DST – NFTDC Centre for Materials & Energy Storage Platforms – H2

DST – NFTDC MECSP / H2

DST – NFTDC MECSP / H2

DST – NFTDC Centre for Materials & Energy Storage Platforms (MECSP)' involves **graduation from TRL – 3 to TRL – 7**, wherein multitude of core competencies (differentials) are brought together in a solution path integral. This TRL 3 to 7 translational R & D is predominantly anchored on Material - Process – Product integration and optimization involving and dovetailing many materials and processes in a functional product design as systems.

The Projects are executed under three work packages :

WP#1: Bio Syngas & CNG Reformation System + CHP & BOS for SOFC System
WP#2 : Magnesium – Carbon based H_2 Storage Systems Development
WP#3: Metal – Hydride Sorption Cooling based on Waste Heat / Solar Thermal (CSH) – Materials, Design and Device Development

Three work packages are inked via five institutions focusing on **Materials – Process – Product Integration**.

CONSORTIA

NFTDC|IISc|IITM|IITBBSR|SCTCE

QUOTES

OBJECTIVES

Conduct state of art **TRL 3-7 translational R & D** in Materials to H_2 based Energy Devices in the area of SOFC, H2 Storage and Metal Hydride sorption cooling

Conduct Research & Development of **novel materials** as composites, graded materials, mixtures, materials + catalysts around the well – proven base materials to meet the figure of merit for **SOFC, H2 storage and Metal – Hydride sorption cooling**

OBJECTIVES OF THE CENTRE

Develop cost effective processes for synthesis, deposition, thermal treatment, thermo-mechanical processes, joining, precision manufacturing and assembly for enabling both **materials development** and their **scale – up** on one hand and **materials to products** manufacture on the other

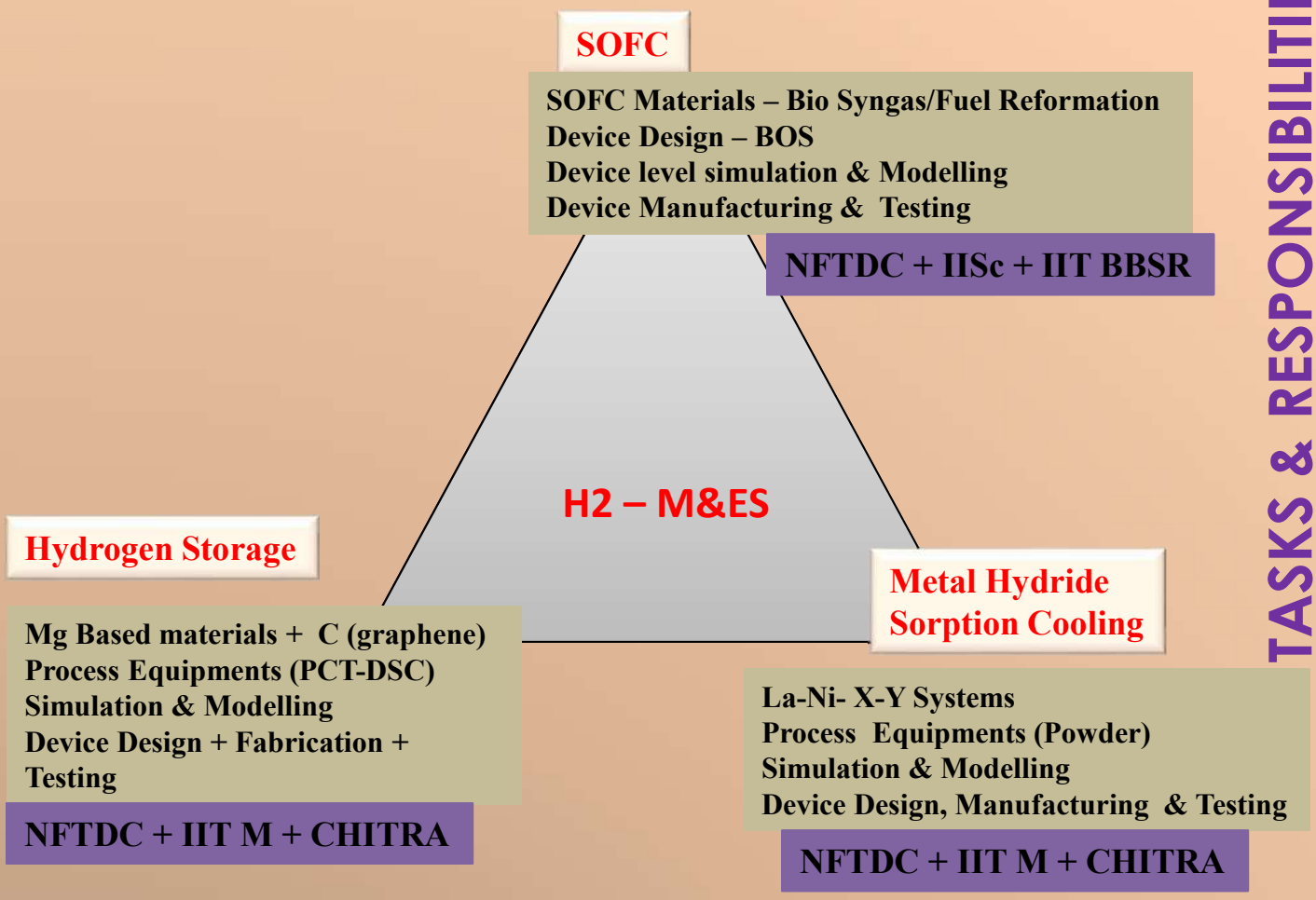
Develop innovative designs and design for manufacture **(DFM & DFA) of energy devices** and conduct extensive simulation and modeling to distil high performance design configurations;

Design, develop and fabricate **cost effective process equipments** for materials synthesis and manufacture of devices

Render device designs in a **process – product integration and optimization paradigm** in TRL 4-6 translation to manufacture prototypes;

- **BOS** and **BioSyngas & CNG Reformation** and undertake larger system level development and eventually graduate to TRL -7 pilot production of SOFC devices.
- **Develop functional test – beds and conduct long duration testing of the device**; integrate the device in field level applications;
- **System level modeling and simulation** to iterate the designs to optimize the performance parameters of efficiency, cycle life, ease of manufacture and cost metrics;
- **Upgrade pilot plants and establish pilot plant for scale – up of advanced materials** RE oxides, catalysts, RE alloys to ensure supply chain based on indigenous RE materials;
- **Study techno – economics for feasibility** of large scale product manufacture and market acceptance;
- To **conduct focused workshops on SOFC, H2 storage and Hydride Sorption cooling.**
- To **train the next generation researchers in SOFC, H2 storage and Hydride Sorption** and develop system level thinking and engineering
- To **interact with energy companies** in India and abroad to **translate product to business**

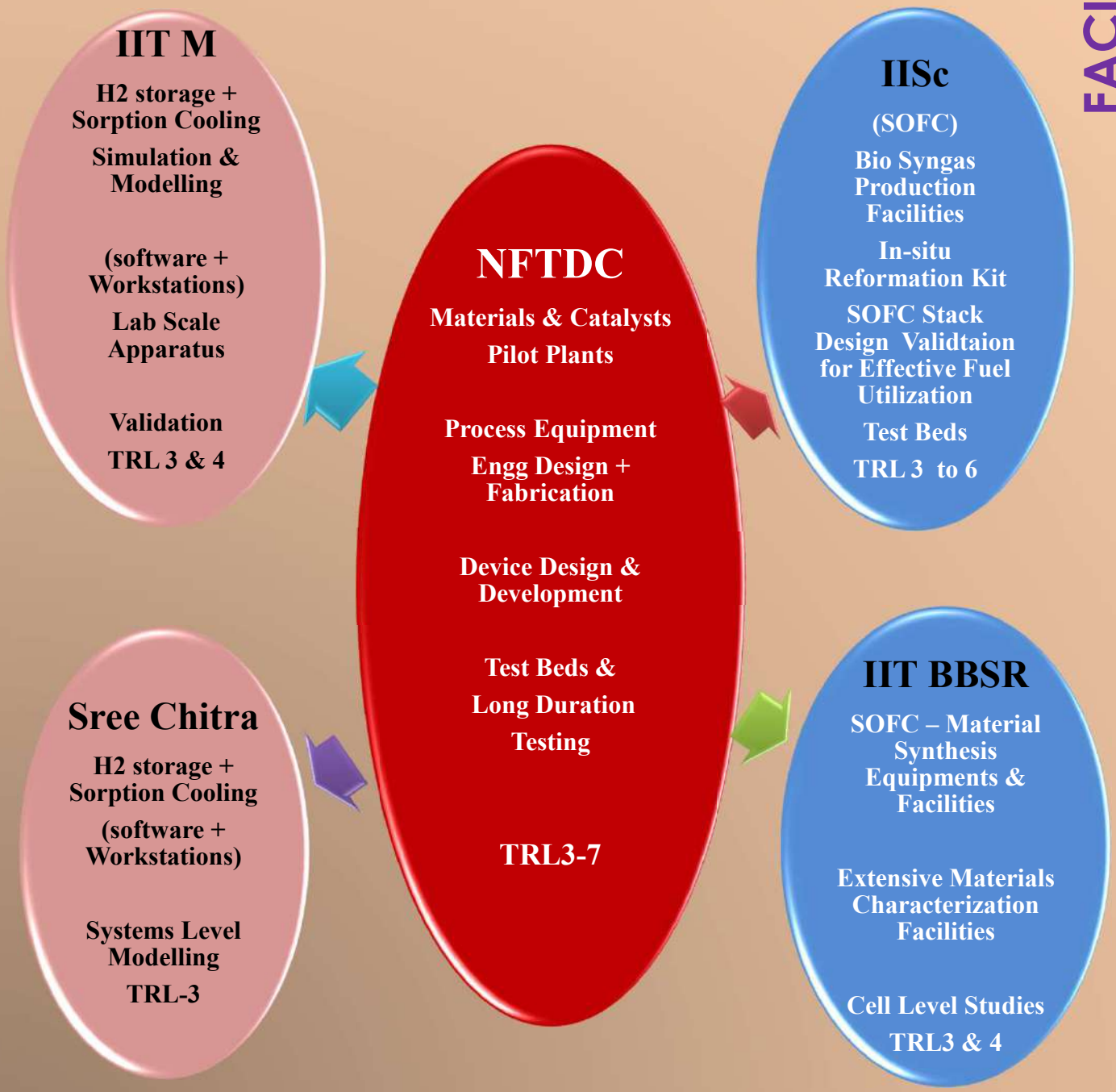
TASKS & RESPONSIBILITIES



Macro Tasks + Shared Responsibilities

Four centres, **IISc, Bangalore, IIT M, Chennai, IIT Bhubaneswar and Sree Chitra Thirunal College of Engineering, together with NFTDC** have appropriate core competence, decade(s) of experience, infrastructure facilities and proven track record to handle the problems chosen in this consortium.

FACILITIES & TASKS



Reformation, CHP & BOS for SOFC System

WORK PACKAGE -1

WORK PACKAGE – 1
SOFC Systems

NFTDC | IISc | IIT BBSR

Target Device

- Bio Syngas reformation kit; CNG reformation kit
- 1 kW & 5kW SOFC stack as CHP System
- BOS >> Power Electronics (DC-DC & DC-AC)
- Cell: 0.9 -1.0 V & 60 Watts (100 x 100 mm)

Materials & Components

- Porous SS / Ni metallic foam anode support (area 80x80/100x100 mm)
- NiO/GDC (Gadolina doped Ceria) anode & LSCF cathode
- GDC as electrolyte & YSZ as interlayer
- Stainless Steel as interconnects.
- Active brazing materials (TiCuSil); Silicate insulation seals

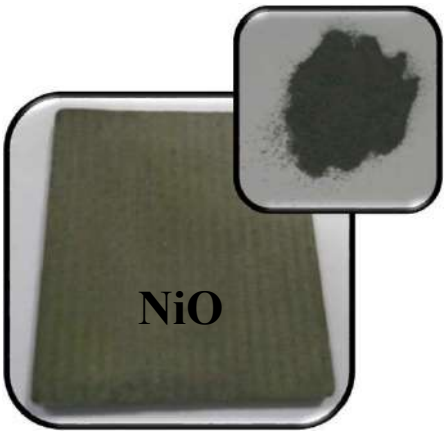
Apparatus:

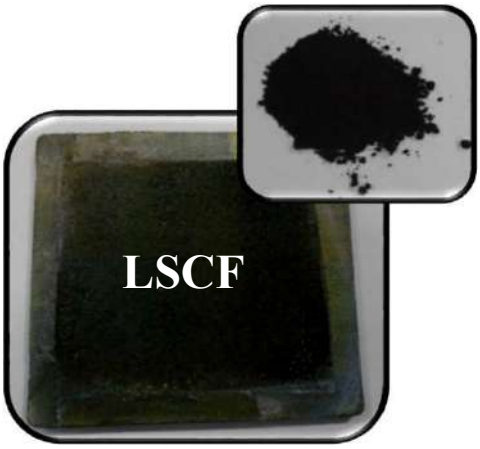
- Modification of **Plasma Gun** for liquid + solid spray deposition
- Design and Development of **Ink Jet Printer nozzles**.
- SOFC Stack level **Test Bed** for fuel optimization & SOFC performance

- **Integrated SOFC BOX with all of above connected to Demonstration Load`**

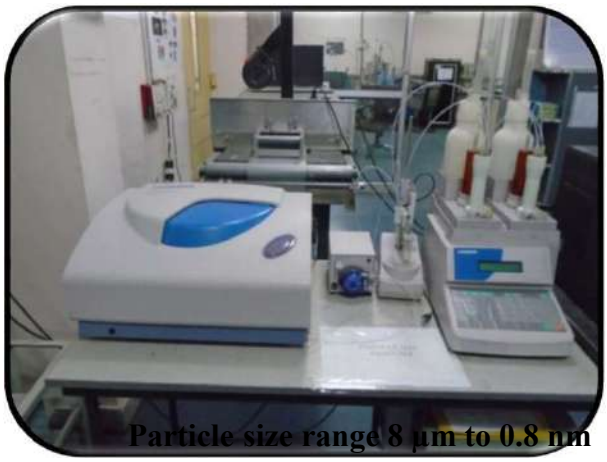
WORK PACKAGE -1

Input Powders (15-20 kg/batch) Synthesized in NFTDC





Particle Size Analyzer



Particle size range 8 µm to 0.8 nm

Facilities: NFTDC >>Powder Production & Heat Treatment Processes

Jet mill >> powder Preparation

- Vacuum >> **10^{-5} mbar**
- Max T >> **1500°C**

HV-HT Furnaces for heat treatment

- Particle size 2 micron
- Batch size up to 8 Kg

Helium leak detector

- Leak detection to $1X10^{-12}$ m.bar.lit/sec

WORK PACKAGE -1

Facilities: NFTDC >> SOFC Cell Fabrication

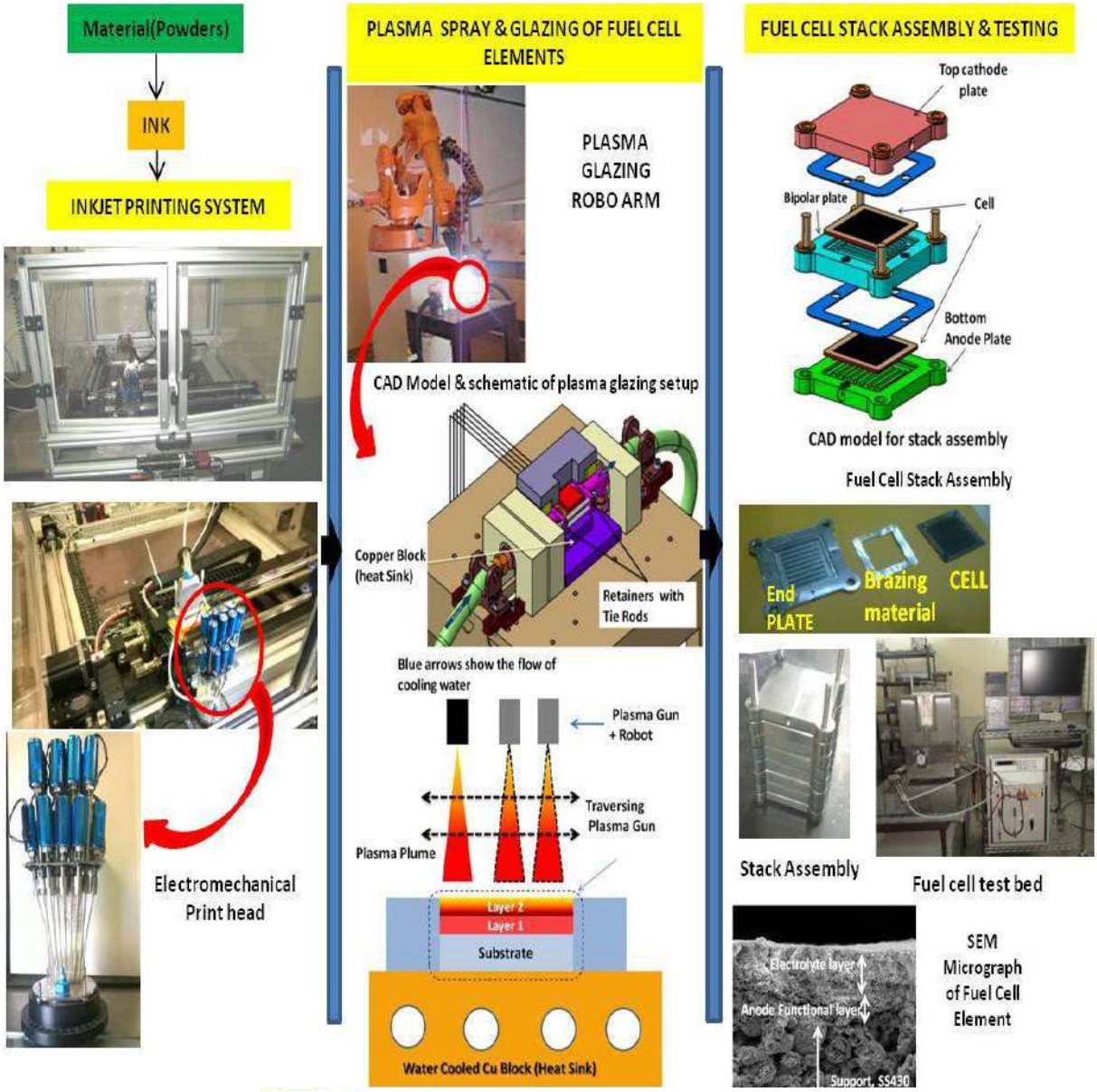
Thin film & micro manufacturing

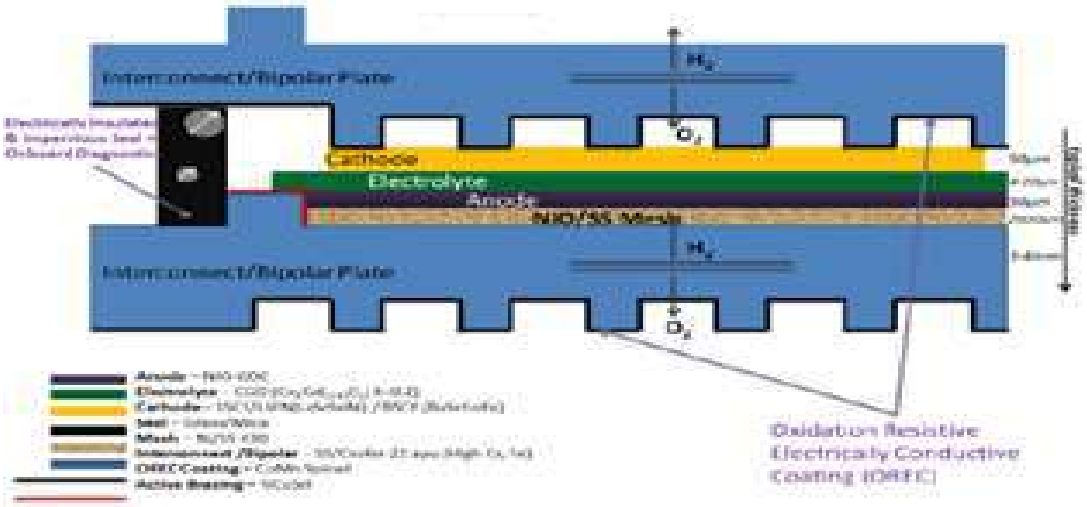
Ink Jet Printer - 16 nozzle assembly
(Deposition : 0.5 µm / layer)

Plasma Spray Equipment + Robotic Arm

Plasma Gun Nozzle with Liquid Precursor or
Powder Spray Deposition (2 – 5 µm / layer)

Process Flow from Materials to SOFC Stack >> NFTDC





Facilities: IISc >> Biomass to Syngas Fuel to SOFC Stack

WORK PACKAGE -1

Inputs to Biomass Gasification

1 kW Biomass Gasification System

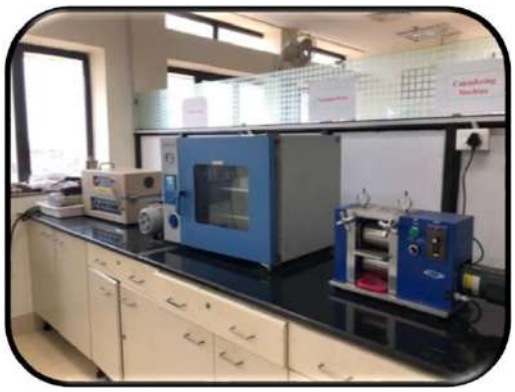
10 kW Biomass Gasification System

SOFC Test Bed

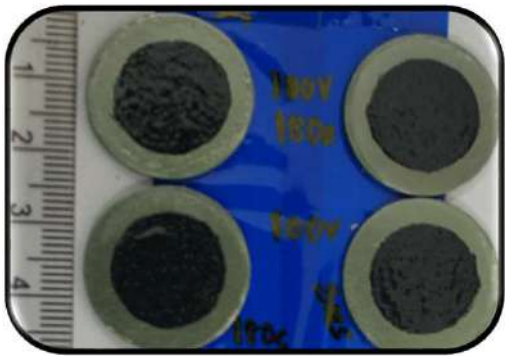
Gas Chromatograph

Facilities: IIT BBSR >> Materials to Button Cells & Characterization

WORK PACKAGE -1



Cell Fabrication Set-up



Button Cells

Testing Facility

H2 Storage – PCT Apparatus

DSC / TGA Equipment

Electrochemical Station

Magnesium – Carbon based H_2 Storage Systems Development

WORK PACKAGE -2

WORK PACKAGE – 2
Hydrogen Storage Systems

NFTDC | IIT M | Sree Chitra Thirunal

Target Device:

- Storage Device Biomimetic Design; Modeling & Optimization
- Adiabatic Solutions
- Fabrication (35 – 50 grams of H_2) with heater (max 300°C)

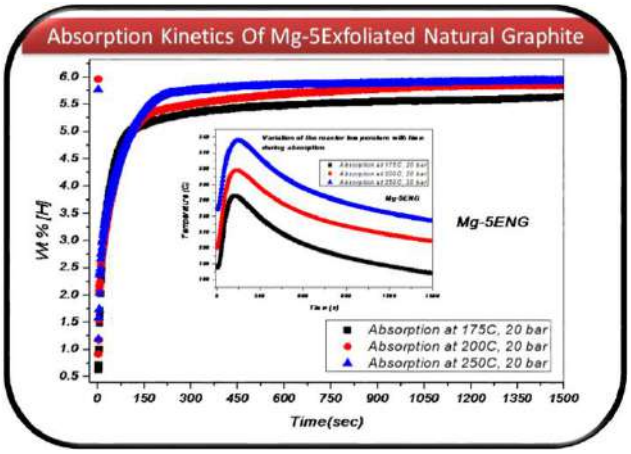
Materials:

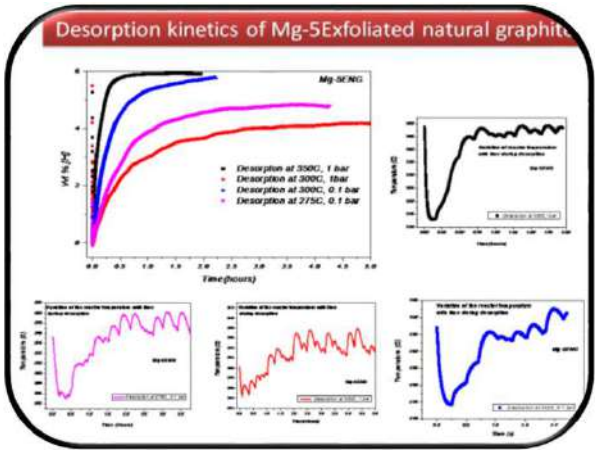
- Mg + Graphene (1 - 5 wt%)
- Mg + Graphene + Dopants (B, N, P)
- Mg + Expanded Graphite (5Wt%) + dopant (B, N, P)
- Mg + Intermetallics + Carbon (Doped Graphene or doped ENG)

Apparatus:

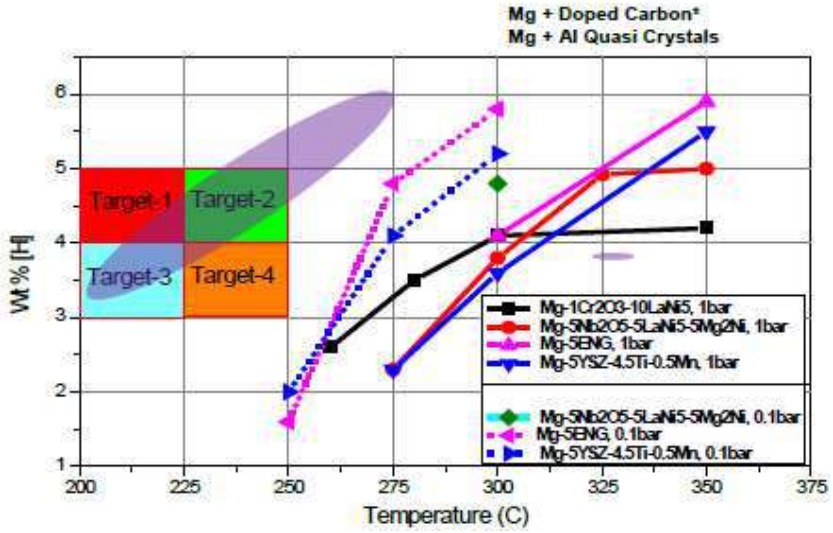
- Microwave – plasma based Graphene Production Apparatus
- PCT – DSC

Sample Results of Magnesium – Natural Graphite System

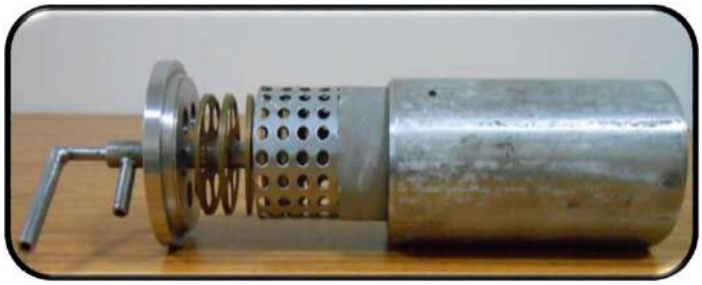




Magnesium – X system: Present Scenario vs Target to be achieved

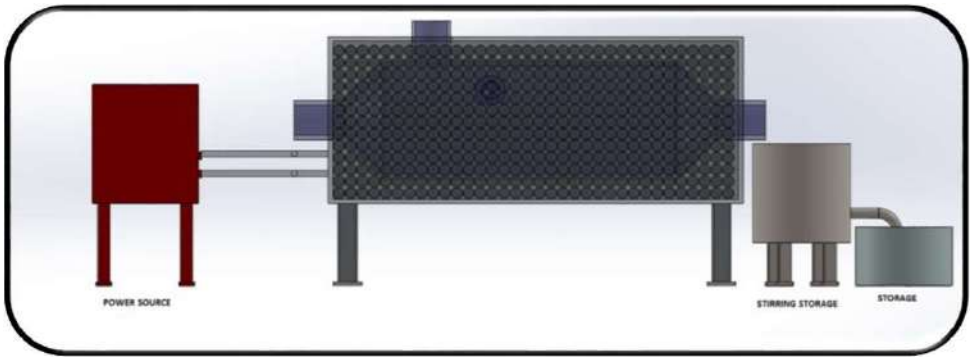


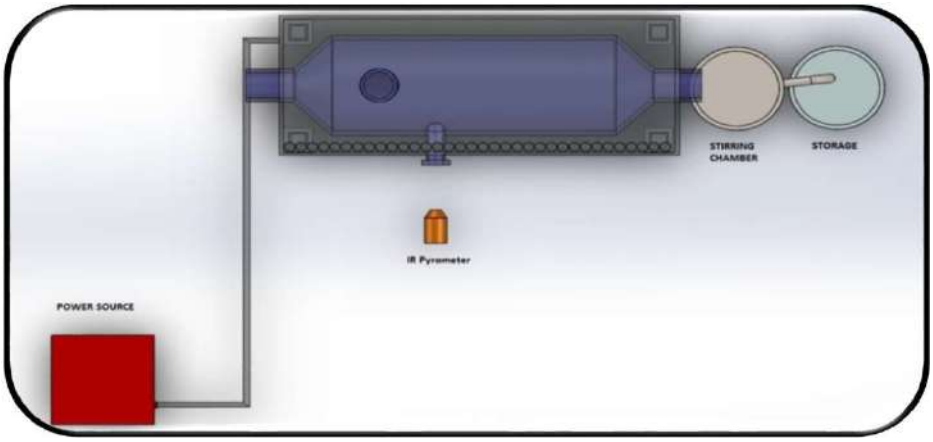
First Iterations of Experimental Hydrogen Storage Devices



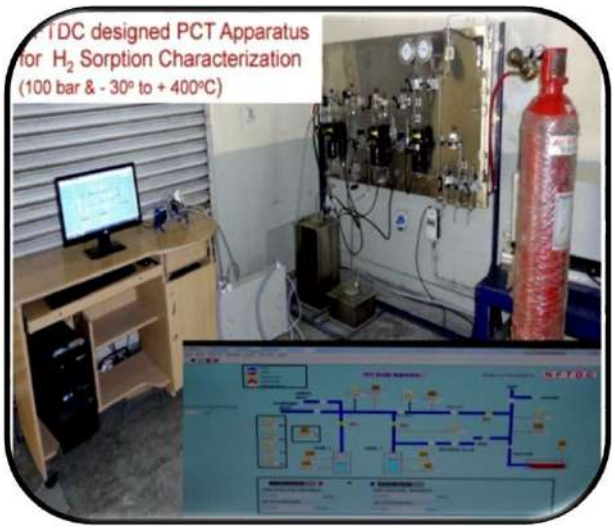
WORK PACKAGE -2

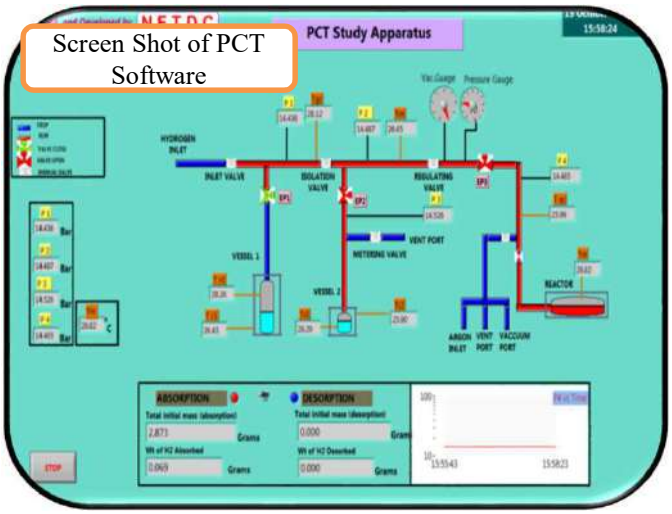
Model of Equipment for Graphene Production – under design at NFTDC





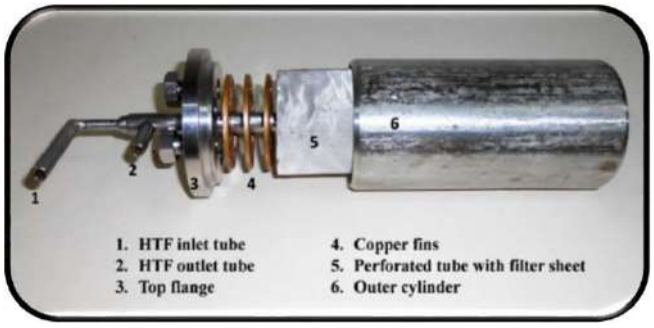
PCT Apparatus and User Interface developed at NFTDC



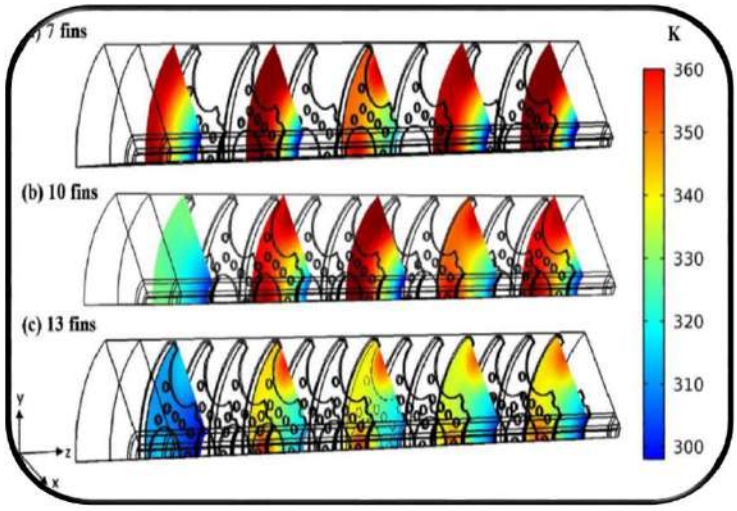


Facilities: IITM >> H_2 Storage Materials to Device

Hydrogen Storage Facility



H2 Storage Reactor Prototype - 1



Temperature Distribution model of fins used in Reactor

Prototype – 2 after optimizing Thermal design of Reactor

Metal – Hydride Sorption Cooling based on Waste Heat / Solar Thermal (CSH) – Materials, Design and Device Development

WORK PACKAGE -3

WORK PACKAGE – 3
Metal – Hydride Sorption Cooling

NFTDC | IIT M | Sree Chitra Thirunal

Target Device

• Biomimetic Design of Cooling Device: Carrier; H_2: 2mm dia; Waste Heat: 3-6 mm dia; Device: diameter = 50 -80mm; length = 250 – 400mm

• Prototype Device with twin cartridges (HT & LT) coupled to waste heat source & $1m^3$ volume to be cooled from 40°C to 15°C as demonstration.

•Two prototype configurations >> cabin and automotive application space.

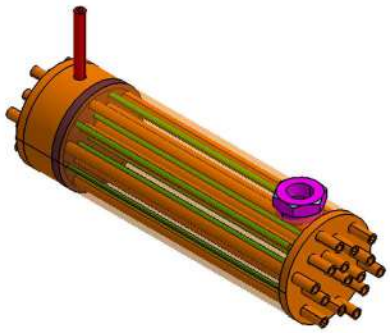
Materials

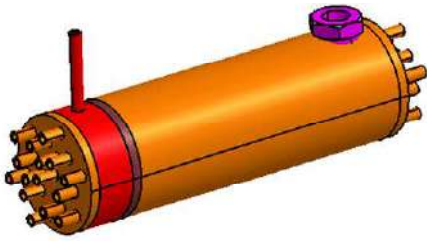
- La – Ni – X (Al, Ce, Fe); 4 Compositions;
- per cartridge: 1.5 - 1.7 kg HT and 0.8-1.0 kg LT

Apparatus

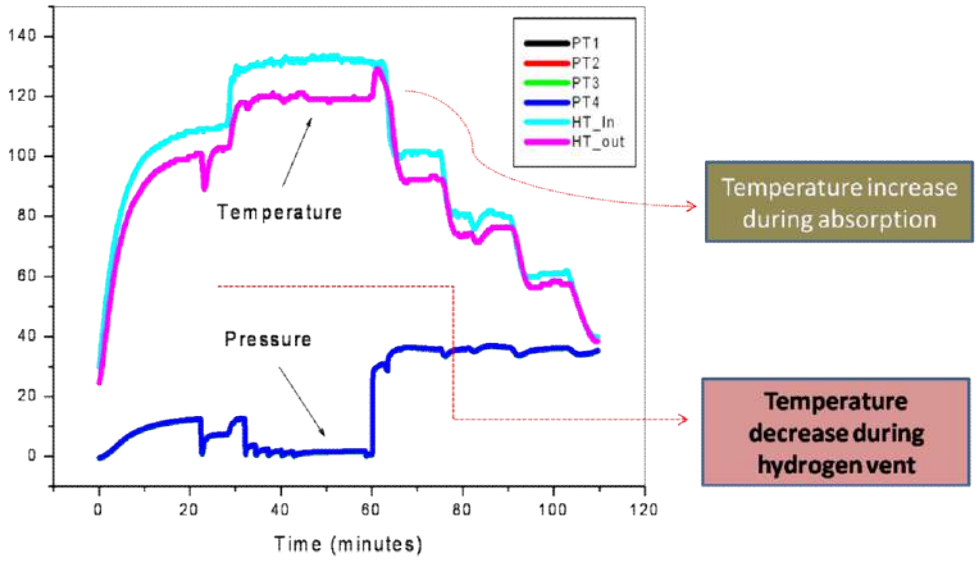
• Centrifugal Powder Preparation Apparatus for 1 kg powder/run.
Attributes: T 2000°C max); Induction heating; Vacuum + Ar;
Multi-layer crucibles to hold & spin liquid melt; ceramic nozzles
Run Time 30 minutes charge to charge; rpm 300 – 500;

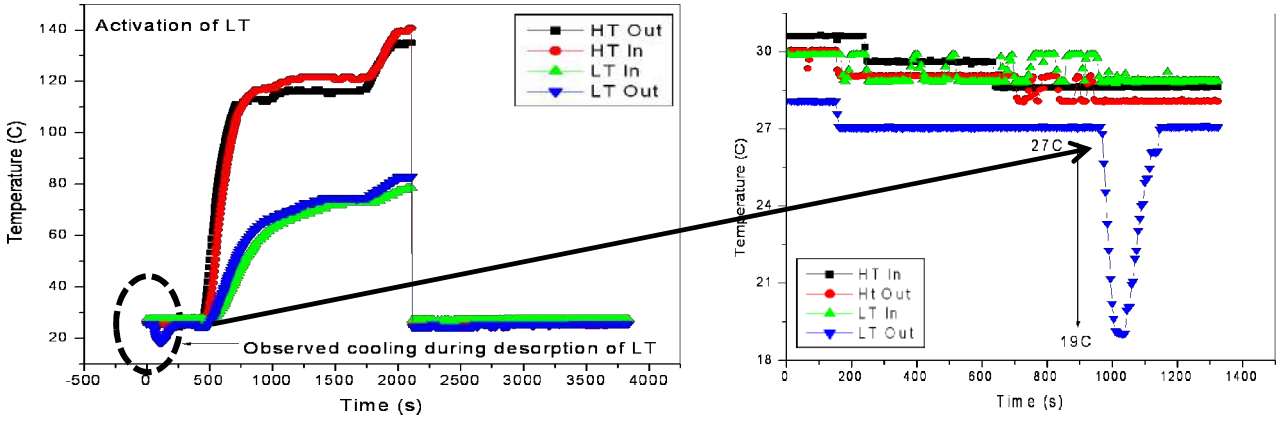
Biomimetic Design of Cooling Device - First Iteration





Sample Results of HT – LT System using Metal – Hydride





T - decrease 8°C per unit air volume in circulation per cycle

Facilities: IITM >> Powders to Sorption Cooling Device & Characterization

Planetary Ball Mill

Attritor Mill

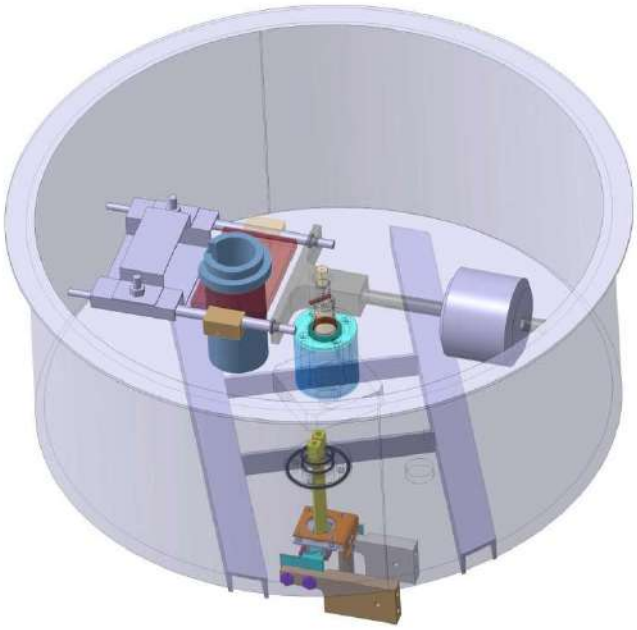
Static & Dynamic PCT Measurement

Effective Thermal Conductivity Measurement

Hydrogen Storage Experimental Facility for Metal Hydrides

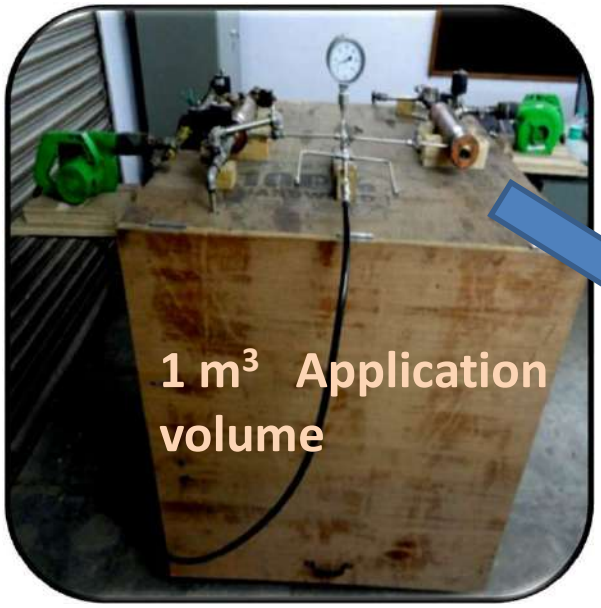
Facilities: NFTDC >> Materials to Device

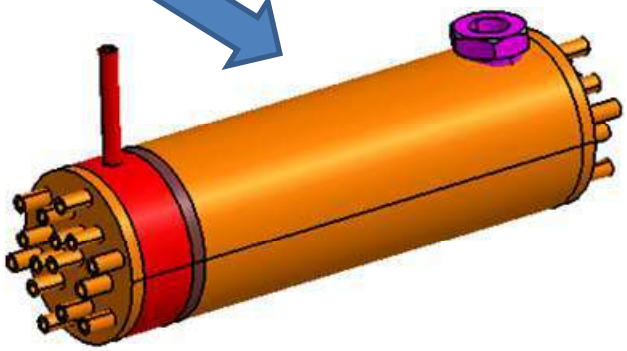
10 kW Induction Melting System



Vacuum Centrifugal Caster – Concept Design

Attritor Mill

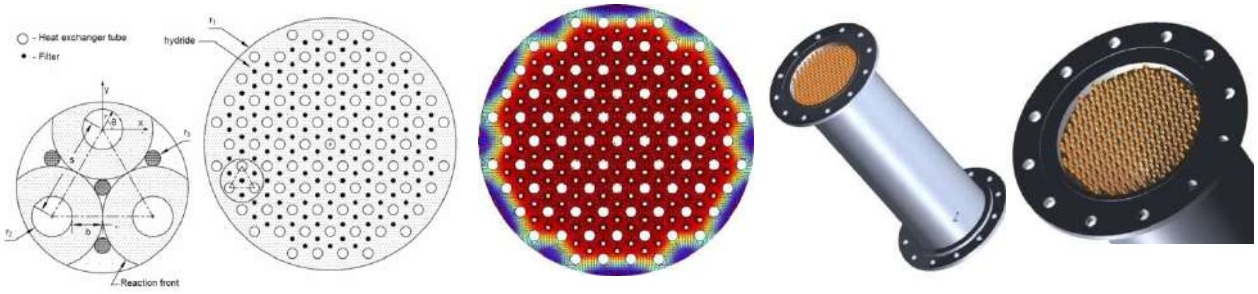




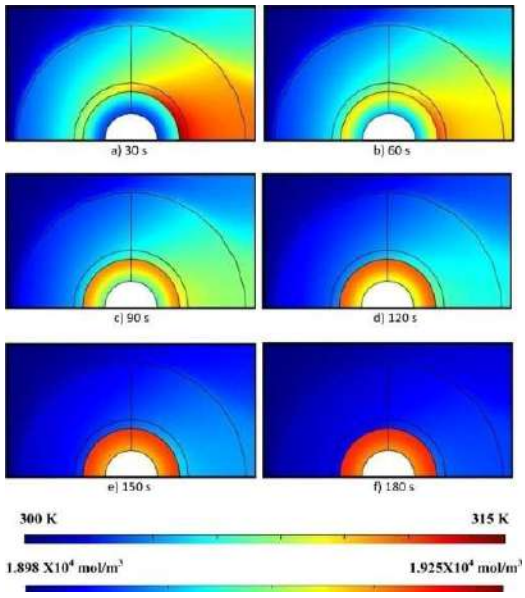
1 m³ Prototype of Metal – Hydride based Cooling Set-up (concept -1)

WORK PACKAGE -3

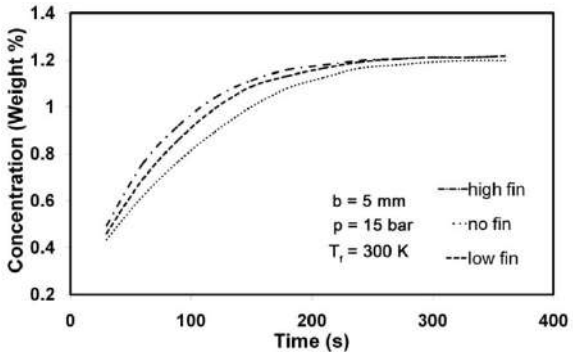
Modeling & Simulation: Sree Chitra Thirunal College of Eng



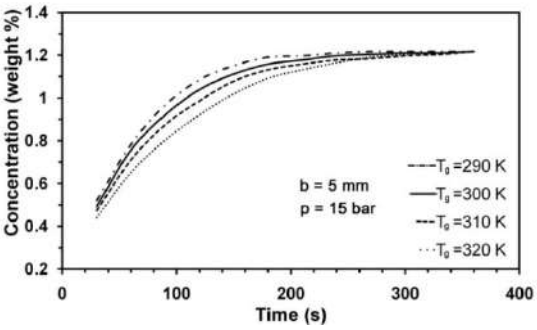
Numerical Study of Metal Hydride Storage Device with Embedded HX Tubes



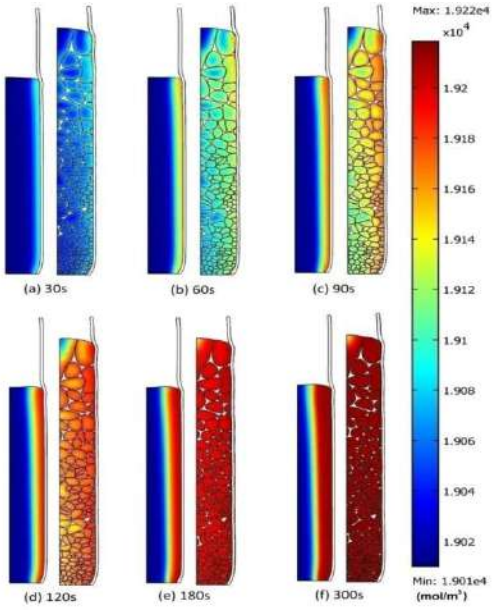
Formation of hydride inside tubular storage within the air stream during absorption



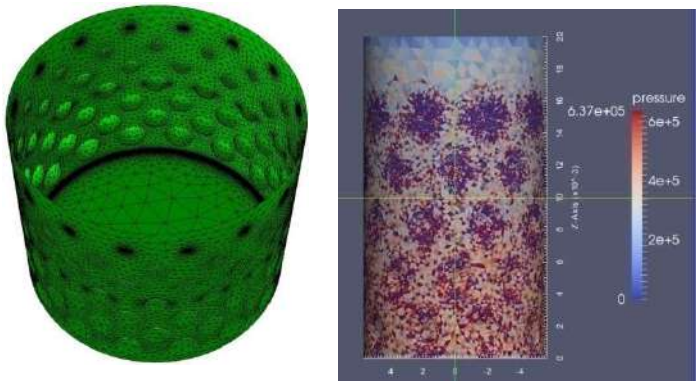
Effect of external fins on rate of hydride formation



Effect of air temperature on hydride formation



Spatial variation of concentration in MH bed with Aluminum Foam (p=15 bar, T_f=300 K)



Wall Stresses in Metal Hydride Container with Dimples

Principal Investigator NFTDC, Hyderabad	Dr. K. Balasubramanian	
Co – PI IISc, Bangalore	Prof. S. Dasappa	
Co – PI IIT M , Chennai	Prof. MP Maiya	
Co – PI IIT Bhubaneshwar	Dr. Soobhankar Pati	
Co – PI Sree Chitra Thirunal College of Engineering, Thiruvananthapuram	Prof. G. Mohan