% excess flow rate gives better performance at higher currents, this is due to excess flow rate of oxygen over theoretical quantity.

7. The Design of Experiment (DOE) methodology with its statistical techniques is well-suited to analyze the tests conducted on fuel cells. The DOE approach leads to simple and precise models which highlight the impacts of the factors on the response and detect possible interactions between parameters.
8. The conditions for operating the stack with respect to pressure and flow rate of the reactants were identified by design of experiments method.
9. The effects of interactions among the various factors at two different levels were also identified along with the major contributor by sensitivity analysis by statistical methods.
10. By conducting the experimental design methodology the number of experiments can be reduced to evaluate the robustness of the stack with respect to operating conditions, thereby saving time and materials.

11. The theoretical model developed for single PEM fuel cell simulates effectively the various conditions that exist in a real fuel cell, which is evident from the comparison of the theoretical results with experimental data.
12. The fuel cell performance is improved with an increase in temperature from 40°C to 70°C. This is due to increase of gas diffusivity, exchange current density and membrane conductivity at higher temperature.
13. As the operating pressure is increased from 1 to 5 atm, the fuel cell performance also increases due to increase in inlet concentration of oxygen.

ACTION PLAN

The figures shown within brackets refer to time period in months.

Stage – 1

- Procurement of equipments–Test station, 25 cm^2single cell and 100 cm^2 single PEM fuel cell system.
- Consumable materials like membranes, carbon cloth/paper, Teflon solution, Nafion solution, flow field plates and other accessories for experimental study. (1-4)
- Hydraulic Hot Press, load boxes, control valves, flow meters, furnace, balance and Probe sonicator are placed order (POs released)

Stage – 2

- Preparation of MEA by using different membranes, catalysts and characterization of these membranes of 25 cm^2. (4–8)

ACTION PLAN

Stage - 3

- To achieve a performance of a single cell up to 0.6 V at 1.0 A/cm^2 by testing with various membranes, catalysts, catalyst loadings, gas diffusion layer thicknesses. (9-12)

Stage - 4

- To develop a 100 cm^2 single PEM fuel cell having a performance of 0.6 V at 1.0 A/cm^2 by continued experimentation with different MEAs and flow fields. (13-15)

Stage - 5

- Preparation of a stack for 1.0 KW with MEA area of 100 cm^2 with a performance of 0.5 V at 1.0 A/cm^2 .
- To carry out thermal studies for 1.0 KW stack (16-18)

Stage - 6

- Feasibility study and application of this system for partial fulfillment of AUV in place of batteries at different temperatures and pressures (19-20)
- Final Presentation with report. (20)

- Introduce an free elective subject in UG and PG level
- M.Tech. projects – 2 per year
- Ph.D. – minimum two will be produced during project period.
- The equipment is useful for PG and Ph.D. student to carry out their research work.
- **Books & Journals: to be procured**

I. Number of International Exchange programmes

Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 28th February 2014
Nil	02	01

II. Progress Status Details

Deliverables		Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
1.Number of individual publications in peer-reviewed journals	National	10	03	03
	International	05	01	02
2. Number of co-authored publications in peer-reviewed journals with names of authors	National	10	03	03
	International	05	05	04

III. Progress Status Details

Deliverables		Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
3. Number of exchange of research students with collaborating institutions	National	0	02	00
	International	0	01	03
4. Number of exchange of research faculty with collaborating institutions:	National	0	02	01
	International	0	03	01

IV. Progress Status Details

Deliverables	Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
5. Number of patents obtained	0	01	01
6. Number of patents filed	0	01	00
7. Number of external R&D projects	12	02	01
8. Number of Industry Chairs secured	0	01	01

V. Progress Status Details

Deliverables		Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
9. Number of MoUs with academia	National	00	01	01
	International	00	01	01
10. Number of MoUs with industry	National	00	02	01
	International	00	01	00

VI. Progress Status Details

Deliverables	Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
11. Number of products	00	01	01
12. Number of research	00	01	02
13. Number of services commercialized	00	01	01

VII. Progress Status Details

Deliverables (AICTE approved Programmes started in the thematic area of CoE)	Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
14.Post Graduation	01	01	01
15. Doctoral programme	01	01	01

VIII. Progress Status Details

Deliverables		Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
16. Name of laboratory(ies) established in the thematic area of CoE		Mechanical testing lab	Characterization lab	Synthesis lab Adv.Synthesis lab
17. No. of enrolment in the participating department(s) of CoE	MTech	04	05	05
	PhD	04	05	06
18.No. of Assistantship given in the thematic area of CoE	MTech	02	03	05+06*
	PhD	Nil	04	06*
19. No. of degrees awarded by the participating department(s)	MTech	07	15	36
	PhD	Nil	Nil	03

*Shortly going to be finalized

IX. Progress Status Details

Deliverables		Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
20.No. of training programmes organized in the thematic area of CoE	Workshops	Nil	03	01
	Seminars	Nil	02	01
	Conference	Nil	03	01
21.No. of faculties of the participating department(s) attended training programmes in the thematic area of CoE	Workshops	Nil	03	09
	Seminars	Nil	02	06
	Conference	Nil	02	04
	CEP	Nil	04	02

X. No. of students of the participating department(s) attended training programmes in the thematic area CoE

Deliverables	Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
Workshops	Nil	03	01
Seminars	Nil	02	01
Conference	Nil	02	01

XI. No of course curricula updated in the participating department(s) of CoE

Deliverables	Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
UG	02	02	04
PG	04	04	03

XII. Research Awards and Publications

Deliverables		Base-line (2012-13)	Targets to be achieved at the end of 2 years	Progress as on 05th June 2014
No. of External awards for research	National	Nil	01	01
	International	Nil	Nil	01
No. of Publication in the thematic area	Books	Nil	01	Nil
	Technical Reports Published	Nil	Nil	01

1. DETAILS OF INSTITUTIONAL COE UNIT			
S. No	Name & Designation	Mobile No.	E-mail ID
1	Principal	9440389136	auceaprincipal@gmail.com
2	Coordinator	9440670584	ramjidme@gmail.com
3	Principal Investigator-1	9441293204	profnaidu90@gmail.com
4	Principal Investigator-2	9848416455	nrmrbhargava@rediffmail.com
6	Nodal Officer(Academic)	9989878974	nallurichitti@rediffmail.com
5	Nodal Officer (Procurement)	9866017067	gmjraju@gmail.com
6	Nodal Officer (Finance)	9440670584	ramjidme@gmail.com
7	Nodal Officer (M&E)	9866017067	gmjraju@gmail.com

2. STATUS OF FUNDS RECEIVED/UTILISED as on 31-05-2014

Funds Received	Utilized	Unspent
1	2	3 = 1 - 2
Rs.25000000	**Rs.1230000**	**23770000**

3. STATUS OF EXPENDITURE AS ON 31-05-2014

S. No	Category of expenditure	Amount		Expenditure		Fore cast up to	
		Allocated	utilized	Committed	Pipe line	August-2014	Dec-2014
1	Procurement	2.750	Nil	0.203	0.125	1.900	0.650
2	Asst. ships	0.500	0.018	0.020	0.045	0.105	0.315
3	R&D	0.500	Nil	0.010	0.035	0.085	0.325
4	FSD	0.500	0.090	0.050	0.065	0.095	0.265
5	I-I-I- Cells	0.250	Nil	0.020	0.025	0.035	0.165
6	IOC	0.500	0.015	0.023	0.045	0.075	0.355
GRAND TOTAL		**5.000**	**0.123**	**0.326**	**0.590**	**2.295**	**2.075**

4 . STATUS OF PROCUREMENT AS ON 31-05-2014 in Crores

Approved by NPIU			Initiated / Pipe Line Exp.		Committed Expenditure		Actual Expenditure	
Proc method	No. of Pkgs	Amount	No. of Pkgs	Amount	No. of Pkgs	Amount	No. of Pkgs	Amount
Direct	01	0.050	01	0.050	-	-	-	-
Shopping	10	0.543	01	0.075	06	0.203	-	-
NCBs	04	2.040	-	-	-	-	-	-
TOTAL	15	2.633	02	0.125	06	0.203	-	-

5. Have you identified/Conducted/ Attended :

1. Collaboration with Foreign Universities - Yes/Nil/01
2. National/International Seminars/Conferences -03/01/01
3. Joint Publications with International Authors - 01/Nil/Nil
4. Notified for M.Tech (Teaching Assistant ships) - 09
5. Notified for Ph.D (fellow ships) – 06 (Process is going)
6. International exchange of credits - 01

6. DIFFICULTIES / SUGGESTIONS IN IMPLEMENTATION OF THE COE:

Difficulties:

1. **Each and every stage of web based PMSS is time consuming and hence delay in procurement**
2. **Delay in Recruitment of Faculty in the Institution causes the overload on existing faculty**

Suggestions:

1. **Extension of period of plan of TEQIP - CoE**
2. **PMSS web site can be made with simple requirement of data like, data of vendors etc.,**
3. **The Performance of PMSS should be improved**

DETAILED ACTIVITIES ENVISAGED AND EXPENDITURE AS PER NPIU GUIDELINES

Activity/ Category of Expenditure	PLANNED		PERMITTED	
	Mode of Procurement	Cost in Lakhs	%	Cost in Lakhs
1. Improvement in Research and Development facilities a) Establishment of New laboratories i) Nanotechnology laboratory ii) Fuel cell laboratory	➢ **NCBs – 04** ➢ **Shopping – 18** ➢ **Direct Contract - 01**	**216** **64** **05**	**55**	**275**

EQUIPMENT

S.No	Equipment	Procurement method	Amount
1	GAS CONTROL FACILITY (HYDROGEN,OXYGEN,NITROGEN SUPPLY LINES WITH REGULATORS FOR THREE SYSTEMS)	SHOPPING	8,00,000
2	FUEL CELL HARDWARE (SINGLE CELL 25 SQ. CM - 2NO 100 SQ.CM - 2 NO)	SHOPPING	1,50,000
3	INJECTION MOULDING MACHINES	SHOPPING	6,00,000
4	PIN ON DISC MACHINE	SHOPPING	6,00,000
5	ARC DISCHARGE EQUIPMENT	SHOPPING	4,00,000
6	PHOTOELASTIC BENCH WITH VISION CAMERAS	SHOPPING	4,50,000
7	HYDRAULIC HOT PRESS	SHOPPING	6,00,000
8	COMPUTER BASED UTM	SHOPPING	4,50,000
9	ULTRA SONICATOR, PORTABLE ROUGHNESS TESTER, DIFFERNETIAL SCANNING CALORIMETER, VACCUM CHAMBER, HIGH SHEAR FORCE STIRRER	SHOPPING	7,50,000
10	Chamber type furnace	Shopping	7,00,000
11	HIGH ENERGY BALL MILL	SHOPPING	7,50,000
12	Probe Sonicator & Mettler Balance	Shopping	6,00,000
13	LOAD BOXES	SHOPPING	6,00,000
	TOTAL		74,50,000

EQUIPMENT

S.No	Equipment	Procurement method	Amount
1	SEM	NCB	1,30,00,000
2	PEM FUEL CELL TEST STATION	NCB	35,00,000
3	SPUTTERING MACHINE	NCB	24,00,000
4	CNC LATHE MACHINE	NCB	15,00,000
	TOTAL		2,04,00,000

S.No	Procurement method	No. of packages	Amount
1	SHOPPING	13	74,50,000
2	NCB	04	2,04,00,000
3	DIRECT CONTRACT	01	5,00,000
	TOTAL	18	2,83,50,000

DETAILED ACTIVITIES ENVISAGED AND EXPENDITURE AS PER NPIU GUIDELINES

Activity/ Category of Expenditure	PLANNED		PERMITTED	
	Mode of Procurement	Cost in Lakhs	%	Cost in Lakhs
1. Improvement in Research and Development facilities	➢Print and digitized Books, e-Journals and reference material	**07**	**1.5**	**7.5**
b) Establishment of a knowledge resource centre (library)	➢ICT Hardware Support and associated software for storage and dissemination through web	**0.5**		

DETAILED ACTIVITIES ENVISAGED AND EXPENDITURE AS PER NPIU GUIDELINES

Activity/ Category of Expenditure	PLANNED		PERMITTED	
	Details	Cost in Lakhs	%	Cost in Lakhs
1. Improvement in Research and Development facilities c) Procurement of Furniture	➢Work Tables ➢Chairs ➢Store Wells	**01** **0.75** **0.75**	**0.5**	**2.5**

DETAILED ACTIVITIES ENVISAGED AND EXPENDITURE AS PER NPIU GUIDELINES

Activity/ Category of Expenditure	PLANNED		PERMITTED	
	Details	Cost in Lakhs	%	Cost in Lakhs
1. Improvement in Research and Development facilities d) Minor Civil Works	➢ Refurbishment of existing structures ➢ Spaces to create new laboratories for thematic research	**08**	**1**	**5**

DETAILED ACTIVITIES ENVISAGED AND EXPENDITURE AS PER NPIU GUIDELINES

Activity/ Category of Expenditure	PLANNED		PERMITTED	
	Details	Cost in Lakhs	%	Cost in Lakhs
2. Providing additional Assistantships for enrolment in Masters & Doctoral programmes in topics linked to economic or social needs in the thematic areas	➢Teaching and Research Assistant-ships of High Quality for non gate qualified PG and Ph.D students P.G – 05 Ph.D – 06 ➢Foreign Fellowships not exceeding 3 months duration for Doctoral candidates subject to BoG approval on case to case basis - 04	➢ 10 ➢ 26 ➢ 14	**10**	**50**

DETAILED ACTIVITIES ENVISAGED AND EXPENDITURE AS PER NPIU GUIDELINES

Activity/ Category of Expenditure	PLANNED		PERMITTED	
	Details	Cost in Lakhs	%	Cost in Lakhs
3. Collaboration with Industry for Applicable Thematic Research & Product Development	➢ Industry Collaboration for Applicable Thematic Research 1.Securing sponsored projects and consultancy assignments 2.Involvement of Students Industry Sponsored Projects 3. Travel expenses; boarding, lodging, and sundry expenses/ allowances for faculty visiting Industries within India and abroad to develop and implement joint projects with well defined deliverables	**15**	**05**	**25**
	➢ Innovative Ideas into Projects/ Products in Collaboration with Industry 1.Commercialization of research products 2. Patenting of research products	**10**		

DETAILED ACTIVITIES ENVISAGED AND EXPENDITURE AS PER NPIU GUIDELINES

Activity/ Category of Expenditure	PLANNED		PERMITTED	
	Details	Cost in Lakhs	%	Cost in Lakhs
4. National/ International Collaboration for Research and Development Activities with Academic and R & D organizations.	➢ Securing sponsored projects and consultancy assignments	7.5	10	50
	➢ Publication of Research papers in peer reviewed Journals	7.5		
	➢ Travel cost, hospitality and honorarium paid to consultant for participation in Research & Development and for delivering expert lectures	05		
	➢ Travel expenses; boarding, lodging, and sundry expenses/ allowances for faculty visiting Institutions within India and abroad to develop and implement joint projects with well defined deliverables.	10		
	➢ Commercialization of research products and MoUs	10		
	➢ Patenting of research products	10		

DETAILED ACTIVITIES ENVISAGED AND EXPENDITURE AS PER NPIU GUIDELINES

Activity/ Category of Expenditure	PLANNED		PERMITTED	
	Details	Cost in Lakhs	%	Cost in Lakhs
5. Faculty training for enhancing research competence in thematic areas, both within India and abroad	➢ Course fee; travel expenses, boarding and lodging, and sundry expenses/ allowances as per applicable norms and rules when faculty is deputed out-station to another Institution (within India or abroad) for the duration of the Course, travel time and the time permitted by the BoG for visits to Institutions/ Organizations of interest and relevance to the faculty in the vicinity of the location of training		10	50
	a) Subject knowledge and Research Competence up gradation	15		
	b) Participation in Seminars, Conferences and Workshops	25		
	c) Seed Grant for venture into new directions	10		

DETAILED ACTIVITIES ENVISAGED AND EXPENDITURE AS PER NPIU GUIDELINES

Activity/ Category of Expenditure	PLANNED		PERMITTED	
	Details	Cost in Lakhs	%	Cost in Lakhs
6. Incremental operating costs	➢ Salaries	05	10	50
	➢ Operation and maintenance of equipment	03		
	➢ Office expenses	03		
	➢ Consumables	20		
	➢ Hiring of Vehicles	02		
	➢ Allowances for temporary Staff	02		
	Visits to NPIU, SPFU and Universities, IITs, NITs etc. and Organizing thematic area training programmes, workshops, seminars and conferences	15		

Macro Action Plan of Sub-component 1.2.1

S. No.	Activities	Project Life Allocation	Targets to be achieved	
			2013-14	2014-15
1	Improvement in research and development facilities through: i) Establishment of new laboratories for applicable thematic research ii) Establishment of knowledge resource center (Library) in the thematic area iii) Procurement of furniture iv) Minor Civil Works	2.75	0.75 0.10 0.05 0.10	1.50 0.05 0.10 0.10
2	Providing Teaching and Research Assistantships for enrolment in Masters and Doctoral programmes in topics linked to economic or societal needs in the thematic areas	0.50	0.20	0.30
3	Collaboration with Industry for applicable research and product development	0.25	0.10	0.15
4	National/International collaboration for Research and Development activities with academic institutions and R&D organizations	0.5	0.20	0.30
5	Enhancing research competence of faculty and knowledge sharing in thematic areas, both within India and abroad	0.5	0.20	0.30
6	Incremental Operating Cost	0.5	0.20	0.30
	TOTAL	5.0	1.90	3.10

Micro Action Plan of Sub-component 1.2.1

S. No.	Activities	Project Life Allocation	Targets to be achieved		
			August 2014	October 2014	December 2014
1	Improvement in research and development facilities through: i) Establishment of new laboratories for applicable thematic research ii) Establishment of knowledge resource center (Library) in the thematic area iii) Procurement of furniture iv) Minor Civil Works	2.75	2 NCB 1 DC5 NS 1 CW	6 NS 2 NCB	Proc. Comp.
2	Providing Teaching and Research Assistantships for enrolment in Masters and Doctoral programmes in topics linked to economic or societal needs in the thematic areas	0.50	ME-9 Ph.D-6	ME-9 Ph.D-6	ME-9 Ph.D-6
3	Collaboration with Industry for applicable research and product development	0.25	4	7	6
4	National/International collaboration for Research and Development activities with academic institutions and R&D organizations	0.5	3 2 3	4 3 6	5 4 6
5	Enhancing research competence of faculty and knowledge sharing in thematic areas, both within India and abroad	0.5	7 5	8 6	7 4
6	Incremental Operating Cost	0.5	6	7	5

Incremental Project Targets for Centre of Excellence

S. No.	Deliverables	Baseline (2010-11)	Targets to be achieved	
			At the end of 1 year	By Project closing
1	Number of International Exchange programmes	Nil	02	04
2	Number of individual publications in peer-reviewed journals: (a) National (b) International	 Nil Nil	 Nil Nil	 Nil Nil
3	Number of co-authored publications in peer-reviewed journals with names of authors: (a) National (b) International	 10 5	 03 05	 07 09
4	Number of exchange of research students with collaborating institutions: (a) National (b) International	 0 0	 02 01	 05 03
5	Number of exchange of research faculty with collaborating institutions: (a) National (b) International	 0 0	 02 03	 04 06
6	Number of patents obtained	0	01	02

Incremental Project Targets for Centre of Excellence

S. No.	Deliverables	Baseline (2010-11)	Targets to be achieved	
			At the end of 1 year	By Project closing
1	Number of International Exchange programmes	Nil	02	04
2	Number of individual publications in peer-reviewed journals: (a) National (b) International	 Nil Nil	 Nil Nil	 Nil Nil
3	Number of co-authored publications in peer-reviewed journals with names of authors: (a) National (b) International	 10 5	 03 05	 07 09
4	Number of exchange of research students with collaborating institutions: (a) National (b) International	 0 0	 02 01	 05 03
5	Number of exchange of research faculty with collaborating institutions: (a) National (b) International	 0 0	 02 03	 04 06
6	Number of patents obtained	0	01	02

Incremental Project Targets for Centre of Excellence

S. No.	Deliverables	Baseline (2010-11)	Targets to be achieved	
			At the end of 1 year	By Project closing
7	Number of patents filed	0	01	02
8	Number of external R&D projects	12	02	05
9	Number of Industry Chairs secured	0	01	02
10	Number of MoUs with academia: (a) National (b) International	 0 0	 01 01	 03 01
11	Number of MoUs with industry: (a) National (b) International	 0 0	 02 01	 03 01
12	Number of products, research and services commercialized	0	01	02
13	Any other (maximum three)			
(i)	National workshop/Seminar	0	03	06
(ii)	International workshops/seminar/conferences	0	02	04
(iii)	Workshops for skill deployment	0	02	05

STATUS OF EXPENDITURE AS ON 31-05-2014

S.No.	Category of expenditure	Amount Allocated	Amount utilized upto 31-05-2014
1	Procurement of goods (equipment, furniture, books, LRs, software and minor items) and civil works for improvement in research and development facilities	2,75,00,000	Nil
2	Provide Teaching and Research Assistantships for enrolment in Masters and Doctoral programmes in topics linked to economic or societal needs in the thematic areas	50,00,000	1,80,000
3	Collabration with industry for applicable research and product development	25,00,000	Nil
4	National / International collabration for Research and Development activities with Academic Institutions and R & D organisations	50,00,000	9,00,000
5	Enhancing research competence of faculty and knowledge sharing in thematic areas, both within India and abroad	50,00,000	1,50,000
6	Incremental & Operating Cost	50,00,000	Nil
GRAND TOTAL		**5,00,00,000**	**12,30,000**

ACTION PLAN

Center for Nanotechnology

1.	Testing of material properties and will be extended to private and public sector at a pre-estimated cost.
2.	Generate finances through consultancies and R&D projects.
3.	Courses will be offered on self-finance bases to generate finance to support center. Etc.
4.	Number of Panel discussions to be organised with the Industry and R&D people.
5.	Number Workshops/Symposiums/conferences/Courses will be conducted for the benefit of more number of people in the society.
6.	Guest/Invited lectures will be arranged with the eminent people from the Industry and R & D organisations.

Outcome of the CoE

Center for Nanotechnology

- Outcome will be delivered to the industries involved in manufacturing
- The same will be offered to other R & D establishments involved in the research in the above said field.
- Delivering commercial product of Nanocomposite Structures
- Delivering commercial product of Multiscale Composites

Outcome of the CoE (Contd.,)

Center for Nanotechnology

- Improving the performance of the PEM Fuel Cell by using less platinum catalyst
- Delivering the commercial product of 1 KW PEM Fuel cell.
- Any patentable idea arising out of these works will be patented
- Establishment of Incubation Center

Center of Excellence (CoE)

THANK YOU