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# **Chemical Engineering**

**Title** : **Aspects of Liquid Antisolvent Precipitation of Nanoparticles of Poorly Water Soluble Drugs: Nucleation Kinetics, Precipitation Pathways and Long Term Stability**

**Researcher** : Yadav, Manishkumar D.

**Supervisor** : Dalvi, Sameer V.

**Department** : Chemical Engineering

**Year** : 2014

**Pages** : 51

**Call No.** : 660.042 YAD

**Acc. No.** : T00018

**Keywords** : Induction Time, Interfacial Energy, Nucleation Kinetics, Non-classical crystallization, Metastable Zone Width, Solid-Liquid Interfacial Tension, Self-Assembly, Ultrasound

**Abstract** : Poor aqueous solubility of drug molecules is a major challenge for the pharmaceutical scientist involved in drug development. Particle size reduction to nanoscale appears as an effective and versatile option for solubility improvement. Unlike the traditional methods used for particle size reduction, liquid antisolvent (LAS) process offers advantages ranging from superior particle size control to easy scalability. There are number of factors in effect during LAS processing. These factors can be grouped into two main categories; formulation related and process related. In order to design a robust LAS process, it is extremely important to understand impact of all the variables such as solvent to antisolvent ratio, temperature, mixing techniques etc on the desirable product attributes, such as particle size, particle size distribution, particle morphology, particle stability, nucleation kinetics etc. Although several researchers have studied these variables, there is a widespread disagreement amongst them which makes it difficult to follow a particular methodology reported. Hence, the objective of the thesis is to address the gaps in the literature. Nucleation kinetics of a poorly water soluble drug curcumin during LAS process in presence of ultrasound and surfactant has been estimated. The induction time and metastable zone width (MSZW) for curcumin precipitation and the effect of ultrasound and stabilizers on these parameters have been estimated. A significant increase in nucleation rates and decrease in induction time and MSZW was observed for LAS precipitation carried out in presence of ultrasound. Solid-liquid interfacial energies were also estimated using induction times obtained experimentally. It shows that the value predicted using Mersmann equation and Bennema&Sohnel equation are higher than the experimental interfacial energies. Additionally, we devised a simple criterion for prediction of a long-term stability of aqueous suspensions of ultrafine particles of curcumin. A new “stability parameter” ( $\gamma_0\epsilon/\gamma\epsilon_0$ ) has been defined, which is a ratio of non-dimensional mechanical (mainly ultrasonic) energy ( $\epsilon/\epsilon_0$ ) to the non-

dimensional solid-liquid interfacial energy ( $\gamma/\gamma_0$ ). The stability of aqueous suspensions of curcumin particles over a period of one year and nine months have been correlated with this parameter. It was found that precipitations carried out with higher values of  $\sigma_0/\sigma_0$  (more than 100) result into aqueous suspensions with particle size less than  $1\mu\text{m}$ . It was further observed that these suspensions remain stable (i.e. no or negligible change in average particle size) for a period of one year and nine months. On the other hand, the suspensions of particles precipitated at lower values of  $\sigma_0/\sigma_0$  (less than 10) were found to be highly unstable (i.e. the average particle size changes drastically). These results suggest that  $\sigma_0/\sigma_0$  can be used as a parameter to engineer stable aqueous suspensions of curcumin particles. Further, it was found that the use of Mersmann equation to estimate solid-liquid interfacial surface tensions can help in making this criterion predictive. In addition to aspects of nucleation kinetics and stability of aqueous suspensions the precipitation pathways of poorly water soluble drug griseofulvin during liquid antisolvent precipitation were also explored. It was found that griseofulvin particles undergo non-classical crystallization pathway during liquid antisolvent precipitation in presence of ultrasound and stabilizers. Ultrasound was found to facilitate fusion of assemblies formed during non-classical crystallization.

**Title** : **Colloidal Rhombohedral Particles in Hexagonal Liquid crystal: - Rheology and Microstructure**

**Researcher** : Mishra, Nishi S.

**Supervisor** : Theraja, Prachi

**Department** : Chemical Engineering

**Year** : 2014

**Pages** : 76

**Call No.** : 660.2 MIS

**Acc. No.** : T00014

**Keywords** : Liquid crystal, Rheology, Tetraethyl orthosilicate

**Abstract** : Liquid crystals are a state of matter between solid and liquid which act as tunable solvents for particles self-assembly. These self-assembled structures can have unique mechanical, optical, electrical and magnetic properties [1,7, 17]. We report the self-assembly of 104 nm Rhombohedral Fe<sub>2</sub>O<sub>3</sub> (iron oxide) particles in hexagonal phase of lyotropic liquid crystal. Visually, the sample is a low viscosity liquid above TH and turns into a soft solid as the temperature is lowered. This is also manifested in the rheological properties of this material where the storage modulus ( $G'$ ) shows several orders of magnitude increase at the isotropic-hexagonal transition temperature and almost plateaus as the temperature is further lowered. Rheological measurements show that the storage modulus of the material depends on two factors: 1) Particle loading 2) The rate at which the sample is cooled. As observed for cooling rates of 0.5°C/min iv and 1°C/min,  $G'$  increases with an increase in particle loading up to 1.5wt% however, such monotonic increase with cooling rate is not observed as the particle loading is varied from 2.5-10wt%. However when cooled at 2°C/min, the increase in modulus with particle loading is pronounced at higher particle loading. Interestingly, the modulus of the particle free sample shows hardly any effect of cooling rate. The rheological data suggest that the final microstructure and mechanical properties are dictated by interplay between the rate at which the hexagonal domains nucleate and how fast the particles are swept by these domains to form a compact particle layer at the hexagonal liquid crystal and isotropic fluid interface. The process has been observed under polarised microscopy for lower particle loadings. The packing of the particles is very much dependent on the cooling rate as well as particle fraction. Therefore, both particle loading and cooling rate affect the mechanical properties of final structure. We have synthesized silica nano-rods with different total volume of reactants to see its effect on size of rods and also the effect of Tetraethyl orthosilicate (TEOS) [26]. Increase in the total volume of reactant led to decrease in the size of rods with lesser effect on diameter, while the variation

in TEOS concentration showed similar effect but with marginal effect on diameter.

**Title** : **Hydrogen Production Via Catalytic Partial Oxidation Of Methane On Lanthanum Oxide and Nickel-Lanthanum Oxide Catalysts**

**Researcher** : Menon, R. Aparna

**Supervisor** : Bhargav, Atul  
& Sharma, Sudhanshu

**Department** : Chemical Engineering

**Year** : 2014

**Pages** : 47

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**Acc. No.** : T00013

**Keywords** : Hydrogen, Nickel, Lanthanum oxide, Methane, Partial oxidation

**Abstract** : Lanthanum oxide (La<sub>2</sub>O<sub>3</sub>) has been of interest as a catalyst due to its lattice Oxygen content and relatively low cost. However, it has been known to promote complete oxidation, rendering it unusable for Hydrogen production through the catalytic partial oxidation (CPO) of methane. Although some previous studies have been carried out CPO of methane on La<sub>2</sub>O<sub>3</sub>, a detailed analysis of the promotion of complete combustion even in highly reducing atmospheres has not been fully documented. It was observed that when 5 wt% of Nickel was loaded on La<sub>2</sub>O<sub>3</sub> catalyst (Ni/ La<sub>2</sub>O<sub>3</sub>), the Hydrogen selectivity increased to almost 8 times. In this paper, we report coking studies during long term tests on both La<sub>2</sub>O<sub>3</sub> and Ni/ La<sub>2</sub>O<sub>3</sub> catalysts. La<sub>2</sub>O<sub>3</sub>, prepared by solution combustion method and Ni/La<sub>2</sub>O<sub>3</sub>, prepared by chemical reduction method, were used in granule form and were packed inside a quartz tube. Nitrogen was used as the carrier gas for methane and Oxygen. Operating conditions such as temperature, residence time and O/C ratio were first optimized so as to get maximum Hydrogen yield. The CPO reaction was carried out in a temperature range of 200-750°C. Results indicate that both methane and Oxygen conversions increase with temperature. An optimum in methane conversion was observed with residence time, indicating a complex interaction between lattice Oxygen and coke formation. The decrease in conversion was thought to be because of coke deposition on the catalyst which has the capability of deactivating the catalytic activity. A long term durability test for 160 h was done for the reaction and amount of carbon deposited was quantified by conducting TGA analysis. The nature of the coke deposited was studied using FTIR and SEM. These results are part of a larger effort aimed at understanding the catalysis of La<sub>2</sub>O<sub>3</sub> and Ni/La<sub>2</sub>O<sub>3</sub> systems.

**Title** : **Kinetic Study and Advanced Control of Bechamp Reduction of p-Nitrotoluene Process in a CSTR**

**Researcher** : Khan, Patan Ameer

**Supervisor** : Padhiyar, Nitin

**Department** : Chemical Engineering

**Year** : 2014

**Pages** : 43

**Call No.** : 660.28443 KHA

**Acc. No.** : T00016

**Keywords** : Advanced Control, Bechamp Process, Frossling correlation, Kinetics, MPC, p-nitrotoluene reduction, SBHS

**Abstract** : In any process control study, the first step is to develop a reliable process model. This model can then be used for process control and other process engineering tasks. Further, kinetic study is the heart of the process model of a Chemical reactor. We in this work present the experimental kinetic study of aromatic nitro reduction reaction by Bechamp process followed by a simulation study of advanced control of a continuous reactor. Bechamp process is a process for the reduction of aromatic nitro compound using zero valent iron in acidic conditions. The Bechamp process is especially more popular in the ground water treatment, where the contaminants such as nitro aromatic compounds (NACs) are converted to less harmful counterpart aromatic amines [1]. Further, the Bechamp process is also used to produce aromatic amines from their counterpart nitro compounds. Bechamp process is one of the specific requirements for most of the pharmaceutical products, which is an alternative process to catalytic hydrogenation. Usually, in the Bechamp process, by products such as p-azotoluene and p,p'-ditolylamine are also obtained along with the amine product. Kinetic study for nitro benzene and p-nitro toluene (PNT) [1] using Bechamp process has been studied earlier [2]. The latter study was conducted for the effect of rpm and temperature with 6-9  $\mu\text{m}$  of iron particle. Further, they also concluded that the adsorption of the PNT on the solid surface is the limiting step, which was confirmed by Frossling Correlation [3]. Considering the high cost of such small sized iron particles, they may not be commercially useful even though the smaller particles have large surface area. Hence, it is logical to study the kinetics with coarser iron particles. We in this work have first reproduced few results reported in Popat and Padhiyar [2] in a 500 ml of batch reactor with 6-9  $\mu\text{m}$  iron particles at different rpm. Further, we in this work have focused on the kinetic study of PNT reduction using Bechamp process similar to Popat [2], though with the coarser iron particles, which is commercially more applicable. Apart from the effect of iron particle size, the effect of

temperature and the initial composition has also been studied on the Bechamp reduction of PNT. Chemical analysis has been carried out with Gas Chromatography (GC) to find out the compositions of various components involved in the reaction mixture. Further, Frossling correlation of mass transfer coefficient and rpm has been fitted in the current study. Since the kinetic study of PNT was not sufficient to develop a process model for the control of a reactor, we present the advanced process control study of Bechamp reduction of PNT in a continuous reactor. An advanced control algorithm, Model Predictive Control (MPC) has been used for this purpose, which has number of advantages over the conventional single loop, linear controller, namely PID controller. Before applying the MPC to a reactor, an experimental study of process dynamics and control has been presented for a popular temperature control system, namely Single Board Heater System (SBHS) as well.

**Title** : **Model Predictive Control Strategy for Optimizing Biological Nitrogen Removal (BNR) Processes Accounting for Greenhouse Gas Emissions**

**Researcher** : Behera, Chitta Ranjan

**Supervisor** : Srinivasan, Babji

**Department** : Chemical Engineering

**Year** : 2014

**Pages** : 29

**Call No.** : 628.357 BEH

**Acc. No.** : T00015

**Keywords** : Ammonia oxidizing bacteria, Biological Nitrogen Removal (BNR), Gas, Greenhouse

**Abstract** : Biological Nitrogen Removal (BNR) process comprises sequential oxidation of ammonia to nitrate and subsequent reduction of nitrate to nitrogen gas under a sequence of aerobic and anoxic conditions. Ammonia oxidizing bacteria (AOB) which are used for nitrification are the main contributors of Nitrous Oxide (N<sub>2</sub>O), a powerful greenhouse gas having a potential of 300 times greater than Carbon Dioxide (CO<sub>2</sub>) [1] and Nitric Oxide (NO), which is a toxic gas. Due to unavailability of unified model for capturing the dynamics of N<sub>2</sub>O it is difficult to control its emission from waste water plants. In this study, a model is chosen that captures the dynamics of N<sub>2</sub>O during recovery to aerobic condition after a period of anoxia (which is a common practice in waste water treatment plant) that is used for control purposes. Further, many of the states (like cell concentration, nitrous oxide and nitric oxides) used in the model cannot be or are expensive to measure (unknown states) in a real BNR process. In order to mitigate the emission of N<sub>2</sub>O its concentration is first estimated with a soft sensor (Extended Kalman Filter) and then a nonlinear model predictive control is implemented. Finally, a control algorithm is provided to address a multi objective problem such as mitigation of liquid N<sub>2</sub>O (0:001(mg=L)), maintaining DO (2(mg=L)) and NH<sub>4</sub><sup>+</sup> concentration (1(mg=L)) [2] in effluent water.

**Title** : **Ultrasonication Assisted Synthesis of Few Layers Thick Chemically Modified Magnesium Diboride Nanosheets**

**Researcher** : Bedar, Amita

**Supervisor** : Jasuja, Kabeer

**Department** : Chemical Engineering

**Year** : 2014

**Pages** : 39

**Call No.** : 660 BED

**Acc. No.** : T00017

**Keywords** : Chemicals, Magnesium, Selected Area Electron Diffraction, Scanning Electron Microscopy

**Abstract** : Graphene has generated enormous research prospects over the last decade owing to its atomic thin sheet structure that has enabled newer thresholds in several physico-chemical properties. Recently significant efforts have been directed towards synthesizing inorganic analogues of graphene which offer a rich prospect for fundamental and applied science. Boron being the immediate neighbor of carbon in the periodic table, offers a curious case to be explored in the search for nanostructures isostructural to graphene. Currently, there exists no experimental evidence detailing synthesis of 2-D nanostructures based on boron honeycomb lattice. This thesis reports a chemical method that we developed to synthesize nanosheets based on boron honeycomb lattice. This method involves ultra-sonication assisted exfoliation of layered magnesium diboride in water. This simple sonochemical route results in a colloidal dispersion of chemically modified MgB<sub>2</sub> nanosheets which were characterized for their morphology and chemical nature. Field emission scanning electron microscopy (FE-SEM), high resolution transmission electron microscopy (HRTEM), selected area electron diffraction (SAED) pattern and zeta particle size analysis revealed that the MgB<sub>2</sub> nanosheets had average effective diameters of ~7–50  $\mu\text{m}$  and average thickness of less than 10 nm. Chemical characterization using Fourier transform infrared (FTIR) spectroscopy, zeta potential analysis and energy-dispersive X-ray (EDX) spectroscopy suggests that the chemically modified MgB<sub>2</sub> nanosheets (CMMBs) exhibit a substantial degree of hydroxyl functional groups. This functionalization stabilizes the colloidal dispersion by facilitating a net negative charge on the surface of nanosheets. The concentration of ionized groups present on the nanosheets was quantified by acid-base titration at different pH values. At pH 7, the nanosheets exhibit a net negative charge. The discovery of nanosheets comprising boron honeycomb lattice could serve as an important advance in the science of two-dimensional inorganic nanomaterials. These nanosheets are expected to provide an avenue to tap the availability of boron at the atomic level and their functionalized surface is expected to

facilitate the attachment of chemical/biological moieties, providing rich potential to fabricate and study several unprecedented constructs.

**Title** : **Colloidal particles self-assembly in liquid crystals**  
**Researcher** : Gite, HemantBapurao  
**Supervisor** : Thareja, Prachi  
**Department** : Chemical Engineering  
**Year** : 2013  
**Pages** : 52  
**Call No.** : 660.2 GIT  
**Acc. No.** : T00003  
**Keywords** : Liquid Crystals; Colloidal Crystals; Self-assembly; Metal-containing liquid crystals; Crystal devices; liquid crystal displays  
**Abstract** : Liquid crystals, being anisotropic, act as tunable solvent for the dispersion of colloidal particles. They also have shown to provide very good support for the self-assembly of particles into well-organized structures. We experimentally study the behavior of colloidal particles dispersed in liquid crystal medium. We have successfully prepared, nematic and hexagonal, lyotropic liquid crystalline phases. When dispersed into such a solvent, colloidal particles aggregate to form structures such as chains, clusters, strands, and the network of particles. Formation of these structures is driven by interaction arising from the orientation elasticity of the solvent. We used spherical Polystyrene (PS), Titanium Dioxide (TiO<sub>2</sub>), Zinc Oxide (ZnO), Silica (SiO<sub>2</sub>) and anisotropic Iron Oxides (Fe<sub>x</sub>O<sub>x</sub>) particles to study their behavior in liquid crystal medium.

We have studied the effect of particle concentration, size and shape on the self-assembly process. The type of liquid crystal phase and the shape of nematic liquid crystals are also shown to control the interaction between particles. Particles with size greater than 1 $\mu$ m form small chains and cluster like structures in nematic phase while smaller particles do not show any structure formation in this system. In hexagonal phase particles with size less than 1 $\mu$ m shows network and strand like structures formation while larger particles do not show such structures. Effect of cooling rate on network formation was studied. We have also prepared free standing microporous structure of SiO<sub>2</sub> nanoparticles by templating of hexagonal domain.

**Title** : **Computational assessment of air pollution dispersion in urban centers**

**Researcher** : Kar, Sayan

**Supervisor** : Damodaran, Murali

**Department** : Chemical Engineering

**Year** : 2013

**Pages** : 63

**Call No.** : 628.530151 KAR

**Acc. No.** : T00007

**Keywords** : Air pollution dispersion; advection-diffusion equation; Gaussian plume model; branched Atmospheric Trajectory model; suspended particular matter

**Abstract** : For air quality modeling, the Gaussian plume model has been extensively used to analytically solve the steady and unsteady transport equations including the effects of particle deposition and settling. Along with the standard analytical solution of the Gaussian plume model for modeling air pollution dispersion in the atmosphere this work explores the adaptation of a Lagrangian Branched Atmospheric Trajectory approach for computing ground level concentrations of PM<sub>10</sub> (suspended Particulate Matter of aerodynamic diameter of less than 10 micro meter), PM<sub>2.5</sub> emitted from different air pollution sources in and around the city of Ahmedabad, India. With a transport time step of 6 hrs, the model includes necessary meteorological data which couple with multi-pollutant emission grid. The results obtained from the model are found to be very close to the measured data (2009-2011) from Gujarat Pollution Control Board.

**Title** : **Design of an evaporator for vaporization of glass forming silica precursor**

**Researcher** : Jadhav, Deepak Babasaheb

**Supervisor** : Ghoroi, Chinmay

**Department** : Chemical Engineering

**Year** : 2013

**Pages** : 85

**Call No.** : 666.1 JAD

**Acc. No.** : T00002

**Keywords** : Glass Forming; OMCTS; Design of Evaporator

**Abstract** : Use of silicon tetrachloride ( $\text{SiCl}_4$ ) for high purity glass forming silica is very convenient due to its high vapor pressure. However, in presence of oxy-hydrogen flame, it forms hydrochloric acid (HCl) which creates environmental hazard. In contrast, halogen free organometallic precursor such as Octamethylcyclotetrasiloxane (OMCTS) is a promising alternative. However, evaporation process of OMCTS is only available in the patent literature with considerable gaps in the scientific understanding in open literature. In this work, properties of OMCTS are studied and analyzed the different patented designs of Corning Inc. A packed bed evaporator is designed and fabricated. Different experiments were conducted and tested for performance of the designed evaporator. The designed evaporator can generate very highly pure OMCTS vapor required for high purity silica glass. Unlike previous observations mentioned in the available patent literature, there was no high molecular species observed in the residue of the designed evaporator.

**Title** : **Experimental study of Bechamp process for nitrobenzene reduction to aniline**

**Researcher** : Singh, Umesh

**Supervisor** : Padhiyar, Nitin

**Department** : Chemical Engineering

**Year** : 2013

**Pages** : 48

**Call No.** : 660.28 SIN

**Acc. No.** : T00009

**Keywords** : Kinetics; Bechamp Process; nitrobenzene reduction; aniline production; rpm effect on kinetics; Frossling correlation

**Abstract** : Bechamp process is a well-known process for the reduction of aromatic nitro compounds using zero valent iron powder in acidic conditions. The Bechamp reaction is a multiphase reaction with gas, liquid and solid phases. The complex reaction mechanism contains series and parallel reactions resulting into by products and side products apart from the amine product. Overall reduction of nitrobenzene to aniline is a process of three steps in series, namely adsorption of nitrobenzene on the iron surface, surface reaction of nitrobenzene to aniline and desorption of the product from the iron surface. In the literature it is suggested that the adsorption step is the rate limiting step for nitro aromatic reduction. Nitrobenzene is a carcinogenic pollutant and is used in dye, agrochemicals and rubber industries. It is reported in literature that nitrobenzene is dangerous even at lower concentrations (ppm) and it is non-biodegradable in nature. Reduction of nitrobenzene to aniline by Bechamp process is carried out in a 500 ml batch reactor in this work. Gas Chromatograph (GC) is used for the sample analysis. A GC method has been developed with toluene as the solvent for determining the compositions of various reaction components.

In our literature study we found that using Bechamp process, nitrobenzene reduction was studied at ambient temperature and at lower rpm (up to 50). The effect of temperature on the Bechamp reduction of nitrobenzene was absent. Also at higher concentrations of nitrobenzene the study was not available. In this work we filled this gap by studying the Bechamp reduction of nitrobenzene at various temperatures (30 oC to 100 oC) and higher rpm (up to 600). We also present the effect of rpm on rate constant and model this relation of mass transfer constant and rpm by Frossling correlation.

Finally, we have extended the work of reduction of nitrobenzene in a batch reactor work to the

industrial semi-batch system with gradual addition of Fe. Based on these results, a reaction mechanism of the reduction of nitrobenzene is suggested in this work.

**Title** : **Experimental study of Bechamp process for p-nitrotoluene reduction to p-toluidine**

**Researcher** : Popat, Vivek Rasikbhai

**Supervisor** : Padhiyar, Nitin

**Department** : Chemical Engineering

**Year** : 2013

**Pages** : 45

**Call No.** : 660.28 POP

**Acc. No.** : T00010

**Keywords** : Kinetics; Bechamp Process; p-nitrotoluene reduction; p-toluidine production; rpm effect on kinetics; Frossling correlation.

**Abstract** : Bechamp process is a well-known process for the reduction of aromatic nitro compound using zero valent iron powder in acidic conditions. The Bechamp reaction is a multiphase reaction with gas, liquid and solid phases. The complex reaction mechanism contains series and parallel reactions resulting into by products and side products apart from the amine product. Overall reduction of p-nitro toluene (PNT) to p-toluidine (PT) is a process of three steps in series, namely adsorption of PNT on the iron surface, surface reaction of PNT to PT and desorption of the product from the iron surface. In the literature it is suggested that the adsorption step is the rate limiting step for nitro aromatic reduction.

Reduction of PNT to PT by Bechamp process is carried out in a 500 ml batch reactor in this work. Gas Chromatograph (GC) is used for the sample analysis. A GC method has been developed with toluene as the solvent for determining the compositions of various reaction components. In this work, we have carried out experiments to find out the limiting step for PNT reduction. We have considered selectivity of PT as performance criteria in this study at various operating conditions. We also present the effect of rpm on rate constant and model this relation of mass transfer constant and rpm by Frossling correlation. Finally, we have extended the work of reduction of PNT in a batch reactor work to the industrial semi-batch system with gradual addition of Fe. Based on these results, a reaction mechanism of the reduction of PNT is suggested in this work.

**Title** : **Modeling of microbubble dissolution in aqueous medium**  
**Researcher** : Joshi, Jignesh Rajendrakumar  
**Supervisor** : Dalvi, Sameer V.  
**Department** : Chemical Engineering  
**Year** : 2013  
**Pages** : 157  
**Call No.** : 660.2 JOS  
**Acc. No.** : T00004  
**Keywords** : Microbubbles; Ultra sound contrast agent; drug delivery vehicles; dissolution; stability; Aqueous  
**Abstract** : Aqueous suspensions of microbubbles find use in various biomedical and pharmaceutical applications. Microbubbles of size from 1-10  $\mu\text{m}$ , comprise of a gas core and a shell made of protein, SDS or polymeric material. Most of the biomedical applications involve intravenous administrations of microbubbles. Once administered in body, microbubbles start dissolving in the body media. The effectiveness of these microbubbles depends on their circulation time in blood. The circulation time (or persistence time) of these microbubbles largely depends upon the kinetics of their dissolution in body media. It is therefore necessary to know/predict the time for which the microbubbles made from a particular formulation will circulate in blood. Accordingly, the objectives of this work were to model microbubble dissolution and predict dissolution time.

There are several models available in the literature aimed at attempting the modeling of microbubble dissolution. However, it was found that, the existing models do not take into account either the shell elasticity or the variation in surface tension with change in microbubble size. In this work, attempt has been made to account for these factors which may affect microbubble dissolution process greatly.

The model for microbubble dissolution in an aqueous medium saturated with gas used to make microbubble has been developed. The values of shell resistance, elasticity and initial surface tension have been regressed by comparing model with the experimental data available I literature. It is found that, the shell resistance and elasticity of shell increases with number of carbon atom in lipids, thus dissolution time of the microbubble increases with number of carbon atoms in lipids. The dissolution time also increases with level of saturation and initial radius of the microbubble. As the Ostwald coefficient decreases, it is also observed that the dissolution time increases. The life time of gas with lower Ostwald coefficient microbubble is higher.

The degree of variations in shell resistance and surface tension also increases with number of carbon atom in lipid. However, based on the regressed shell properties, SDS can be considered as inelastic material as the variation in surface tension and shell resistance is negligible.

The model for dissolution of microbubble in multi gas environment in water and in blood has also been developed. Two way diffusion of core gas to the bulk and the diffusion of air dissolved in the bulk to the gas core have been considered. The growth in microbubble was observed during its dissolution due to higher influx of gases dissolved in the aqueous medium than outflux of gas used to make microbubble. The shell resistance of gases and surface tension of the microbubble first decreases and then increases. The dissolution time increases with number of carbon atom in a lipid molecule, initial radius and level of saturation of the aqueous medium.

**Title** : **Morphology and optical properties of nanoparticle thin films fabricated by spread coating**

**Researcher** : Singh, Amit

**Supervisor** : Thareja, Prachi

**Department** : Chemical Engineering

**Year** : 2013

**Pages** : 55

**Call No.** : 667.9 SIN

**Acc. No.** : T00001

**Keywords** : Morphology and Optical Properties; Nanoparticle Research; Films Fabricated

**Abstract** : Thin films are deposited on substrates such as glass slides, silicon wafers, mica etc with the help of an in house designed Spread Coating Device. Many particle types such as titanium, silica thin films can be deposited by this device and the morphology is based on the principle of Convective Deposition Assembly. The device consists of syringe pump and two glass side holders, one is inclined at an angle of 40° and the other is moving at a user defined velocity. Different volume fractions of solutions varying from 0.01-0.4 are prepared using TiO<sub>2</sub>-960 (3.9 g/cm<sup>3</sup>) at different velocities from 1 μm/sec to 300 μm/sec at room temperature. Thickness, assembly of particles, roughness and optical properties are measured using SEM, AFM and UV-VIS spectroscopy. Our experiments show that as the spreading velocity is increased the films become progressively more uniform. Concomitantly, the transmittance of the films decreases. The method provides a versatile way to fabricate thin films with a variety of microstructures with different properties.

**Title** : **Protein-polysaccharide nano-complexes at air water interface**

**Researcher** : Mukherjee, Satyajit

**Supervisor** : Thareja, Prachi

**Department** : Chemical Engineering

**Year** : 2013

**Pages** : 63

**Call No.** : 660.634 MUK

**Acc. No.** : T00006

**Keywords** : Polysaccharide synthesis; Airwater Interface; Nano-Complexes; Protein interactions

**Abstract** : Complexation between bovine serum albumin (BSA) and citrus peel pectin (CPP) was studied by changing pHs and mass ratios with turbidity, dynamic light scattering, centrifugation and viscosity measurements. Interfacial behavior at specific pHs and mixing ratios were also carried out by individual measurements using bubble tensiometer and wilhelmy plate technique. We investigate comparative long term stability of foam in protein solution and in a mixed protein (BSA) - polysaccharide (CPP) system. The foam stability is improved for samples containing soluble complexes which are almost at pH around isoelectric point of BSA. Initial foam formation solely depends on free protein content in bulk, and soluble complexes slow down the drainage rate by their presence at air/water interface, which finally results in the stabilization of foam. Atomic force microscopic image analysis shows how this interaction between BSA and CPP leads to change in morphology with size and shape by forming complexes. These findings have significant value for application of protein- polysaccharide complex in foam stabilization which is useful in different engineering applications such as food, pharmaceutical industries, and cosmetics.

# Civil Engineering

**Title** : **Effect of Water Content on Shear Strength Behaviour of Micaceous Kutch Soil**

**Researcher** : Pandya, Pavni

**Supervisor** : Sachan, Ajanta

**Department** : Civil Engineering

**Year** : 2014

**Pages** : 59

**Call No.** : 624.1517 PAN

**Acc. No.** : T00012

**Keywords** : Soil, Water effect, Micaceous Kutch Soil

**Abstract** : Micaceous soils are generally known for their high compressibility and low compacted density behavior. Mica flakes in soils are usually small and have fine sand and silt sizes. Mica particles have an influence on the compaction properties of soil due to their platy shape, ability to split into very thin flakes and the inter-space within the thin flakes. The mica flakes also impart resilience to the soil, which makes it difficult to compact. The spring nature of mica flakes helps them to recover their shape, when the stress is removed. In micaceous soils, a mica particle may simply replace an individual granular particle or fill a void, but as the quantity of mica increases, there is a corresponding increase in void spaces. Individual mica particles are capable of spanning over voids instead of filling them. If the mica flakes are sufficiently numerous to interact, the bridging phenomenon is further augmented. If mica content in soil is more than 10%, it has strong impact on compressibility, compressive strength and volume stability of micaceous soil. Some research has been performed on mica-sand mix to evaluate the effect of mica on geotechnical behavior of mix. In the current research, effect of water content on shear strength behavior of naturally available micaceous silty soil (Kutch, Gujarat) has been studied. The resilience behavior of mica particles and the presence of water molecules in the inter-space of their thin flakes were studied to understand the variation in shear strength behavior of micaceous Kutch soil (14% mica) due to the change in its water content. A series of shear strength tests were performed on micaceous Kutch soil at different water content varying from 0% to 23.5%. A series of XRD, SEM and AFM tests were also performed on Kutch soil to determine the mica content and understand the size, shape and geometric arrangement of particles (mica, silt, sand) within the soil mass. Micaceous silty soil samples were collected at 4 m depth near Dhori site, located in Kutch region (Gujarat); which had experienced severe liquefaction during Bhuj Earthquake 2001. The research can be used to understand the effect of mica on liquefaction behavior of micaceous soils.

**Title** : **Response of Smartphones to Roadway Surface Irregularities**

**Researcher** : Majhi, Subhra

**Supervisor** : Mukherjee, Abhijit

**Department** : Civil Engineering

**Year** : 2014

**Pages** : 69

**Call No.** : 625.7 MAJ

**Acc. No.** : T00019

**Keywords** : Accelerometers, Dynamic response, pass filters, Road bumps, smartphones

**Abstract** : Smartphones are ubiquitous all over the world. As they are carried while travelling, their in-built accelerometers should feel the irregularities of the roadway as they are felt by the passengers. Investigations are carried out for the response of smartphones to roadway surface irregularities when they are carried by the passengers. A range of road vehicles is mathematically modeled as mass, spring, and damper systems. The dynamic response of the phone while passing over a road bump is estimated using the model. The accelerometer of a smartphone is characterized by oscillating them on a shaker in the laboratory and comparing the results with that of high precision accelerometers. The response of the smartphones while travelling in different classes of vehicles is recorded. The recorded acceleration signals have been filtered and compared with the predictions of the theoretical model. There is excellent correlation between the theoretical and experimental results. The theoretical data is compared with the experimental data to ascertain the veracity of smartphone in recording data for road surface monitoring. Thus, smartphones have the potential to automatically monitor the surface quality of roadways obviating costly manual inspections. The methodology has the potential to involve user community in the maintenance of infrastructure.

**Title** : **Shear Strength and Compressibility Behavior of Bhavnagar Expansive Soil with Varying Mineralogical and Swelling Properties**

**Researcher** : Mehta, Bhavini

**Supervisor** : Sachan, Ajanta

**Department** : Civil Engineering

**Year** : 2014

**Pages** : 72

**Call No.** : 624.15136 MEH

**Acc. No.** : T00011

**Keywords** : Bhavnagar, Cation exchange capacity (CEC), Expansive Soil, Specific surface area (SSA), X-ray diffraction (XRD)

**Abstract** : Expansive soils contain large amount of montmorillonite clay mineral; which have tendency to swell by imbibing water in monsoon season & shrink or become harder by leaving cracks in drier seasons. Excessive drying and wetting of the soil progressively deteriorates structures over the years and cause severe damage particularly to the light buildings, and pavements either through heave or differential settlement. Limited research has been reported regarding the identification of expansive soils and determination of its expansiveness & shrinkage-swelling potential based on soil's different index properties at various wetting-drying conditions. Few researchers also worked on the chemical stabilization of expansive soils by mixing various admixtures and evaluated the method for improvement in soil's mechanical behavior in terms of volume stability, strength response, permeability and durability. The fundamental understanding of expansive soil in terms of relationship of its mineralogical properties, swelling parameters, consistency limits, compressibility, and shear strength parameters are still unexplored. The current research has been performed on expansive soil (black cotton soil) covering major part of Bhavnagar, located along the coast line of Gulf of Khambhat in Gujarat. This research is focused on the evaluation of mineralogical properties, swelling-shrinkage potential, consistency limits, compressibility and shear strength response of expansive soils collected from ten different locations of Bhavnagar. X-ray diffraction (XRD), cation exchange capacity (CEC), and specific surface area (SSA) tests were performed on Bhavnagar expansive soil to identify its mineralogical properties at different locations. A series of 1D consolidation and UU triaxial tests were performed on ten soil samples to evaluate the compressibility and shear strength properties of Bhavnagar soil. This extensive experimental research work has been used to develop the mathematical correlations for expansive soils to predict the compressibility and shear strength behaviour of soil based on its mineralogical parameters, swelling properties and consistency

limits.

**Title** : **Estimation of Linear Spring Constant for Laterally Loaded Monopile Embedded in Nonlinear Soil**

**Researcher** : Rani, Shivani

**Supervisor** : Prashant, Amit

**Department** : Civil Engineering

**Year** : 2013

**Pages** : 110

**Call No.** : 624.15 RAN

**Acc. No.** : T00008

**Keywords** : Linear spring-mass systems

**Abstract** : A single large diameter pile, known as monopile, is often provided to carry all the loads and moments being transferred from the superstructure. In such a case, accurate estimation of displacement and slope become imperative. 1D, 2D or 3D modelling can be done to simulate deflection of pile. For 1D simulation using Winkler's model, the spring constant can be calculated from shear modulus of soil. There are many recommendations available in the literature to estimate maximum shear modulus of soil. The predicted maximum shear modulus from various recommendations indicates that the direct correlations with SPT value have relatively less uncertainty of prediction. 1D model predictions using existing simple correlations between spring constant and soil modulus generally overestimate the deflection of pile when compared to 3D model. Through a comparative study of results from 1D and 3D simulation, a new expression for estimation of spring constant from soil modulus is proposed which incorporates relative stiffness of soil and pile. It is also known that soil is nonlinear material and its stiffness reduces with increase of strain level, hence, it is important to know the amount of expected lateral strain in soil at different depths. A coefficient has been proposed to estimate the approximate value of equivalent lateral strain in soil by assuming strain as a function of top deflection and diameter of pile.

**Title** : **Mechanical Behavior of Slurry Consolidated Specimens of Cement Treated Soft Soil Using Shear Strength and CRS Consolidation Testing**

**Researcher** : Bhuria, Nidal Raj

**Supervisor** : Sachan, Ajanta

**Department** : Civil Engineering

**Year** : 2013

**Pages** : 83

**Call No.** : 624.151 BHU

**Acc. No.** : T00005

**Keywords** : Slurry Consolidated Specimens; Compressibility of soils test; CRS consolidation--Testing

**Abstract** : Soft soils are generally known for their extremely high compressibility, low stiffness & low shear strength behavior; and cement treatment is one of the most commonly used techniques to treat such soils to acquire the required engineering behavior and specifications to allow the structure to be placed safely on soft soils without undergoing large settlements. This research is focused on the evaluation of compressibility and shear strength properties of soft soil due to cement treatment at different cement contents and curing time. The soft soil used in this research was found to be too soft (SPT N=1) to collect the undisturbed samples at soil site. Therefore, disturbed representative samples were collected from the soil site located at Kanjur Marg, Mumbai. The remolded specimens of collected soft soil with same in-situ water content and density were prepared in the laboratory by using slurry consolidation technique. A self-reacting pneumatic slurry consolidometer has been developed in the laboratory to produce the solid cylindrical specimens of fine grained soils. These slurry consolidated specimens were used to perform the UC (Unconfined Compression) tests and CRS (Constant Rate of Strain) tests to evaluate the shear strength and compressibility properties of soft soil before and after the cement treatment respectively. The Conventional 1-D consolidation test (oedometer) was found to be unsuitable for treated soft soil due to its long testing duration (~10 days), which caused major changes in compressibility properties of treated soil at chosen curing time.

This motivated the author to develop the 1-D CRS consolidation testing setup in the laboratory to evaluate the compressibility behavior of treated soft soils in few hours without any change in chosen curing time. A wide range of cement contents (2%, 4%, 6% & 8%) and curing time periods (1, 3, 7 & 28 days) were explored in this research to investigate the relationship of compressibility parameters, shear strength properties, cement content and curing time period for highly compressible soft soils.

# **Electrical Engineering**

**Title** : **A Novel Active Anti-Islanding Protection Scheme for Grid-Interactive Roof-Top Solar PV Systems**

**Researcher** : Varier, Rohith

**Supervisor** : Pindoriya, Naran M.

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 45

**Call No.** : 621.3 VAR

**Acc. No.** : T00033

**Keywords** : Anti-Island, Distributed Generation, Low Tension, Photovoltaic, Solar Systems

**Abstract** : The rising popularity of renewable resources has resulted in increased penetration levels of Distributed Generation (DG) into the utility grid. Unintentional islanding is one of the most important safety concerns associated with grid connected roof-top solar Photovoltaic (PV) systems. The occurrence of islanding can be fatal to utility workers who may not realize that the local area is still powered and encounter severe electric shock. For this reason, DG must be equipped to detect islanding and isolate itself from the grid immediately, which is commonly referred to as anti-islanding. In conventional systems, there exists a scenario in which exact balance of PV generation and load would result in failure of passive anti-islanding schemes. This problem if rectified by changing the limits of Overvoltage/Undervoltage (OV/UV) and overfrequency/Underfrequency (OF/UF) relay, would result in nuisance tripping which causes further malfunction of the protection system. This thesis work proposes a novel active anti-islanding scheme for inverter fed roof-top solar PV generation connected to Low Tension (LT) distribution grid with unbalanced non-linear loads. The method is based on creating a perturbation in the system using positive feedback and d-q implementation algorithm. The conventional passive schemes fail to detect islanding during power balancing conditions, but the novel active anti-islanding controller ensures that the voltage (or frequency) at the point of common coupling (PCC) is automatically driven beyond the threshold preset values. This proposed scheme has been tested in the presence of non-linear loads and development has found faster islanding detection compared to the existing methods. Further, the islanding conditions are simulated and accurately verified on real time.

**Title** : **A Step towards Developing a Virtual Reality Based Rehabilitation System for Post-Stroke Hand Movement Disorder**

**Researcher** : Bhattacharya, Sutapa

**Supervisor** : Lahiri, Uttama

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 58

**Call No.** : 621.3 BHA

**Acc. No.** : T00025

**Keywords** : Electromyogram, Movement Disorder, Rehabilitation System, Support Vector Machines (SVM)

**Abstract** : Stroke is a leading cause of adult death and disability, often followed by muscle weakness, loss of control and coordination in limbs and movement disorders. Consequently, stroke-surviving individuals with hemiplegia are often unable to perform simple tasks like opening and closing of their affected (unhealthy) hand, making them dependent on a caregiver for day-to-day activities. At the same time their healthy hand retains ability for normal activities. Rehabilitation aims to improve their ability to use their affected hand similar to their use of healthy hand. The degree of closure (flexion) of one's hand can be mapped from surface Electromyogram (sEMG) signal of Flexor Carpi Radialis muscle present on the anterior side of one's forearm. The different degrees of flexion can be classified with the help of Support Vector Machines (SVM) using the sEMG signals from the Flexor Carpi Radialis muscle. In this study we developed a proof-of-concept Virtual Reality based real-time rehabilitative system for post-stroke hand movement disorder. Our developed system uses the sEMG data obtained from the healthy hand of stroke-surviving individuals as training dataset for classifying the degree of flexion of their respective stroke-affected hand while they interact with the VR-based tasks, and triggers therapeutic electrical stimulation to be applied to the muscles of the unhealthy hand of the stroke-surviving individuals based on their performance feedback. This system can be used by the patient at home as per his convenience, with minimal dependency on a physiotherapist or a caregiver. The preliminary results of testing and feasibility studies suggest that the hand flexion and extension skills of the participants (six able-bodied and two stroke-surviving persons) improved with repeated attempts. This indicates that our system has the potential to take a definite step towards becoming a simple, technology-assisted solution for rehabilitation of hand movement disorder.

**Title** : **Analysis and Modeling of Stress Overlayer Induced Threshold Voltage Shift in High-K Metal Gate MOSFETs**

**Researcher** : Parihar, Narendra

**Supervisor** : Mohapatra, Nihar Ranjan

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 59

**Call No.** : 621.3815284 PAR

**Acc. No.** : T00026

**Keywords** : CMOS, High-K Metal Gate, MOSFET, Newer Channel Material, Standard

**Abstract** : Uniaxial process induced stress along with high-K Metal Gate has been extensively adopted for 45nm and below CMOS technology node to improve the performance of deep sub-micron devices. Stress generates strain in the MOSFET channel which alters the bandstructure of silicon and improves the performance by enhancing the carrier mobility. Incorporation of process induced stress using stressed overlayer has become very popular due to its ease of implementation in standard CMOS process flow. Traditionally, process induced stress was preferred because of its less bandgap narrowing and hence less threshold voltage shift compare to substrate induced biaxial stress. However, in case of devices with high-K metal gate along with stressed overlayer the experimental data shows a large threshold voltage shift. Various models have already been proposed to calculate the threshold voltage shift by in-plane uniaxial stress. Note that the large threshold voltage shift owing to stressed overlayer and high-K metal gate devices cannot be explained by conventional in-plane uniaxial stress model. This is because the stressed overlayer also generates a significant out-of-plane transverse stress along with the in-plane uniaxial stress. In this work, the stress transfer mechanism of stressed overlayer and the physics behind the large threshold voltage shift are explained. A model has been proposed to calculate the threshold voltage shift due to stressed overlayer for [110] channel oriented devices for a (100) wafer. The proposed model considers the effects of conventional in-plane uniaxial stress along with out-ofplane transverse stress generated by stressed overlayer.

**Title** : **Behavioral analysis of control room operator during plant operation using display interaction and eye gaze information for effective plant monitoring**

**Researcher** : Sharma, Chandresh

**Supervisor** : Srinivasan, Babji  
and Srinivasan, Rajagopalan

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 57

**Call No.** : 621.381 SHA

**Acc. No.** : T00022

**Keywords** : Distributed Control System, Graphical Display Unit, Human, Plant Monitoring

**Abstract** : Safety in process plants is at top in list of issues that are yet to be resolved fully. Recent accidents and their impact on economy, environment and human lives have raised this issue once again. There are many causes for such accidents and many reports have been published to explain why such accidents had happened. All of these have a common point of view which is related to control room. Human operator is at the heart of control room as operator is responsible for proper monitoring and controlling of plant by observing information from resources present inside control room. A lot of information, sudden bombardment with lot of alarms under abnormal situations makes operator paralyzed. A variety of methods are available in literature such as root cause analysis, removal of alarm chattering etc. to help operator and make control room much more friendly to operator. But their implementation and usefulness in process plant is yet to see a significant level of success. Usefulness of these methods depends on the extent in which these methods can help operators. In this study an attempt has been made towards understanding behavior of control room operators. A Graphical Display Unit(GUI) is designed based on display panel's outlook in Distributed Control System(DCS) room. Participants are asked to perform duty of operators where they are exposed to abnormal situations and asked to control plant through suitable actions. This is for the first time eye tracker has been used for this kind of study. A variety of man machine interface data has been gathered. Results related to effect of training, effect of more exposure to GUI etc. have been observed. Moreover a metric for operator's performance based on GUI interaction data has also been formulated. Eye gaze data has been used for identifying key factors for effective controlling have been identified at preliminary level.

**Title** : **Demand Response Algorithm Incorporating Electricity Market Prices for Residential Energy Management**

**Researcher** : Nair, Arun Gopalakrishnan

**Supervisor** : Pindoriya, Naran M.

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 44

**Call No.** : 621.3042 NAI

**Acc. No.** : T00030

**Keywords** : Algorithm, Demand Response, Energy Management, Market

**Abstract** : Demand Side Energy Management has now been established in the smart grid framework in order to meet the fluctuating demand supply gap that exists mainly during peak load periods. Along with the potential of energy efficiency and conservation measures, due to the increasing use of modern domestic appliances in a developing country like India, Demand Response (DR) has gained a lot of importance in the residential sector. Most of the DR algorithms that have been developed mostly focus on energy consumption scheduling without considering electricity market prices. In this thesis we have proposed a DR algorithm for residential customers, which can be used to optimally schedule appliances, making use of actual day-ahead electricity market price data and also considering user preferences in the operation of appliances. The algorithm has been simulated for five different customers using a flat pricing scheme and two time-differentiated pricing schemes. For each customer, an estimated saving of around 6% is obtained by using hourly pricing. Analysis of the results underlines the importance of formulating effective dynamic pricing policies for successful implementation of DR algorithms for the residential users thereby tapping into the vast DR potential that exists in India.

**Title** : **Design and Finite Element Analysis of Micromachined Piezoresistive Polyimide Nanocantilevers for Surface Stress Sensing Applications**

**Researcher** : Chandnani, Ashita

**Supervisor** : Mohapatra, Nihar Ranjan

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 53

**Call No.** : 621.3 CHA

**Acc. No.** : T00024

**Keywords** : CoventorWare, MEMS and NEMS, Nanocantilevers, Surface Stress

**Abstract** : The rapid progress in the field of micro- and nano- electromechanical systems (MEMS and NEMS) coupled with the advent of nanotechnology has led to the development of a very promising field of bioMEMS. A typical example of this class of devices are MEMS based sensors for biomolecular detection which use knowledge of various domains like biology, nanotechnology, microfabrication, material science, optics, electrical and mechanical engineering. This thesis explores the suitability of polyimide based nanocantilevers for surface stress sensing applications. Polyimide is a mechanically flexible biocompatible polymer. In our study, the cantilevers are modeled and analyzed using the commercial Finite Element Analysis tool oventorWare. The von Mises stress and the relative percentage change in resistance of the integrated polysilicon piezoresistor are analyzed by changing the geometric parameters of the cantilever. The effect of partial and complete etching of the cantilever structure near the clamped end is also studied. It is shown that these etched parts act as stress raisers and result in approximately 50 85% increase in surface stress sensitivity of the device. It is also shown that the effect of Joule heating on the thermal sensitivity is critical for overall improvement of signal to noise ratio of the device.

**Title** : **Design of High Resolution Low Power ADC**

**Researcher** : Mohapatra, Satyajit

**Supervisor** : Gupta, HariShanker  
and Mohapatra, Nihar Rajan

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 65

**Call No.** : 621.3815 MOH

**Acc. No.** : T00020

**Keywords** : CMOS technology, Low power ADC, SAC, ISRO

**Abstract** : Analog to digital converters are frequently used in imaging payloads developed for different satellite applications for space based astronomy and earth observations which include visible imaging, spectroscopy and star-tracking etc. Apart from this, A/D conversion is the perfect solution for high-resolution scientific, medical, industrial applications because it has characteristics of high precision, better accuracy, higher sensitivity and linear dynamic range. ADC's are being used for onboard/satellite applications as it provides high linearity, lower noise and higher dynamic range in CCD and CMOS detectors. An efficient ADC helps in reducing the overall power consumption in all payload designs. All imaging payloads consist of video processors cards which invariably use an ADC for quantizing signal from the real world sensors. In this work, a 16 bit 5 MS/s pipeline in 0.18 $\mu$ m CMOS technology ADC is designed with the state of art performance. Since designing at sub-micron technologies is highly challenging, a systematic methodology in Matlab is developed to ensure the accuracy and performance of the design while optimizing power consumption to 140 mW. Amplifiers with gain as high as 140 dB and large unity gain bandwidth of 260 MHz has been implemented in this design to take care of its 3.5 bits/stage complexity, high speed comparators with offset in range of micro-volts, switch optimization for accurate residue transfer, stage scaling for power optimization and digital error correction logic implementation are some of the criticalities of this design. Design methodologies which helped in achieving state of art performance, design criticalities and challenges faced during the entire design has been discussed in this report in details.

**Title** : **Dynamic Modelling Based Reference Current Extraction Technique for the Control of Shunt Active Power Filter**

**Researcher** : Muduli, Utkal Ranjan

**Supervisor** : Ragavan, K.

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 75

**Call No.** : 621.3 MUD

**Acc. No.** : T00032

**Keywords** : Active Power Filter, Current Harmonic, Distribution Networks, IEEE standards, Passive Filter, Power Quality Problems, Shunt Active Power Filter  
Source Inverter, Voltag

**Abstract** : In the recent decades, use of power electronic loads have increased because of their better control and reduced cost. However, these loads draw non-sinusoidal currents from the utility which affects the power quality of the system. This has led to the use of passive filters. Though the passive filters have addressed the issues concerning the power quality, they are encountered with problems such as resonance, single frequency compensation, system parameter dependency and bulkiness. This has motivated the researchers to use active power filter as an alternative to the existing passive filters. Recent studies have shown that the use of shunt connected active power filter not only solves the power quality issues, it also solves the generic problems associated with passive filters. Shunt active power filter (SAPF) works efficiently for power quality improvement and reactive power compensation. The performance of the shunt active power filter depends on the method of reference current extraction. Though the conventional extraction methods have shown good results for balanced load conditions, they have failed to accurately determine harmonic and reactive currents, in cases of (a) distorted and unbalanced supply and (b) unbalanced load. This study presents a method to estimate the harmonic component and the unbalanced and reactive current components having fundamental frequency, based on adaptive interference cancellation theory. An adaptive PI control based DC-link voltage regulator is developed to avoid the effect of continuous change of load in the distribution end. Simulations are performed in MATLAB/SIMULINK environment to verify the feasibility of the proposed method. The results show that the Total Harmonic Distortion (THD) of utility current from this method falls well below the prescribed IEEE-P519 limit of 5%.

**Title** : **Effect of Device Geometries on HCI and PBTI of Gate First High-K Metal Gate NMOS Transistors**

**Researcher** : Jain, Sharad Kumar

**Supervisor** : Mohapatra, Nihar Ranjan

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 59

**Call No.** : 621.3815284 JAI

**Acc. No.** : T00023

**Keywords** : Gate, HCI, High-K Metal, PBTI of Gate

**Abstract** : As the scaling of MOS transistor is approaching the physical limits, large leakage current is becoming a major obstacle. Therefore, high-K materials have been introduced as gate dielectrics in the transistors to further continue technology miniaturization. However, reliability of MOS transistors with high- K/Metal gate structure has become a serious concern, because of more defects in gate dielectric, and introduction of capping layers (La for NMOS and Al for PMOS). Hot carrier injection (HCI) and bias temperature instability (BTI) still remain the key reliability issues. In recent technology nodes, the Positive BTI (PBTI) component cannot be avoided in HCI stress, and this seriously affects the accurate life time prediction of the device. This work aims at decoupling of the PBTI component from HCI stress using their distinct behaviour at elevated temperature. A unique trend of HCI degradation with the variation in the device width has been shown where wider devices are more prone to degradation. It can be due to more number of nonuniformly distributed oxygen vacancies present in the wider devices. It has also been observed that increase in capping layer (La) thickness in the NMOS transistor increases the total degradation and we have attributed this to the stress induced trap generation in the bulk oxide.

**Title** : **Evaluating the Scaling Effects on Synchronizers and Global Interconnects in Multicore SoCs**

**Researcher** : Saranya, Yeleswarapu Bala

**Supervisor** : Mekie, Joycee

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 59

**Call No.** : 621.3815 SAR

**Acc. No.** : T00027

**Keywords** : Computer Aided Design, Global Interconnects, High Level Design Phase, Multicore SoCs, PVT, Systems on Chip

**Abstract** : Aggressive technology scaling enables the implementation of multicore SoCs (Systems on Chip) for achieving better performance, but it also poses a great challenge due to various bottlenecks varying from architecture level, design level, gate level to interconnect level. This thesis evaluates the scaling effects on two issues- Global Interconnect Delay issue and Metastability issue during Synchronization. The critical paths of a chip are made of global interconnects which impact the chip performance. These critical paths need to be identified and their delays need to be optimized ahead of the HLD (High Level Design Phase) for the fastest timing closure. This puts the EDA (Electronic Design Automation) community in a challenging scenario as the existing CAD (Computer Aided Design) tools do not support this analysis. This thesis proposes a methodology for synthesizing the critical paths and automating the design with RTL Compilers. Due to the homogeneous and heterogeneous clock regions in multicore SoCs, there is a need for synchronizing the data passing between these clocking domains and hence study of synchronizers is important. This thesis also focuses on evaluating the scaling effects on synchronizers and study of metastability parameters with PVT (Process, Voltage and Temperature) variations. It is found that synchronizer performance degrades due to technology scaling. Detailed statistical simulations and an accurate small signal analysis is done to confirm the above results. The observations match with the measurement trends proposed in the past. This thesis provides an intuition for the reported measurement trends from the process simulations.

**Title** : **Finite Control Set MPC based Distribution Static Compensator (DSTATCOM) for Load Compensation**

**Researcher** : Sreejith, R.

**Supervisor** : Pindoriya, Naran M.

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 46

**Call No.** : 621.3 SRE

**Acc. No.** : T00035

**Keywords** : DSTATCOM, FCS-MPC, Nonlinear, Synchronous Reference Frame

**Abstract** : With the proliferation of nonlinear loads especially the power electronic loads, high harmonic content and poor power factor at the distribution end, the use of DSTATCOM (Distribution Static Compensator) for reactive power control is gaining immense popularity. This state-of-the-art dynamic shunt compensator has immense potential to solve many power quality problems in power distribution systems. The dynamic performance of DSTATCOM under nonlinear/ linear and unbalanced loads in 3-phase, 3-wire 415 V distribution system is studied using Simulink SimPowerSystem based simulation. The purpose of shunt compensator is to balance the supply side currents balanced and sinusoidal with unity power factor. The secondary control objective is to regulate the DC Voltage in order to incorporate for the losses in the inverter. Two control strategies, namely, Hysteresis based current control with Synchronous Reference Frame (SRF) theory based reference current extraction and Instantaneous Symmetrical Component Theory (ISCT) based reference current extraction are compared and their performance is evaluated. Here, we have implemented Finite Control Set-Model Predictive Controller (FCS-MPC) with Instantaneous Symmetrical Component Theory based reference current extraction method for DSTATCOM and compared its performance with the PI Controller. Also, the real time simulation of the proposed model is carried out with the help of OP5600 Real Time Digital Simulation Test Bed.

**Title** : **Frequency Driven Alteration In Cellular Morphology During Ultrasound Pulsing In A Microfluidic Confinement**

**Researcher** : Banerjee, Hritwick

**Supervisor** : Srinivasan, Babji  
and Chakraborty, Suman

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 59

**Call No.** : 621.3 BAN

**Acc. No.** : T00029

**Keywords** : Cellular Morphology, Cytomechanical, Microfluidic Confinement

**Abstract** : To instigate therapeutic potential of low-intensity ultrasound further, it is essential to characterize the bio-physical interaction of living cells with alteration of ultrasound frequency. Although, this study is frequently been the subject of speculation in therapeutic ultrasound regime there has been a distinct shortage of attempts to characterize in situ physical-biological interaction in this process. The dearth of effort in this domain inherently calls for our investigation on frequency dependent shape transition in micro confined biological cells. Here, we used a microfluidic platform for single cell analysis with bio-physical interaction to ultrasound frequency alteration, in line with the fact that microfluidic channels to a large extent mimic the confinement effect induced by micro confinement of physiological pathways. In this dissertation, with the help of series of single-cell direct observation, we show that low intensity ultrasound frequency alteration would reversibly perturb cell membrane structure and count for inherent cell oscillation. However, during post exposure ultrasound period the cytochemical perturbation of cell membrane is relatively more compared to ultrasound exposure period leading to an inherent residual strain which follows a transition zone near to the resonating frequency of the composite system. Together, these findings indicate that alteration of low intensity ultrasound frequency, if applied to a microfluidic platform on the order of minutes, would produce a reversible effect on physical structures of living cells based on the system resonant frequency during and post exposure ultrasound pulsing.

**Title** : **Least Distance Predictor Model for Short Term Load Forecasting**

**Researcher** : Jain, Sherry

**Supervisor** : Pindoriya, Naran M.

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 52

**Call No.** : 621.3 JAI

**Acc. No.** : T00036

**Keywords** : ARIMA model, Load Forecasting, Predictor Model

**Abstract** : One of the foremost issues concerning the stability of power system around the world is regulation of frequency. A balance between supply and demand maintains the frequency constant or within a permissible range. In India, this balance is regulated by imposing Charges of Deviation on power utilities like distribution and generation companies that deviate from their scheduled transactions of energy. This charge is dependent on the system conditions and varies inversely with the system frequency. Imposition of these charges on the participants helps maintain grid discipline, increase grid efficiency, and make the participants more responsible and accountable. The main objective of this study is to identify a constructive approach to reduce the unscheduled energy transactions thereby reducing any deviations from the schedule of a distribution utility. It is proposed that this could be realized in real time through accurate short term forecasting of load demand. Two year (Jun 2011- May 2013) past data of daily load demand of Uttar Gujarat Vij Company Ltd. (UGVCL), a distribution utility in the State of Gujarat is used as a case example. In this thesis, Seasonal ARIMA model is taken as a base model for short term load forecasting. It is clearly seen from the results that the model is not able to capture the characteristics of particular group of days. To overcome this, a least distance predictor model is developed to forecast the daily load of the distribution utility. It results in better load characterization and improved forecast accuracy compared to the similar shape predictor model. This is achieved without using massive amounts of training data, thereby reducing time of execution.

**Title** : **Online Health Monitoring of the Polymer Electrolyte Membrane Fuel Cell**

**Researcher** : Laya

**Supervisor** : Srinivasan, Babji

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 44

**Call No.** : 621.312429 LAY

**Acc. No.** : T00021

**Keywords** : Electrochemical Impedance Spectroscopy, Fuel Cell, PEMFC, Polymer Electrolyte Membrane

**Abstract** : The Polymer Electrolyte Membrane (PEM) Fuel Cell is a widely researched fuel cell, and a very promising candidate for alternate power generation. However, technical issues such as cell flooding and drying prevent its deployment in many applications. Electrochemical Impedance Spectroscopy (EIS) is a very powerful technique used to isolate flooding and drying in a fuel cell. However, the time required to obtain measurements in EIS can sometimes be too large to cause irreparable damage to the cell, rendering it a mere post-mortem technique. This is because EIS perturbs a fuel cell with multiple cycles of a large number of sinusoidal signals at different frequencies. A new technique is proposed that uses the concept of EIS, but excites the cell with a chirp signal, allowing scanning a large range of frequencies in a relatively short time. This technique which we call Fast EIS, is computationally much faster than traditional EIS. Processing of data obtained with Fast EIS is done using two methods - the traditional Fourier Transform division method, and a new Wavelet Coherence method. Simulation results of Fast EIS with PEMFC models taken from literature are shown with performance comparable with that of traditional EIS. The information extracted from Fast EIS is also used for implementing a preliminary control technique to maintain the health of the fuel cell.

**Title** : **Outage Management System for Power Distribution Network**

**Researcher** : Kumar, Gourav

**Supervisor** : Pindoriya, Naran M.

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 48

**Call No.** : 621.3 KUM

**Acc. No.** : T00031

**Keywords** : Advanced Metering Infrastructure (AMI), Outage Management System (OMS), Power Network, SCADA

**Abstract** : Outage detection is the first and foremost step in the electric power distribution Outage Management System (OMS). Unplanned outage detection is very important for improving the distribution system reliability and accessibility. Traditionally, customers' trouble calls are the primary source of outage notification. However, customers report only one third of outages in the first hour of outages. The advanced metering infrastructure (AMI) can send outage notifications almost instantly to the utility and could also give restoration notification when power is restored. AMI data may be corrupted due to communication channel noise and there may also be unnecessary outage notifications due to the temporary outages. In this thesis, an algorithm is proposed to filter out the meter notifications due to corrupted data and temporary outages of duration less than one minute. An AMI data filter is modelled by probabilistic and fuzzy membership functions to remove the corrupted data. Integration of distribution supervisory control and data acquisition system (SCADA) with AMI for outage location finding is also proposed by fuzzy membership function based model. Proposed models have been tested on a radial distribution test feeder and results are analyzed.

**Title** : **Power Flow Control of Hybrid AC-DC Microgrid using Master-Slave Control Technique**

**Researcher** : Kaushik, Rahul Anand

**Supervisor** : Pindoriya, Naran M.

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 48

**Call No.** : 621.3 KAU

**Acc. No.** : T00034

**Keywords** : Hybrid AC-DC, MATLAB, Master-Slave Control, Power Flow Control

**Abstract** : Harvesting the maximum possible energy from distributed renewable energy resources makes the modern electric grid more secure and sustainable. Considering that fact, various technological advancements and government initiatives are initiated to connect this distributed generation (DG) through microgrid to utility grid at point of common coupling. The hybrid AC-DC microgrid is an upcoming trend of microgrid which not only allows the connection of variable distributed AC and DC resources to utility but also reduces multiple conversions in individual AC or DC microgrid. In this thesis, Master-Slave control technique is proposed for smooth power transfer between AC and DC microgrid. It overcome various problems like voltage, frequency variation and circulating current among various DGs in hybrid AC-DC microgrid and applicable for both grid tied and island mode. A hybrid AC-DC microgrid with proposed control scheme has been modeled using MATLAB simulink and real time digital simulator to verify control scheme for reliable and stable grid operation under various load and supply conditions.

**Title** : **Terahertz detection with CMOS: Simulation Studies**

**Researcher** : Jain, Ritesh

**Supervisor** : Mohapatra, Nihar Ranjan

**Department** : Electrical Engineering

**Year** : 2014

**Pages** : 83

**Call No.** : 621.381 JAI

**Acc. No.** : T00028

**Keywords** : CMOS, High-speed communication, MOS, MOSFETs, Terahertz

**Abstract** : ‘Terahertz gap’ refers to the still widely un-utilised part of electromagnetic spectrum. EM waves in THz frequency range have great uses in areas like security and inspection, spectroscopy and material identification, medical diagnosis and high-speed communication. These applications can be efficiently realized only if inexpensive sources and detectors operating at such frequencies are developed. Silicon MOSFETs have a cut-off frequency in range of few tens of GHz. However, active research in recent years has established that Si MOS transistors can be used as power detectors for electromagnetic waves up to frequencies in the THz range, i. e. far beyond their cut-off frequencies. The detection is based on self-mixing of THz signals in the transistor channel resulting in a photoresponse in the form of a DC voltage proportional to the power of incident radiation. Based on this principle, a 1k pixel video camera for 0.7- 1.1 THz imaging application has been recently realised using 65 nm CMOS technology. The transistor operation in THz power detectors differs fundamentally from the operation in typical digital and analog circuits. herefore, it should be expected that the optimum transistor design for THz detectors is different from that of the standard CMOS transistors. Device simulations to study the impact of transistor geometries and doping profiles on the performance of THz detectors can be very useful and such analysis can be used to suggestfor improvements in transistor design. In this work, detailed TCAD simulations to study of the impact of NMOS device design and doping distribution on detector performance are presented. Extensive time-domain simulations are used to obtain the THz response and the impact of different device parasitics and design parameters on this response is analyzed. Improvements in the device design are suggested to enhance the performance of Silicon MOSFET THz detectors.

# **Materials Science and Engineering**

**Title** : **Evaluation of Forming Limit Diagram of Aluminum alloy 6061-T6 at Ambient Temperature**

**Researcher** : Kumar, Manoj

**Supervisor** : Mukhopadhyay, Jyoti

**Department** : Materials Science and Engineering

**Year** : 2014

**Pages** : 92

**Call No.** : 620.11 KUM

**Acc. No.** : T00046

**Keywords** : Digital Image correction (DIC), Die and Punch, Forming, Forming Limit Diagram, Genetic Algorithm

**Abstract** : Forming is a compression-tension process involving a wide spectrum of operations and flow conditions. The result of the process depends on various parameters and their interdependence. The selection of these parameters is still based on trial and error methods. In the present communication a new approach to optimize the geometrical parameters of components and process parameters such as blank holder pressure and coefficient of friction etc. is introduced. The optimization problem has been used with the objective of optimizing the maximum forming load required for the forming. A Genetic Algorithm is also used as a tool for the optimization of drawing load and process parameters. Presently, automobile industries, mainly focus on light weight and fuel efficient vehicles. Their main challenges are to reduce the energy consumption and air pollution. Aluminum alloys have excellent strength, corrosion resistance, recyclability, durability, resistance, ductility and formability etc. Such unique combination of properties makes aluminum the best metal to use in automotive and aerospace industries. One automotive grade Aluminum alloy 6061-T6 is selected for this study. Most of the material properties for both the usage and formability requirements are determined by the tensile test. The tensile test can measure not only elastic properties, but also plastic properties, especially the strain hardening coefficient and plastic strain ratio, which are very important for formability analyses. One of the major formability engineering analyses is to measure strains and strain distributions regarding different stamping quality concerns. In the present work Digital Image Correlation (DIC) technique is used. The Forming Limit Diagram is the primary form of representing formability in the case of sheet metal and it is analyzed in this research.

**Title** : **Mathematical modeling of heat transfer, fluid flow and solidification in melt spinning process**

**Researcher** : Mishra, Rohit

**Supervisor** : Mehrotra, S P

**Department** : Materials Science and Engineering

**Year** : 2014

**Pages** : 65

**Call No.** : 621.4022 MIS

**Acc. No.** : T00045

**Keywords** : Melt spinning process, Navier Stokes, Volume of Fluids, Amorphous Ribbon, SIMPLE Algorithm

**Abstract** : The present work deals with the study of heat transfer, fluid flow and solidification phenomena of rapidly solidifying amorphous ribbons in the melt spinning process. Finite volume based mathematical model using Navier-Stokes equation coupled with heat transfer equations has been developed for the melt spinning process. The model uses volume of fluid method to capture free surface interface. The surface tension force has been coupled with the governing equation in order to get capillary effects on shape and size of the metal pool. The SIMPLE algorithm is used to solve the governing equations.

The model Predicts the effects of different process parameter such as wheel RPM, wheel geometry, superheat, crucible gap and cooling conditions on ribbon thickness, wheel temperature and melt pool, Transient development of heat transfer coefficient over wheel surface and wheel temperature have been studied. The simulation result have been verified with the experimental data. Reasonably good match between the simulated and experimental results indicates that the mathematical model in the thesis can be used for optimizing the melt spinning process.

**Title** : **Processing and Characterization of Pcl-Ha Composites for Medical Application**

**Researcher** : Rooprai, Navjodh Singh

**Supervisor** : Mishra, Abhijit

**Department** : Materials Science and Engineering

**Year** : 2014

**Pages** : 59

**Call No.** : 610.28 ROO

**Acc. No.** : T00043

**Keywords** : Biomaterials, Hydroxyapatite, PCL-HA composite, Polycaprolactone

**Abstract** : The focus of this research is fabricating a polymeric composite for biomedical applications, like bone plates, joint replacement, dental implant etc. and gaining a better understanding of its properties and behavior. Polymers are available in a wide variety of compositions, properties and different form that they can easily be fabricated into complex shapes and structures. But they have poor mechanical properties compared to bone. The biodegradability and the possibility to be mechanically strengthened makes polymers very promising as candidate material for bone replacement. The improvement of the mechanical properties of polymer can be achieved either by the modification of the structure of the polymer, or by strengthening of the polymer with fiber and/or filler. To achieve this objective, the fundamental properties of biomaterial, polycaprolactone (PCL) and their composite with hydroxyapatite are examined. PCL-HA composites are fabricated by using solvent technique. PCL-HA composite samples are prepared to examined their thermal (TGS and DSC), mechanical properties (density, tensile test, 3-point bend test and hardness), according to ASTM standard (D638-03 and D790-03), degradation behavior and viscoelasticity. The results show that adding HA particles o the PCL matrix improves the mechanical, thermal and degradation properties of composite structure. The young's modulus of PCL-HA composites is similar to that of trabecular bone and, therefore, can be used for one replacement.

# **Mechanical Engineering**

**Title** : **CFD Based Coal Combustion and Erosion Modelling for A 660 MWE, Super-Critical Tangentially Fired Pulverized Coal Boiler**

**Researcher** : Pillai, Manish

**Supervisor** : Narayanan, Vinod

**Department** : Mechanical Engineering

**Year** : 2014

**Pages** : 67

**Call No.** : 621.4023 PIL

**Acc. No.** : T00042

**Keywords** : Coal Combustion Modelling, eddy Break-up Model, Erosion Modelling, Super-Critical Boiler, Oka Model

**Abstract** : A CFD based numerical modelling of coal combustion is performed in conjunction with erosion modelling for two samples of blended coal to estimate combustion characteristics, particle and gas flow field and erosion due to ash particles for a large scale, tangentially fired 660 MWe supercritical pulverized coal boiler. The numerical simulation was performed on commercially available CFD code, STAR-CCM+. The Eulerian approach is used to model gas phase and Lagrangian approach to model particulate phase. The particle track is obtained in terms of particle velocity and temperature. The ash particle velocity and trajectories are utilized to predict erosion on boiler components. The coal combustion with coal moisture evaporation, coal devolatilization and char oxidation is considered incorporating eddy break-up model (EBU) for continuous phase. The ash particle track obtained from coal combustion modelling is used to model erosion on internal pressure parts of the boiler, using Oka erosion model. The simulation results show the good agreement with the flow pattern, gas velocity, particle velocity, and temperature distribution with existing boiler. The predictions made for erosion have been found to be in good agreement with the erosion trend observed on existing boiler.

**Title** : **Computational Aerodynamics and Flight Dynamics of Perching Maneuver of Unmanned Aerial Vehicles**

**Researcher** : Dwivedi, Vinay

**Supervisor** : Damodaran, Murali

**Department** : Mechanical Engineering

**Year** : 2014

**Pages** : 101

**Call No.** : 629.1323 DWI

**Acc. No.** : T00037

**Keywords** : Computational Aerodynamics, Flight dynamics, Perching Maneuvers, Propeller performance, Unmanned Aerial Vehicle

**Abstract** : The aerodynamics and flight mechanics of the dynamic maneuver of a low speed propeller powered puller-type Unmanned Aerial Vehicle (UAV) have been modeled solving unsteady incompressible Navier-Stokes equations and six-DOF rigid body flight dynamics equations. The flight maneuver of this UAV is accomplished by swiveling the outboard wings relative to the inboard wing fixed to the fuselage to change the angle of attack towards stall angle to slow down the UAV. To set the stage for a computational aero-mechanics modelling, the performance characteristics of a propeller and the interference aerodynamic effects of its installation on the UAV aerodynamics is assessed numerically. Along with time accurate studies, standard UAV aerodynamic characteristics are modeled on the basis of high fidelity computational aerodynamics. The flight trajectory of the UAV considering the variation of aerodynamic characteristics during the flight maneuver is computed as part of the overall computed solution by coupling the aerodynamics and flight dynamics. A comparative study for various configurations in terms of swivel point and perching rate are also addressed in order to better comprehend and understand the phenomenon.

**Title** : **Computational Modeling of the Condensed Phase Aerosol Based Fire Extinguisher**

**Researcher** : Sharma, Himanshu

**Supervisor** : Damodaran, Murali

**Department** : Mechanical Engineering

**Year** : 2014

**Pages** : 79

**Call No.** : 621.811 SHA

**Acc. No.** : T00039

**Keywords** : Aerosol, Chemical Pellets, Condensed Phase Fire Extinguisher, Solid propellants

**Abstract** : The computational modeling of a novel condensed phase aerosol based fire extinguisher is considered in this study to assess its operational details and performance. A solid propellant is present inside the canister which is ignited using piezoelectric actuators producing hot fire extinguishing gases. The cooling of these hot gases is facilitated by a matrix of chemically active cooling pellets placed along the canister which condenses hot gas and discharges solid aerosol particulates. The initial experimental investigation of the extinguisher carried out at the premises of the industrial partner showed that improper cooling of the hot gases by the pellets can lead to high temperature of the effluent gases and sparks at the exit. This provided the basis for exploring computational modeling to develop a better understanding of the physics of the extinguisher performance and to develop improved experimental procedures on the basis of the results from a computational fluid dynamics model. Initial modeling efforts centered on the finite volume solution of the Euler equations modified to incorporate the essential physics of the problem such as mass flow from the pellets and the heat transfer. On the basis of the computed results from this simplified model, a multi-component combustion gas flow inside the extinguisher is computed by solving high fidelity three-dimensional Navier-Stokes equations. While detailed chemical kinetics are not accounted for in the computation, initial experimental estimates of these processes are used in the simulations to account for the effects on dynamics of the process. The computed results show how improper cooling by the pellet region may lead to hot spots in the extinguisher. These results will be used to improve the experimental design.

**Title** : **Computational Modeling of Wing In Ground Effect Aerodynamics**

**Researcher** : Prasad, Rachit

**Supervisor** : Damodaran, Murali

**Department** : Mechanical Engineering

**Year** : 2014

**Pages** : 82

**Call No.** : 629.1323 PRA

**Acc. No.** : T00040

**Keywords** : Fixed and Rotary Wing Aerodynamics, Ground Effect Vehicles, Wing in Ground Effect, Wings near Wavy Free Surfaces, Volume of Fluid

**Abstract** : The impact on the aerodynamics of a fixed wing, UAV and rotary wing, due to the presence of a ground and free surface in close proximity, is studied using computational methods in this work. The Reynolds Averaged Navier Stokes (RANS) equation are solved for the fluid flow, while the interface between the two fluids is captured using the Volume of Fluid (VOF) technique. The motivation behind this work is to study the effect of wavy or calm surface of a water body or sea on the fixed wing and rotor aerodynamics and compare the difference in the vicinity of a rigid ground surface, which is the approach normally taken to model ground effect in most of the existing computational studies. In order to study the perturbation of the free surface, this study uses a multiphase approach to capture the free surface, rather than pre defining it as a rigid boundary. Waves of different patterns are generated by using appropriate source terms in the momentum equation (by way of a numerical wave maker) and the effect of these on the fixed wing and rotor aerodynamic characteristics are analyzed. The results observe a significant variation in aerodynamic quantities depending on the wave characteristics.

**Title** : **Computational Modelling of Positive Displacement PumpsBoiler**

**Researcher** : Bhandari, Neelesh

**Supervisor** : Damodaran, Murali

**Department** : Mechanical Engineering

**Year** : 2014

**Pages** : 67

**Call No.** : 610.28 BHA

**Acc. No.** : T00043

**Keywords** : Gear pump, Lobe pump, Overset mesh, Positive displacement pumps, Rope washer pump, Volume of fluid (VOF)

**Abstract** : The computational modelling of positive displacement pumps based on Reynolds Averaged Navier Stokes (RANS) equations on unstructured meshes by the finite volume method is addressed in this study. The Volume of Fluid (VOF) method is used to capture the interface between the working fluid and air. Turbulence is modelled using a two equation k- $\epsilon$  RANS turbulence model. The main aim of the study is to compute the flow variables in the pump and to extract pump performance characteristics over a range of varying flow conditions. Experimental studies of pumps only provide data related to flow rates and heads which the pumps can achieve, while with computational study, it is possible to obtain insight on the flow physics inside the pump, and use these insight to propose design improvements for more efficient pump operation. Overset mesh techniques are used to facilitate the motion of the pump components in this computational study. Leakage between pump components has also been considered in this computation. The pump characteristics have been defined in terms of volumetric efficiency, effective flow rate, pressure rating and pump torque. These performance characteristics are used for evaluating optimum range of pump speed, with highest efficiency and flow-rate. This study aims to provide a basis for further research on several design aspects of the pump.

**Title** : **Design And Performance Calculation of a Solar Aided Super Critical Coal Power Plant with Thermal Energy Storage**

**Researcher** : Gupta, Sonia

**Supervisor** : Bhargav, Atul

**Department** : Mechanical Engineering

**Year** : 2014

**Pages** : 80

**Call No.** : 621.042 GUP

**Acc. No.** : T00038

**Keywords** : Parabolic Collector Field, Performance, Solar aided coal fired plant, Thermal energy storage

**Abstract** : To reduce fuel costs and to reduce the impact of power generation on the environment, retrofitting traditional coal powered power plants with clean, renewable solar thermal power has been proposed. However, a detailed estimate of the costs and benefits of such a retrofit need to be quantified in the context of the specific plant location and its load profile. This work presents the concept of Solar Aided Power Generation (SAPG), where a conventional coal fired power plant is hybridised with the parabolic trough field. The operation of a 660 MW supercritical coal fired plant in Gujarat, India integrated with solar field of parabolic trough collectors has been designed for part load conditions. A solar field, based on calculations of solar angle is proposed. A comparative study of both North-South alignment and East-West alignment has been made. The main feature of this hybrid system is the molten salt carrying the solar energy. The energy from a fixed solar field size, coupled with a thermal energy storage mechanism has been designed to replace steam in one of the feed water heaters. The effect of this retrofit on the net efficiency of the coal plant has been examined. Also, a concept of two tank direct molten salt storage has been introduced for this hybrid plant. When thermal energy storage is removed, the improvement in the coal plant efficiency is in the range of 7-14 %. Calculations for the storage systems and the salt-water heat exchanger are also shown. The improvement in the net efficiency of the coal plant comes out to be in the range of 1-3% by using two tank direct thermal storage system.

**Title** : **Recursive and Delayed Reconstruction of Unknown Inputs for Dynamical Systems**

**Researcher** : Chavan, Roshan Anandrao

**Supervisor** : Palanthandalam-Madapusi, Harish

**Department** : Mechanical Engineering

**Year** : 2014

**Pages** : 44

**Call No.** : 620.1074 REC

**Acc. No.** : T00041

**Keywords** : Instrument faults, Dynamical Systems, zeros

**Abstract** : Most dynamical systems have inputs driving the system and the resulting outputs. The inputs to the system can be known or unknown. Unknown inputs in a dynamical system may represent unknown external drivers, input uncertainty, state uncertainty, or instrument faults. In this dissertation we consider delayed recursive reconstruction of states and unknown inputs of a systems. That is, we develop filters that use current measurements to estimate past states and reconstruct past inputs. We further derive results for convergence of these filters in terms of multivariable zeros and show that these methods are a more general form of the methods in the literature. Next, we explore the applicability of input reconstruction methods above to address command following problems in which the objective is to ensure that the system output follows a desired reference command. The key idea is to assume that a control input exists that yields the desired reference output exactly and then use input reconstruction methods to estimate that control input. With this end in view we explore a few control schemes based on the filter-based approach to input reconstruction and demonstrate the efficacy of these methods with illustrative numerical examples.