R& D Newsletter

Indian Institute of Technology Roorkee

Inaugural Issue

Vol. I, April 2017

MESSAGE FROM THE DIRECTOR

"I am happy to learn that our SRIC office has decided to bring out a quarterly R&D Newsletter. As some of you would know, we used to have an R&D magazine more than a decade back. I am hoping that this time around the sustainability of the Newsletter will be a key objective while designing its structure and contents. So many excellent R&D activities are happening in our institute. The Newsletter will go a long way in disseminating them both inside as well as outside our campus. I wish the R&D Newsletter a great readership, as well as circulation."

Ajit Chaturvedi

FROM THE DESK OF DEAN, SRIC

Welcome to the inaugural issue of the R&D Newsletter of IIT Roorkee.It was decided to start a quarterly R&D newsletter of IIT Roorkee for effective dissemination of current R&D activities amongst faculty members and also with the academia and industry outside. This issue highlights recently started research projects with effect from 1st January, 2017, sponsored by several funding agencies and ministries. IIT Roorkee has actively participated in the recently launched Industry-Academia programme like Uchchatar Avishkar Yojana and also in the research projects with an aim to combat some grand challenges with substantial impact in national and global scenario. We hope that in the upcoming issues of the R&D Newsletter we shall be able to incorporate other dimension of Scientific research as well as Technology incubation undertaken at IIT Roorkee. We wish to publish this newsletter quarterly encompassing all the new developments.

Manoranjan Parida

Recently Registered Research Projects

Sustaining Himalayan Water Resources in a Changing Climate (SusHi-Wat)

Sponsor : Ministry of Earth Sciences India and UK Natural Environment Research Council

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The project proposes to investigate how water is stored in, and moves through, a Himalayan river system (the interlinked Beas and Sutlej catchments) in northern India at daily to decadal timescales and to use the resulting insights to develop and test a robust model of the whole system that can be used to inform current and future decision making to support the sustainable development and management of the region's water resources. The project will address user requirements centered on understanding and managing the effects of climatological and hydrological variability and socioeconomic development on delivery of critical ecosystems services, notably the irrigation water supply-hydropower generation-flood risk management nexus. The results will be used to inform decision-making and support the sustainable development of India's water resources and hence long-term socioeconomic growth.

Development of large scale bioethanol production technology from lignocellulosic biomass for small and micro enterprise venture.

(project under Uchchatar Avishkar Yojana)

Sponsor : Ministry of Human Resource Development, Ministry of New and Renewable Energy & Sahaj Inclusive Opportunities India Pvt. Ltd.

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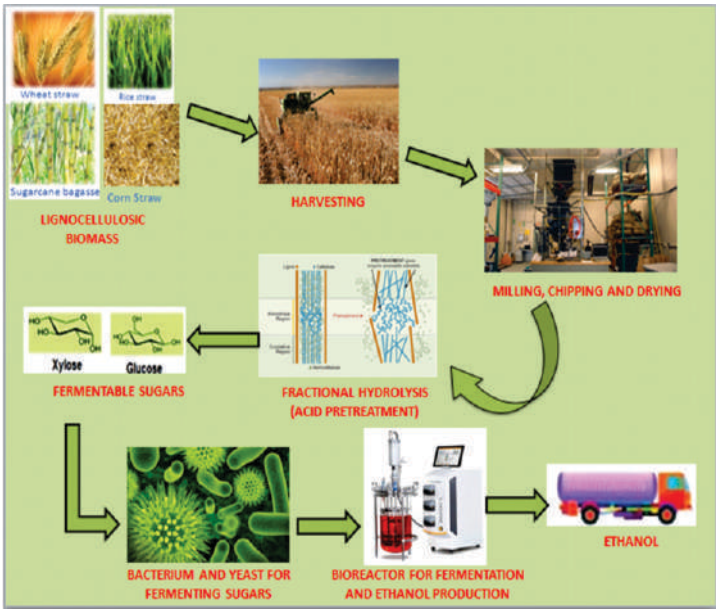

This project is a joint research initiative between Govt of India (MHRD & MNRE) and Industry under UAY (Uchchatar Avishkar Yojana) scheme. This project is mainly focused on processing of lignocellulosic biomass and convert to ethanol in two major stages. The first stage is to convert biomass into fermentable sugar fractions e.g. pentose and hexose rich fractions separately by a process called fractional hydrolysis and the second stage is to convert these sugar fractions into ethanol in one step called sequential-co-fermentation using two microorganisms simultaneously. We target to convert around 90% of available sugars in the raw biomass to fermentable sugars and subsequently to ethanol with more than 90% of theoretical yield at high productivity.

Application of Probiotic Bacteria for Enhancing Nutritional Status of underutilized millets of Uttarakhand

Sponsor : Uttarakhand Council of Science and Technology

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Deficiencies in nutrition inflict long-term damage to society. Nutrition-deficient individuals are more likely to have infectious diseases such as pneumonia and tuberculosis due to weak immune system.

Thus, Under-nutrition leads to a higher mortality rate. On the other hand, over-nutrition also has severe consequences.Although, there are many ready to eat nutritious food products are available in the market but they can't be easily accessible to remote areas of country. Low economic families Due to low socio-economic conditions, poor families can't access to these costly products. These poor families prefer their homemade preparations by using local crops.

Millets are commonly grown crops in Uttarakhand. These crops are equally nutritious to major crops like wheat, maize etc. They are cheap and easy to grow. Millets are rich in minerals and fibres. Due to their good nutritional profile, millets can be used for prevention of both under-nutrition and over-nutrition. They can provide adequate nutrition to the society. These crops may be incorporated to develop a nutritious food product to benefit the community.In this project we shall use probiotic bacteria to enhance the nutritional status of underutilized millets viz. Finger millet and Barnyard millet, of Uttarakhand. These millets are rich in dietary fibres making them a good option for being used as prebiotics. Since these millets are gluten free, we shall find healthy alternatives of gluten so that these millets can be converted into gluten free probiotic bread.

SwachhNeer - Une vie Meilleure: Combating water issues through Indo-French networking

Sponsor : Indo-French Center for the Promotion of Advanced Research

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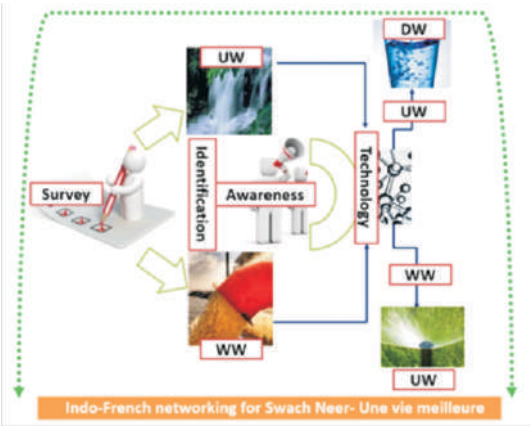

In this project four Indian organizations i.e., UPES Dehradun, IIT Roorkee, NEERI, Nagpur and Venza Water Management. Solutions as well as four French organizations i.e, Montpellier2 University, Université de Poitiers, Université de Rennes1 and Waste et Water SARL are involved. The project aims to combat water issues through Indo-French networking. Main objectives of this project are:

Data collection and review for identifying water issues

Selection of treatment technologies based on criteria required to solve identified issues

Coagulation-fragmentation models: Well-posedness, Numerical approximations and Asymptotic analysis

Sponsor : Science & Engineering Research Board

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A model for the dynamics of a system of particles undergoing simultaneously coalescence and breakup is considered as coagulation-fragmentation equation. Each particle is being assumed to be fully identified by its size. The first aim of the research is to show the existence and uniqueness of weak solutions to the corresponding coagulation-fragmentation equation for large classes of unbounded coagulation and fragmentation rates which can include singular coagulation and fragmentation kernels simultaneously. The next goal is to develop the convergence analysis of some of the numerical schemes for solving such a model. In order to validate our mathematical results, some numerical examples will also be demonstrated. Moreover, we study the asymptotic behavior of time-dependent solutions to the coagulation-fragmentation equation. In this model, the coagulation process is nonlinear while the frag mentation process is linear. In 1988, a nonlinear frag-mentation is introduced which can control the coagulation process so that the mass conservation property of solutions can be maintained. One of the major missions of the proposed project is to show the existence and uniqueness of solutions to the nonlinear fragmentation model. In addition, the regularity and mass conserving property of solution is also addressed. Furthermore, some of the numerical techniques such as fixed pivot technique, cell average technique and finite volume scheme will also be discussed to solve nonlinear fragmentation problem which are already well studied for the linear fragmentation equation.

Solar Energy Assisted Multi-effect Distillation System to Produce Drinking Water in India from Contaminated Water

(Project under IMPRINT program)

Sponsor: Ministry of Human Resource Development & Ministry of Urban Development

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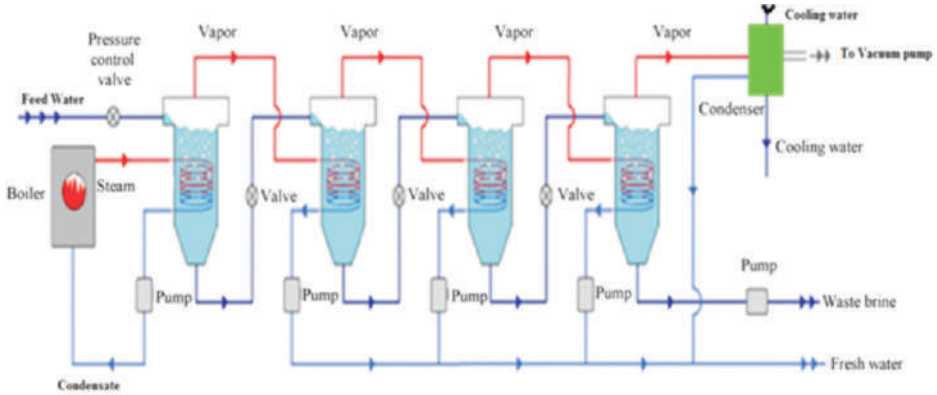
Population in the urban area is increasing rapidly; the decentralized drinking water generation system is in great demand. Water supply from centralized systems needs additional household purification units to make the water drinkable. Water scarcity is a global issue and problem will increase many folds in the near future. Physical performance of two



Schematic diagram of Multi-effect distillation system

coupled technologies like multi-effect distillation (MED) and solar PV cell electricity generation unit would be implemented to produce drinking water from mainnly contaminated groundwater.

This coupled technology would be designed to produce drinking water from contaminated ground/surface water by arsenic and fluoride ions and water from other water bodies, e.g. river, rainharvested water, and sea. It has some advantages over other technology like PV-electrical generation coupled reverse osmosis (RO) system, such as less cost involved in the installment, operation and maintenance. Further, its performance is almost independenttothe feed water quality. The study is aimed to perform modeling and simulation for small scale roof top multi-effect distillation system to obtain the best design parameters to reduce the cost of water treatment.The proposedroof-top MED systemwill produce 1.5-2.0m^3 drinking water/day.

Strain evolution during thermo-mechanical loading of a crack in a microstructure engineered NiTi based shape memory alloy using Digital Image Correlation and Electron Back Scatter Diffraction

Sponsor: Science & Engineering Research Board

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Towards understanding the evolution of strain field ahead of a crack tip and enhancing the fracture toughness of a NiTi based shape memory alloy (SMA), a novel microstructure engineering method along with the macroscopic and microscopic characterization of the strain fields are proposed. Owing to the large shape recovery strain, NiTi based SMA have been widely used in both medical and engineering applications. Successful implementation of SMA as actuators or cardiovascular stents requires a thorough understanding of the fracture behavior and ways to improve the fracture resistance. To avoid the crack growth during cooling under a constant applied load, a novel microstructure engineering method to generate high fraction of low energy special boundaries is being developed an example of crack deflection at such low energy boundaries are provided in the figure. Thermo-mechanical simulation of the deformation in the two-phase filed are employed to engineer the microstructure. Digital image correlation (DIC) will be used to probe the displacement/strain field during deformation, phase transformation and fracture. Along with the macroscopic strain fields obtained from DIC, a high resolution electron back scattered diffraction (HR-EBSD) technique would be used to map the microscopic strain fields. Fracture behavior analysis by combining these two techniques, will strengthen the scientific understanding of crack initiation and propagation and technologically benefit the engineers to design new materials and devices.

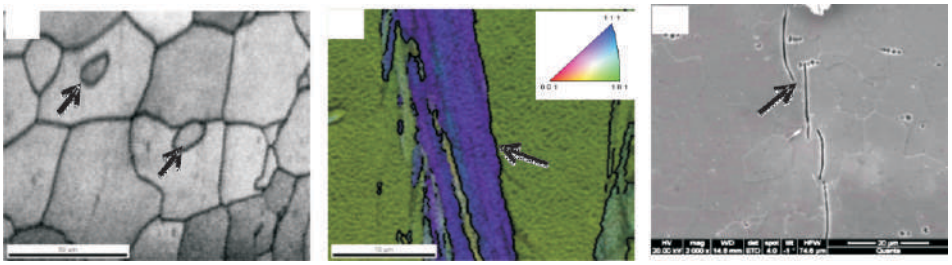

Figure (a) Formation of twin boundaries after thermo-mechanical cycling, and (b) special boundaries highlighted in the inverse pole figure map (c) crack deflection at the location of those special boundaries

Creation of Common Research and Technology Hub: Microwave Absorbing Materials and its Characterization Facilities for Social, Stealth and Electronic Applications (project under CRTDH scheme)

Sponsor: Department of Scientific and Industrial Research

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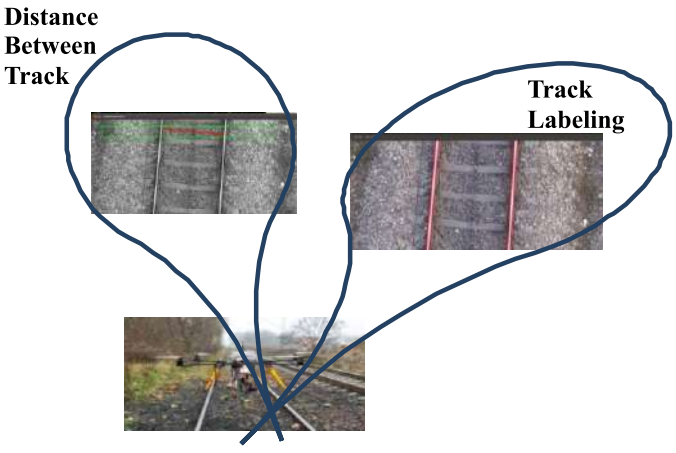
Microwave absorbing materials are a potential candidate for various applications in the commercial as well as in defense purposes. The inevitable use of microwave absorber is in the stealth, where the radar cross section of the defense equipment can be reduced through the microwave absorber coating. The seamless integration of high speed digital communication systems and the ever increasing usage of the mobile phones demand the shielding of harmful electromagnetic radiation which has an adverse effect on the human body. These materials are specially designed to suppress the reflection of electromagnetic energy from the surface by dissipating the magnetic and/or electric fields of the wave into heat. Stealth technology now focuses on development of efficient Microwave Absorbing Materials (MAMs) of light weight, less coating thickness, broad bandwidth of absorption along with cost effective raw materials and manufacturing method. In general, the mechanism of radar wave absorption depends on the appropriate impedance match among the magnetic and electric properties of the materials. The designing of MAM can be tailored by selecting appropriate material combination having both dielectric as well as magnetic elements. Still it is a challenge to obtain a cost effective material which can work for a broad frequency range i.e. from 2-18 GHz. Therefore, this project aims to setup the state of art facilities for characterization of microwave materials with Radar Cross Section and EM wave radiation measurements for benefit of MSMEs with R & D intervention.

Development of Computer Vision Approach for Railway Track Health Monitoring with Drone

Sponsor : RailTel IIT Roorkee Centre of Excellence in Communications

The growth in rail accidents in the Indian railway industry has led to the need of the development of a railway track monitoring that assures real time safety at low cost. There is a need to develop railway tack identification and monitoring system using Drone. The project proposes a track inspection technique based on automated video analysis technique for data acquired from the drone. The technique is aimed to replace or minimize manual visual checks performed by the railway engineers for track inspection.



Development of Fusion Approach for Retrieving High Resolution Soil Moisture Map from Low Resolution SCATSAT-1 data

Sponsor: Indian Space Research Orgaization

Soil moisture (SM) is an important variable that had a major role in energy and water exchanges at land surface/atmosphere interface and in water resource management. It is necessary to develop a satellite based

System/algorithm for estimating the soil moisture in regional and global level. There are several existing approaches to retrieve SM from different SAR data such as PALSAR, PALSAR 2, RADARSAT 2 etc. With the recent launch of SCATSAT-1 that operates at 13.515 GHz (Ku band) with a spatial resolution of 50 Km, it is important to develop an algorithm that retrieves SM from such a low resolution and high frequency data. The proposed project has two main objectives: (i) Estimating soil moisture from the newly launched SCATSAT-1 and (ii) Improving the spatial resolution of the retrieved SM by fusion based techniques with optical/microwave data.

Low cost technology for waste water treatment for domestic and industrial applications

Sponsor: Department of Science & Technology

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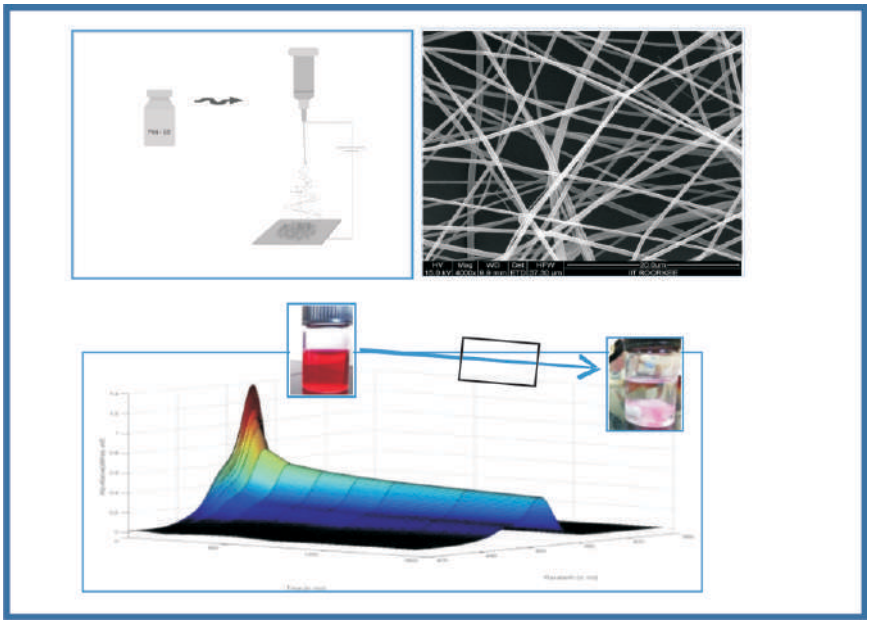
Clean water is of utmost importance for the wellbeing of large population of the country. This is also important for safe domestic water supply. There exist several water purification technologies but such systems are either inappropriate or too expensive to be used by the rural population and also in large scale. Usually in the rural areas, people purify their drinking water using traditional methods such as using cloth, clay, plant materials etc which removes the visible impurities from water collected from the local source. In addition to this, several chemicals are used to treat the water among which chlorination is the most common. But such filtration systems are not effective in the complete removal of carcinogenic dyes from water.

In this regard, novel and smart nanofiber based adsorbent could be a potential alternative for successful removal of dyes from water due to its large surface area and porosity. Here, we propose synthesis of novel graphene based composite nanofibers by electrospinning method and their application for degradation of xanthenes based dyes. These dyes are commonly used in different optoelectronics applications and as a coloring agent in various industries including cotton, silk, wool, fibers leather etc. These large area reusable graphene nanofibers will provide a scalable and novel route for photocatalytic degradation of carcinogenic dyes from industrial water.



depicting the key features of the project

Smart Bipolar Membrane Manufacture for Sustainable Zero Discharge Technology (project under UchatarAvishkarYojana)

Sponsor : Ministry of Human Resource Development, Ministry of Environment & Forests and Permionics Membranes Pvt Ltd.

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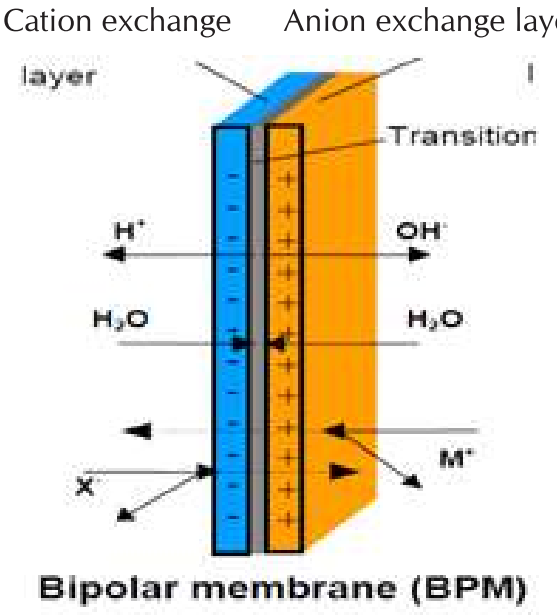

Bipolar membrane (BPM)

Electrodialysis using bipolar membranes (EDBM) are becoming increasingly popular in simultaneous production of acid and alkali from an electrolyte solution. EDBM is economically and environmentally beneficial and can be attached with other process such as ion exchange process, extraction, adsorption etc. Power consumption, durability (wide pH range), water transport/splitting at the interface followed by desorption, heat generation and cost are major concerns limits its wide applicability. This project is directed towards overcoming few challenges associated with the intermediate catalyst layer sandwiched between cation/anion selective monopolar membranes. Role of interface hydrolysing water is not fully understood and two oppositely charged membrane layers seems to form a neutral layer preventing ion transport. Usually an electron rich co-ordination compound at the interface seems to perform better in reducing energy consumption. Therefore, tailoring of functional groups of the base polymer, selection of co-ordination compound at the interface and casting method would be investigated to effectively improve membrane performance, durability and energy consumption.

Development of Numerical models for entrainment and deposition rates to predict dry out in AHWR fuel bundle

Sponsor: Department of Atomic Energy, Board of Research in Nuclear Sciences

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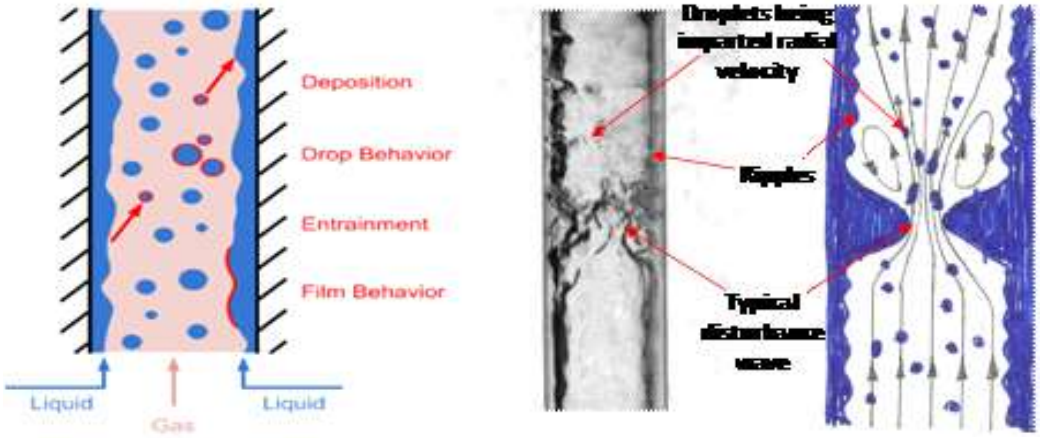
Critical heat flux is an important consideration for the thermal design of nuclear reactor and its operations. Nuclear reactor must be operated well below the critical heat flux limit to allow for the operating flexibility and uncertainty in the prediction. critical heat flux is consequence of dryout of the liquid film in contact with the heated wall in advanced heavy water reactors (AHWR). Modeling of dryout condition accurately is essential so that the design margins could be improved thus potentially leading to an increased power density.. Dryout is defined as a condition in the annular flow when there is complete removal of liquid film on the wall surface. This leads to an abrupt increase in heat transfer coefficient which is not desired condition. A hybrid multiscale model will be developed to evaluate the entrainment rate in droplet-annular flow. Finite volume based volume-of-fluid method will be used to simulate the gas-liquid annular flow situation in sharp interface framework.



Progressive depletion of the liquid film and subsequent droplet formation will be predicted. Interfacial waves in the film will be also captured which in turn will generate entrained drops in the vapor medium and deposition back. Orificing, rolling and undercutting dynamics will be observed in detail in case of evaporating annular flow.

Smoothed particle hydrodynamics, Lagrangian point particle method and Lagrangian particle cloud distribution will be used for modeling the dynamics of the droplet. Entrainment and deposition rates will be predicted numerically which will lead to extrapolation and prediction of film dryout in actuality

Physical Layer development for reconfigurable Software Defined Radios

Sponsor: Vedang Radio Tech Pvt. Ltd.

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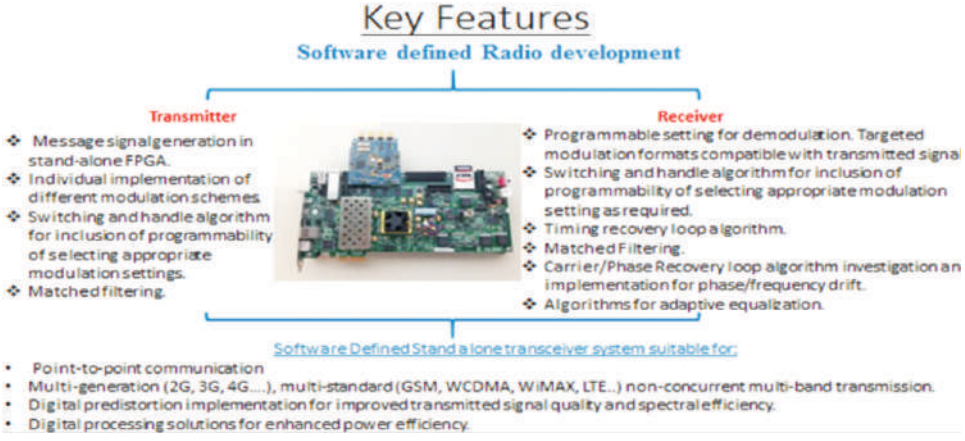
This project targets the software defined radio based transceiver system development. The approaching convergence of third-generation (3G) CDMA2000 and WCDMA/ GSM wireless network standards into the 4G LTE (Long Term Evolution) wireless network standard presents developers of next-generation base stations with a bit of a challenge. The LTE physical layer (PHY) is a highly efficient means of conveying both data and control information between an enhanced base station (eNodeB) and mobile user equipment (UE). Hence, the challenge is the creation of base stations which can support previous and successive standards i.e. base stations should be flexible. The project targets software implementation of transmitter and receiver software-defined functions where functions such as signal generation, time and phase recovery algorithms, equalization and matching filters for both the transmitters and receivers will be implemented in a low-cost FPGA. The final aim is to facilitate point to point communication.



The Ballistic Response of Ceramic Targets Under Various Configuration, Prestress and Obliquity

Sponsor: Defence Research & Development Organization

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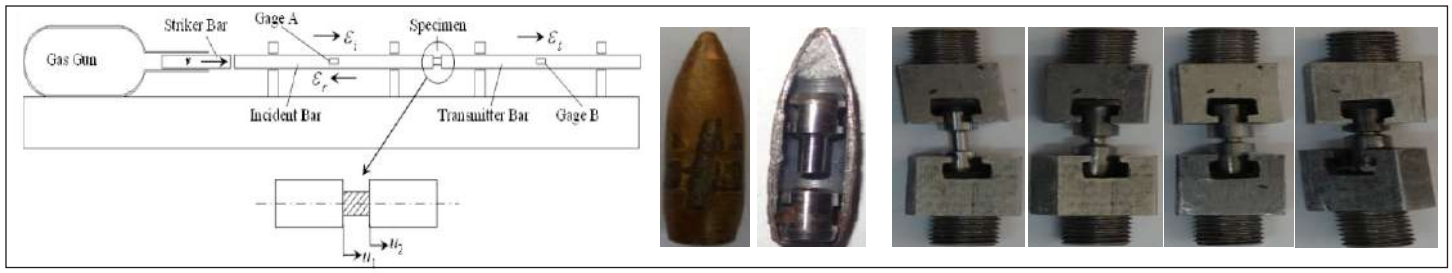
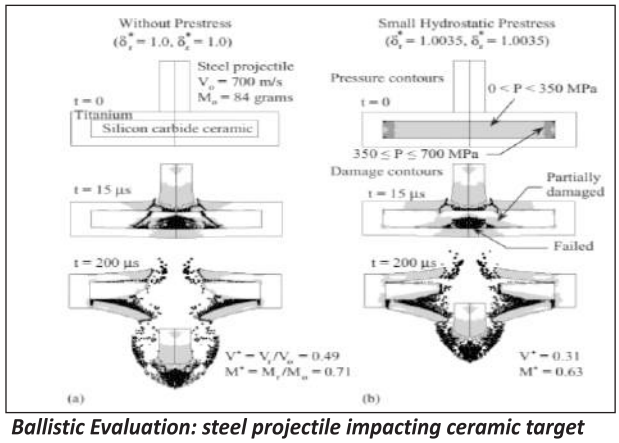
The present research proposal aims to investigate the material behaviour of Boron Carbide and Silicon Carbide ceramics in order to explore their characteristic and suitability as an independent armour. The identified ceramics will be characterized under high strain rate and high pressure in order to study their constitutive behaviour under different situations of impact loading. The suitable material models will be calibrated and simulations for ballistic impact will be carried out against armour piercing projectiles for investigating the resistance and fracture characteristics of both materials. The computed results will be subsequently validated through experiments.

An efficient layered configuration with front layer of boron carbide and back layer of silicon carbide and vice versa will be investigated for its ballistic capability to exploit the distinct characteristics of Boron Carbide (high hardness and low fracture toughness) and Silicon Carbide (low hardness and high fracture toughness). The introduction of prestress is known to improve the compressive and flexural performance of brittle materials under conventional loading. However, the advantage of prestress has rarely been explored under impact loading. The ceramic targets with different levels of induced stress will be subjected to impact loads in order to explore the possible improvement in their ballistic performance. The performance of ceramic targets of different configurations will also be studied at increasing angles of obliquity to establish the energy absorption capacity.



Characterization of Ceramic and Projectile



Ballistic Evaluation: steel projectile impacting ceramic target (a) without prestress and (b) with hydrostatic prestress.

Applications: Lightweight ceramic plates could be used for body armour, vehicle armour and other protective structures.

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