

S E P T E M B E R
E D I T I O N
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EDUCATIONAL ENERGY UNIVERSITY
KUTCH



**GATE
PERFORMANCE**

FIELD EXPOSURE AT KUTCH

**INVESTORS
MEET**

**INTERNATIONAL
WEBINAR
SERIES**

**FACULTY REFRESHER
COURSE**

**SHELL
RESEARCH
PROJECT**

**TWO DAY WORKSHOP WITH
ONGC OFFICIALS AT KUTCH**

**FACULTY REFRESHER
COURSE**

**SPECIAL
COURSES IN SPT**

SPT MIRROR

THE OFFICIAL MAGAZINE OF SPT PDEU

FROM THE EDITOR'S DESK



Dr. Paul Naveen

The yearlong lacuna breaks free with the periodical release of our SPT Mirror. Congenial devours to each and every bibliophiles, reader and reviewers. This volume thoroughfares 15 vitally important coups that the school (SPT) can exult. These coups encompass School's National Board of Accreditation (NBA) evaluation for the very first time at the outset, significant patent filings, aggrandized publications, top scorers in GATE 2021, Special Core Analysis Lab (SCAL) course, SHELL Energy's R&D projects for burgeoning research areas: Carbon capture utilisation and storage, Green Hydrogen, Biofuels, Hosted Investor's Meet for Oil & Gas Exploration and Production Opportunities in Gujarat, Ministry of Micro, Small, and Medium Enterprises (MSME) aided basic petroleum engineering course (2 Modules) for skill development of nation, field trips/geological expeditions, industrial visits, commencement of new courses viz., Petrochemical Engineering, Augmented reality to monitor the SRP health, faculty refresher programs, and significant placement record in epidemic perceptibly. These verticals reinforced the school's cogency in embarking to Institute of "Centre of Excellence" with advancements in infrastructure and curriculum efficaciousness.

We are heartened to mention that this volume is of gargantuan scenic to us to share laurels with our connoisseurs. SPT mirror sanguinely an important medium of connect between all the affairs of school and our beholders. Optimistically it's gratifying to receive



Mr. Gaurav Hazarika

commendations and accolades from various divergent industry and academe. SPT mirror has always fancied the enterprises and endeavours on the anvil of PDEU together with a stage of baffle brains and retaliate with diverse perception. In addition, it will persist to realization of this benign mantle in the succeeding years.

This volume accentuates stupendous efforts of the School as an avenue to bureaucrats, investors, technocrats, and academe for rescripting energy security, by adopting business reforms in Gujarat for ease of doing Oil and Gas E&P business. GSIRF rankings to feature to be the best private university in Gujarat state. School's NBA accreditation. Sanctions of SHELL Energy projects that parallels the school's research ingenuity in the energy arena. The students outreach and GATE 2021 scorers at touchstone achievements in the all India ranks. This issue also encompasses the motley collection of various acumen in a decipherable manner.

We earnestly believe that you will comprehend our enterprises and endeavours through this medium and capture this a decent read. Your impressions on this volume are welcomed and anticipate it will crystallize our efficaciousness.

FROM THE DIRECTOR'S DESK



SPT Mirror is the reflection of the School of Petroleum Technology and an excellent means to instigate freshers about the magnificent achievements and triumphant events conducted by the SPT. It incorporates variety of topics related to various activities, events, fests, cultural programs etc. SPT Mirror is for the students and by the students, so we will be grateful for your assist by sending us shots/pictures of your industrial training work etc. And we might just use it in the future issue of the SPT Mirror.

I also would like to cordially congratulate the team of SPT Mirror. We hope you are enlightened and enjoy reading this issue as well.

Regards
Dr. R. K. Vij
Director
School of Petroleum Technology

THE EDITORIAL TEAM



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AN INTERVIEW WITH GATE TOPPER OF PDEU AIR-1

Patel AyushKumar SatishKumar from Khambhat,Gujarat is Final year Petroleum Engineering student of Pandit Deendayal Energy University. He started his GATE preparation from March 2020 and studied for around 2 hours on daily basis. He stood out as AIR-1 with marks being 90.67/100. He used to prepare two subjects at a time, everyday 1-2 hour for Engineering Mathematics and rest for core technical subjects. In the last 5 months for GATE exam he devoted around 10-11 hours per day to his study. For removing stress he spend some time with friends for playing cricket. Later he practiced test series to access performance. Important books he referred were :

- 1.Reservoir Engineering : Tarek Ahmed, L.P. Dake and Dandekar
- 2.Drilling Engineering : Applied Drilling Engineering SPE textbook, Heriot Watt and M.Hussain for Numerical
- 3.Production Engineering : Boyun Guo, Heriot Watt and economides. Analyzing mistakes and avoiding it is the strategy he followed to

improve his rank. Making notes and highlighting the important formula and concept helped in revising at last moment. As per him although there is lot of competition in Upstream Sector in India but due to discovery of Gas fields there are ample opportunities in downstream sector and still it is lucrative industry to be in.



A FACULTY REFRESHER PROGRAM

It was arranged by the Director-SPT for the young faculties of SPT on Hydraulic Fracturing, a niche area in the Petroleum Technology domain. The program started on the 27th of February' 2021 and ended on the 11th of April' 2021 after 8 weeks of continuous interactive sessions conducted by Dr Rakesh Kumar Vij Director-SPT, PDEU and Prof Subhash Shah, Chief Mentor, SPT, PDEU for the young faculties. Two hour lectures were organised for two days a week during the afore-mentioned period. The following 10 young faculties had been nominated for the refresher course.

Dr. Pawan Gupta
Dr. Vivek Ramalingam
Dr. Shanker Krishna
Dr. Hari Sreenivasan
Dr. Abhijit Kakati
Dr. Nilesh Jha
Dr. Paul Naveen
Dr. Amit Verma
Mr. Gaurav Hazarika
Dr. Maheshbabu Jallu

Dr Vij had begun with the Introduction to Hydraulic Fracturing (HF) Stimulation and stressed on the need for HF and the Scenerio of Hydraulic Fracturing by Indian Operators. This was followed by a lectures on the 16th and 27th of March' 2021. While the former was an offline faculty meeting conducted to have feedbacks from the attendees, the latter was based on a discussion over case studies on the planning of Hydraulic Fracturing on Gamij field of Gujarat which was purely based on his experience and the faculties appreciated the effort for being able to experience the background work before an actual on field job.

On the 3rd and 11th of April, 2021, Dr RK Vij discussed on the stage gate process implementation and its outcome in the Gamij field,

respectively. He discussed about ONGC's initiative of horizontal well drilling and multistage fracturing of the Chattral Pay reservoir of Gamij. He stressed upon the jobs performed by ONGC during his tenure and the challenges faced during the implementation of HF jobs on field.

Prof Shah delivered his lecture on subsurface stress and direction of the stress for hydraulic fracturing which was a very interactive session on the 6th of March' 2021.

Prof Shah discussed about the fundamentals of HF on the 7th, 13th and 14th March, 2021 where he touched upon frac design models, candidate selection; data required for design simulators and sources. These combined with his continuous interactions were fruitful to some of the faculties working in this area.

On the 20th and 21st of February, 2021 Prof Subhash Shah talked about HF design and optimization. This was followed by a discussion on the uniqueness of horizontal wells compared to vertical wells on the 31st of March, 2021 and briefing on the faculties on the types of fluids and field applications of various fracturing fluids on the 1st April, 2021.

Prof Shah on 7th and 8th of April, 2021 Prof Shah discussed on the available literature on field procedures before the commencement of HF job. He stressed on the pre-job requisites for a successful hydraulic fracturing job. He also discussed some case studies of US which was a need of hour towards the end of this marathon lecture series.

This has drawn the faculties towards Hydraulic Fracturing. Dr Vij and Prof Subhash Shah had taken the responsibility and initiated such an initiative to train the young faculties deserves an appreciation. Dr Vij also motivated the young faculties to take projects from industry on HF and arrange courses for the students of SPT by the in-house experts developed during this course. All faculties were present throughout the lectures and appreciate as it helped the faculties to gain knowledge on HF along with US and Indian industry Scenerio. The facilities were highly benefitted by this program.



PANEL DISCUSSION

HYDROCARBON PROSPECTIVITY IN KACHCHH

ONSHORE AND OFFSHORE BASINS

Kachchh with an area of 45,691.895 square km is the largest district of India. Kachchh District is surrounded by the Gulf of Kachchh and the Arabian Sea in south and west, while northern and eastern parts are surrounded by the Great and Little Rann (seasonal wetlands) of Kachchh. The Kachchh landscape comprises an array of tectonic geomorphic elements and is a manifestation of uplifts and residual depressions. As a result, the area is well known throughout India as a research hub.

Kachchh basin has significant reserves of oil and gas which can be extracted profitably and in turn contribute to the reduction of import of crude oil from OPEC countries. It is estimated that by 2024, production will begin in the Kachchh basin and the government have granted permission for the same.

The panel discussion on the Hydrocarbon Prospectivity in the Kachchh basin was attended by highly respected dignitaries from ONGC, PDEU, SPE PDEU Student Chapter, and the University itself. The Panel

Discussion primarily revolved around the surveys and researches that have been conducted for the past few years and the results which they yielded. It was stated by the research scientists of Kachchh University that the basin holds around 7 million cubic meters of estimated Natural Gas reserves. Dr. R. K. Vij, Director, SPT PDEU and Advisor ONGC Ltd. congratulated the research team for their find and stated that this is an effort done by Kachchh University and PDEU laid another important milestone in the country's road to Energy Security.

Dr. Bhawanisingh Desai stated that we present to obtain a large amount of energy from fossil fuels and much of it is imported from foreign countries despite India having a huge number of reserves. So to maximize our production and reduce the cost factor of imports, the government has permitted exploration here. He also mentioned that the mountain rocks near the Bhuj-Mandavi highway and Jara-Jumara rocks play an important role in the exploration of these reserves. The Panel Discussion concluded with the moderator delivering a vote of thanks to all the panelists.

KUTCH OFFSHORE GAS RESERVE FIGURED IN DGH INVESTORS MEET



With an estimated one trillion cubic feet of gas reserves, the Kutch offshore basin being developed by the Oil and Natural Gas Corporation in Gujarat will be one of the hydrocarbon projects that is expected to figure in the day-long “investors meet” being organised by the Directorate General of Hydrocarbons (DGH) at Gandhinagar on Friday. The conclave that will showcase energy-rich Kutch and Cambay basin of Gujarat, will have representatives and investors from more than 25 oil and gas organisations such as Schlumberger, Shell, Halliburton, Al-Mansoori, Reliance Industries, ONGC, GSPC, Vedanta among others.

“One of the motives behind organising this conference in Gujarat is to sensitise all companies about the feasibility of business opportunity in the state. In the Kutch and Cambay basins, 40 percent of the reserves are yet to be explored,” said Professor S Sundar Manoharan, Director General of Pandit Deendayal Energy University (PDEU), which will host

the event along with the state’s energy department.

SCL Das, Director General of DGH, Tarun Kapoor, secretary of Ministry of Petroleum and Natural Gas and Subhash Kumar, CMD of ONGC are expected to attend. “There are two basins in Gujarat — one is the Cambay basin, while the second is Kutch-Saurashtra basin. In the past 60 years, a lot of work has happened in Cambay basin and it has been producing oil. In Kutch basin, production is yet to start,” said Dr Rakesh Kumar Vij, Director, School of Petroleum Technology.

“The government is scouting for investors for the Kutch offshore project where ONGC has discovered gas reserves, about 50 kilometres offshore in shallow waters near Naliya in Kutch. The cost of developing this reserve is about Rs 5,000 crore,” Vij added.

INVESTORS MEET ON EXPLORATION AND PRODUCTION OPPORTUNITY IN GUJARAT



With evolving E&P policy frameworks of current Indian E&P regime, the Directorate General of Hydrocarbons (DGH) partnered with MoPNG and Energy and Petrochemicals Department GoG have conducted Investors Meet for Oil & Gas Exploration and Production Opportunities in Gujarat — at Pandit Deendayal Energy University (PDEU) in Gandhinagar on August 6, 2021.

The PDEU University served as a host and avenue to launch Upstream India (Operator's Forum) - DSF Bid Round-III; OALP Bid Round- VI. In addition, the meet was open to the E&P companies and approximately 92 Industry delegates were in attendance. During the meet, attendees shared opinions, thoughts and suggestions for consideration during the Policy Initiatives in Indian E&P Sector. Shri. Tarun Kapoor (Secretary, MoPNG, GoI), Shri. S. C. L. Das (DG, DGH), Shri. Subhash Kumar (CMD, ONGC), Shri. Sanjeev Kumar (MD, GSPC), Shri. Mamta Verma (Principal Secretary, EPD, GoG), Shri. C. Laxma Reddy (Additional DG, DGH & MoPNG), and Prof. S. Sundar Manoharan (DG, PDEU) were on hand to open the Investor's Meet. Gujarat Chief Minister, Shri. Vijaybhai Rupani and Shri. Saurabh Patel (Honourable Minister, Energy and Petrochemicals Department GoG) have officially talked through a video acclaiming Gujarat state's vibrant policy for investment and ease of doing business.

The opening remarks were made by Shri. S. C. L. Das (DG, DGH) highlighting the DGH's offers to E&P in Gujarat State. He emphasized on various vital aspects such as - 7 Discoveries in Gujarat which are waiting to be monetized, Exciting package for exploration (Greenfield exploration/Rank exploration) for entrepreneurs and investors, Entire Andaman basin is proliferous and open for exploration, Contemplating

largescale geoscientific data acquisition under the capsule: Vision/Envision, Massive upgrade from less than 1 Petabyte to 12 to 15 Petabyte Cloud based architecture/ virtual data base to access for geoscientists, Upcoming New Ecosystem: Unconventional resources policy, URJA Pragati protocol, New Philosophy/New ecosystem (4 Mantras): Economic growth; Growth in Energy consumption; Move for cleaner energy mix and; Balanced sustainable growth. The keynote speaker was Shri. Tarun Kapoor (Secretary, MoPNG, GoI), who spoke about rescripting energy security, willing to bring business reforms, setting up a target for 15 years - to increase the domestic production substantially. In addition, he invited PDEU to be an academic partner because of its remarkable Centre of Excellence (CoE) and world class infrastructure. While other dignitaries, Shri. Sanjeev Kumar (MD, GSPC) explicated on GSPC's 7 times growth in their gas trading / transportation / distribution activities from 2004 to March 2021 and also mentioned their initiatives to grow more than 15% in energy mix by 2030. Shri. Mamta Verma (Principal Secretary, EPD, GoG) elucidated the state's vibrant economy and its support to the ease of doing business and policy driven regimes. Shri. Subhash Kumar (CMD, ONGC) accentuated ONGC's willing to collaborate and facilitate with their state of art facilities such as IRS, CEWELL.

During the day, meeting participants of various E&P companies (Operators and Service providers) have presented their company's portfolio. Where initially, E&P operators in Gujarat such as Sun Petrochemicals Private Limited (SunPetro), Cairn Oil & Gas, Vedanta Limited, Oilmax, GSPC have emphasized their footprints in Northern Cambay, Southern Cambay, Kutch-Saurashtra's exploration,

development, and production activities. In addition, they have spotlight on technical competences in executing E&P projects. Later on, E&P service providers such as Deep group of companies, ALMANSOORI Petroleum Services, SNF, and Shlumberger have furnished their Capitalising on Technology & Innovation, Integrated project management services. Once after the company's talk Prof. R. K. Vij (Director, SPT, PDEU) have conducted a discussion forum to cross-examine and review the various aspects of E&P activities. Then, following a structured process of brainstorming and information exchange of views in resolving various haunting questions of E&P sector. The panel discussion reached consensus on recommendations and discussed related barriers and solutions to bring resolutions in EOR policy, Technology induction, and infrastructure in regard to

attract investment into the state E&P sector.

Professors of SPT PDEU Prof. R. K. Vij and Prof. Bhawanisingh Desai have demonstrated their insights in Cambay, Kutch-Saurashtra basins where Prof. Bhawanisingh G. Desai (Associate Professor, SPT, PDEU) have talked on Hydrocarbon prospectivity and Geological Evolution of Kachchh Basin: A new re-look with new technology and Prof. R. k. Vij have talked on Overview & Present Status of Cambay Basin.

When all said and done, in the full ness of Investor's Meet Prof. R. K. Vij have concluded the day's program with the closing remarks enumerating on various opportunities in offer with aid of DGH to embrace new ecosystem (Ease of doing Business & Policy support) to attract investment to the State, Gujarat.

CATALYSIS AND HYDROGEN RESEARCH LAB

The Catalysis and Hydrogen Research Lab' at SPT has been working in diverse and highly applied research based on central them "Green Hydrogen production & storage and CO2 reduction into green fuels". The current ongoing research project in Catalysis and Hydrogen Research Lab has been funded by Department of Science & Technology (DST), Government of India and Shell Energy India Private Limited (SEIPL). A group of researchers under the mentorship of Dr. Rohit Srivastava developing a low cost and highly efficient system for Green Hydrogen production and CO2 reduction into green fuels such as green ethanol, methanol and formic acid. Green hydrogen is zero-carbon emission energy. Green hydrogen is the best and cleanest source of energy which can play a valuable fundamental role in the word's decarbonization goal. The lab is completely dedicated to provide a better sustainable clean energy fuels as per the vision and mission set by our Honorable Prime Minister, Shri Narendra Bhai Modi on Independence Day under the umbrella "National Hydrogen Mission". Some of the newly joined group members are as follows:



Sankhula Lokesh: Lokesh recently joined as a JRF in Catalysis and Hydrogen research lab and working on "Green hydrogen project" funded by shell Energy India Private Limited (SEIPL). Lokesh earned B.Tech (Chemical) from Andra University Vishakhapatnam and M.Tech (Chemical) from IIT Guwahati

Sneha Lavate: Sneha is full time Ph.D Scholar. She earned integrated M.Sc. (Nano Science and Technology) from School of Nano Science and Technology, Shivaji University, Kolhapur. She is currently involved to design and developed of advance Nano-hybrid material as electro/photocatalyst for Hydrogen production and CO2 reduction into green fuels. Her Ph.D. research work is funded by DST government of Gujarat under the SHODH fellowship



FIRST OF SEVEN DSF FIELDS IN GUJARAT BEGINS COMMERCIAL PRODUCTION : DGH OFFICIALS



The first of the seven Discovered Small Fields (DSF) in Gujarat that are being monetised by the Directorate General of Hydrocarbons (DGH), has begun commercial production at Kamboi in Patan district on June 11, officials said Friday. These seven small discoveries can together yield an estimated 1100-1200 barrels per day of crude oil.

“These seven discoveries in Gujarat are part of the 75 discoveries across the country that have been tendered out,” said SCL Das, Director General, DGH while talking to The Indian Express on the sidelines of “Investors meet on Oil and Gas Exploration and Production Opportunities in Gujarat” held at the Pandit Deendayal Energy University in Gandhinagar.

These seven discoveries are located in Mehsana, Patan, Anand and Bharuch. These are small discoveries, made by Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL) are 15-20 years old and were lying unexploited due to lack of interest from bigger players.

“The first producer of DSF (Discovered Small Fields) is a new entrant in Gujarat who has started commercial production from Kamboi fields from June 11, 2021,” said Dr Anand Gupta, additional Director General (Development), DGH.

The government has awarded contracts with respect to Discovered Small Fields (DSF) Bid Round-I conducted in 2017 and Round-II held in 2019. Under DSF-I and DSF-II, a total of seven contracts have been offered in Gujarat, all of them are new entrants, without prior technical expertise and DGH is hand-holding these companies for the respective projects. Of the four contracts awarded as part of DSF-I, Kolkata-based Nippon Power Limited was given the contract to develop both Kamboi and West Becharaji near Mehsana.

“The big players were not interested and so we encouraged smaller operators to come in. We have given them some fiscal incentives too. Though 1100 barrels per day of crude is not a big volume, it is important that these unmonetised assets will become functional,” said Gupta said

during an interaction on the sidelines.

Apart from Kamboi, the Khambel field (Megha Engineering and Infrastructure Ltd) in Mehsana district is expected to begin commercial production in September 2021 and the South Patan field is expected to be commissioned by Ahmedabad-based South Asia Consultancy in third quarter of the current fiscal.

Buoyed by the success of DSF-I and DSF-II, the DGH is now offering larger contract areas along with the discoveries to enable developers to carry out exploratory activities.

“We have launched DSF-III on June 10, where we are launching more discoveries and inviting investors to bid for them. We are here today as part of the investors meet. The gas discoveries in Kutch offshore also figures in this round of bidding where ONGC is expected to participate,” said Gupta. The gas discoveries in Kutch were made by ONGC a couple of years ago.

Speaking at the investors meet, Subhash Kumar, CMD of ONGC said, “The discovery in Kutch is a large one. There is 20 billion cubic feet of recoverable reserves. The ongoing DSF round will be very helpful because on standalone basis, the development of that much volume of gas in challenging environment is becoming difficult. So while we will participate (in the bidding) and if someone else finds gas in that area, we can come together, will go a long way in making it a win-win situation. Collaboration would be the key to bring in Kutch gas to early production.”

Gujarat currently produces 5.2 million metric tonnes of oil and one billion cubic feet of natural gas, said Kumar. Speaking at the meet, Tarun Kapoor, secretary of Ministry of Petroleum and Natural Gas said Gujarat currently accounts for 16 per cent of the country’s oil production. “Production wise, Gujarat is doing well even now. But the total area available onshore is still largely unexplored. There is a lot of potential within the state,” Kapoor added.

PDPU is renamed as PDEU



“I am glad to see PDPU is creating its own identity, not just in the country but also in the world. And I am very proud to see that this university is far ahead of its time. In the last one-and-half decades, PDPU has expanded in many spheres, including the energy spectrum, besides the petroleum, sector. Given the progress of PDPU today I would request the Gujarat government to rename it from Petroleum University to Energy University by amending laws.”

- Hon'ble Prime Minister of India,
SHRI NARENDRA MODI

@the 8th Convocation of the University on
21 Nov, 2020

Convocation Link : <https://youtu.be/bIHNIv8BFpc>



DEAR STUDENTS AND PARENTS

CAST in the honourable Prime Minister, Shri Narendra Modi's vision of sector-specific university, PDPU came into being in 200. A journey of a thousand miles began with an accept on petroleum. En route to fulfilling its mandate, the university contributed its mile to safeguarding the energy security of the nation. In just about a decade, while digging deep into oil and gas, PDPU forayed into a wider array of energy sources: solar , nuclear , geothermal, biofuels, hydro, wind and hybrid models for renewables. Rechristening as Pandit Deendayal Energy University was apt, the university in its new avatar of PDEU will continue to work with the same passion and perseverance to establish an energy equitable society. As the name changes the university's passion becomes deeper and perseverance that much more sincere.

The PDEU Prident and Chaiman of the board of Governors, Dr Mukesh Ambani ,has given the university the vision of becoming an efficient and competent source of technical human resources for the industry. Towards that end, PDEU's mission remains three fold (i) undertaking education in energy engineering and management, (ii) nurture students of extraordinary motivation for lifelong learning, and (iii) establishing an institution of excellence in energy education and competitive edge in research.

THE WAY FORWARD

As the university takes its first but firm steps under the new name, it also leaps into industry responsive education. While continuing to harness the appetite for excellence of its faculty and staff, PDEU has prepared itself to meet the needs of Industry 4.0. The university is getting into digital transformation of manufacturing and leveraging third platform technologies, such as big data analytics and innovation accelerators like the (Industrial) Internet of Things and robotics. Towards this end, PDEU has established a Translational Research Centre where dedicated infrastructure for promoting translational research in the areas of additive manufacturing, cyber physical systems, IoT, artificial intelligence, biomedical engineering, nanotechnology and communication systems.

All this, and much more, while nurturing the legacy/ teaching-learning at its four schools: School of Petroleum Technology, School of Technology, School of Petroleum Management and School of Liberal Studies. Come, join this journey of a thousand miles. Happiness is assured.

PDEU CONCLAVE



BRAINSTORMS ON MEASURES TO CURB RISING CARBON EMISSIONS

The two-day Carbon Absorption, Collection and Use-Indo Canadian Research Conclave held at Pandit Deendayal Energy University (PDEU) on Friday and Saturday deliberated on measures to curb rising CO₂ emissions.

Director General, PDEU, SS Manoharan said that PDEU is also working on carbon capture and its collection. For this, CO₂ group has been formed in the University. He emphasized on promoting options such as Solar Energy, Geothermal energy, Wind energy and bio-energy to reduce rising carbon emissions in the country and abroad environment. So that carbon emissions are minimized.

Dr. Prachi Kaul, Director, Shastri Indo-Canadian Institute appreciated the efforts initiated to reduce the CO₂ problem and move towards zero carbon emissions by 2050.

Dr. D.K.Tuli, Advisor, Mission Innovation, India said that efforts are being made to reduce carbon emissions in India as well as to reduce

carbon from the atmosphere. He spoke about algae in the option of eliminating CO₂ and also informed that the Government has proposed a large amount of money for research, innovation through Department of Science and Technology (DST) and Department of Biotechnology (DBT) to eliminate carbon problem.

Dr. Ashish Undkat, Coordinator, Conclave briefed about the opportunity of carbon absorption in India. Introduced speakers from India and Canada. Many speakers explained the new technologies that are working in carbon absorption, storage as well as its use. He also displayed many.

During the conclave, students from IIT Bombay, IIT Gandhinagar, CSMCRI-CSIR Bhavnagar, IAI- Gandhinagar, NEERI Nagpur briefed about the work being done to absorb, store the carbon present in the atmosphere.

PETROCHEMICAL ENGINEERING

Bachelor of Technology in Petrochemical Technology it is an undergraduate degree course in engineering. It is a preferred choice for individuals who want to make a career in Petrochemical field.

This area involves an understanding of logical design development and operations of process systems for the extraction, and revival of economically useful materials. The program attempts to develop individuals with a specialization in petrochemicals, petroleum refining, and other relevant fields. The basic eligibility for this is that a person has to pass 10+2 in science stream successfully.

The students who pursue Petrochemical Technology can work as Instrumentation Design Engineer, Estimation Engineer and Analytical Research Executive in various reputed companies like SRF, Reliance Industries Limited, Haldia Petrochemicals Ltd. and Lanxess-Engineering Company.

The undergraduate course is 4 years categorized into 8 semesters. The major subject topics of the course are mentioned below.

- Chemical Engineering Laboratory
- Heat Transfer Operations
- Optimization Techniques
- Introduction to Petrochemical Engineering
- Petroleum Geology
- Engineering Graphics
- Process Equipment Design and Drawing
- Fluid & Solid-fluid Operations

The petrochemical Industry is concerned with the production and trade of petrochemicals. A major part is constituted by the plastics (polymer) industry, then synthetic fibre/yarn, synthetic rubber (elastomers), Synthetic detergent Intermediates. It directly interfaces with Petroleum Industry especially the downstream sector.

About 5% of the oil and gas consumed is needed to make all the petrochemical products.

Because of the low cost and easy availability, oil and natural gas are considered to be the main sources of raw materials for most petrochemicals. Petrochemicals play an important role on our food, clothing, shelter, health care and leisure.

Indian Petrochemical Industry is one of the fastest growing sector. Union Carbide and Reliance Petrochemicals are few of the largest producer of Petrochemicals in India.

Categories of Petrochemicals :

Light Petrochemicals

Eg: methane, ethane and ethylene

Medium Petrochemicals

Eg: gasoline

Heavy Petrochemicals



Eg : diesel oil, heating oil

Major End Products : Polymer, Synthetic Fibre, Synthetic rubber, Synthetic detergent, Chemical Intermediate, dyes and Intermediates and pesticides.

Basic Building Block Process:

- Cracking : Steam Cracking, Catalytic cracking for Olefins Pyrolysis Gasoline byproduct.
- Steam Reforming and Partial Oxidation : Synthesis Gas
- Catalytic Reforming : Aromatic Production
- Aromatic Conversion Processes : Aromatic Production
- Alkylation : Linear Alkyl Benzene
- Oxo-process : Oxo-alcohol
- Polymerisation Process : Polymer, elastomer and synthetic fibre

Petrochemical Feedstock :

- C1 Group : Methane , CO-H₂ synthesis, synthesis gas and derivatives.
- C2 Group : Ethane, Ethylene, Ethylene derivatives, acetylene.
- C3 Group : Propane, Propylene and propylene derivatives.
- C4,C5 Group : Butadiene, Butanes, Butenes, Pentane, Pentene, Isoprene, Cyclopentadiene.
- Aromatic Group : Benzene, Toluene, Xylene, Naphthalene, BTX derivatives.

Integration of Refinery with Petrochemical :

Advances in processing technologies are playing a larger role in integrating refining and petrochemical facilities. A great deal of synergy exist between the refinery, aromatics complexes and steam cracker complex.

- Low to moderate level of integration uses 5-10% of crude.
- High level Integration : these complexes convert 10-25% of crude oil
- Petrochemical Refinery : these complexes produce a significant amount of petrochemicals as compared to fuels.

STUDENT CHAPTER EVENTS

SPE PDEU STUDENT CHAPTER



PDEU SPE FEST 2020

SPE PDEU Student Chapter hosted the 6th edition of the PDEU SPE Fest and the first-ever virtual grand extravaganza, PDEU SPE Fest 2020, themed 'Pioneering the Prospect,' from November 5th to November 8th, 2020. This virtual fest featured key events such as paper presentations, technical quizzes, and a variety of additional competitions such as distinguished guest lectures and workshops connected to the oil and gas industry. The event gave attendees the chance to showcase their skills and put their technical expertise in the oil and gas sector to the test. It aided students in gaining more knowledge and improving their professional abilities. This mega-event brought together many industrial professionals from around the world, including Dr. Thomas Blasingame (SPE International President, 2021), Shri Tapas Kumar Sengupta (SPE Regional Director, Asia Pacific Region), Shri Arun Kumar Singhal (Chief Editor, DEW Journal), Prof. Subhash Shah (Shell Total Chair Professor at PDEU), Shri Omkar Nath Gyani (HOI, IRS ONGC), and many more esteemed professionals.

The fest witnessed many events including, Guest Lecture on "Evaluation of Low/Ultra-Low Permeability Reservoirs" by Dr. Thomas Blasingame, Guest Lecture on "Field Scale Multiphase Flows" by Dr. Damodaran Vedapuri, Guest Lecture on "Operational Excellence in Petrochemical Complex" by Dr. Kanubhai Parmar, Examen: Case Study Solving Competition, Showcase: Paper Presentation Competition, Chemfluence: Equipment Designing Competition, Bid your Block: Block Bidding Competition, Workshop on Well Test Analysis using Python by Mr. Divyanshu Vyas, Panel Discussion on "Impact of COVID-19 on the Oil and Gas Industry", Catechize: International Quiz Competition, Feud-A-Nation: Dispute Solving Competition, and many more. With their words of wisdom, the dignitaries inspired the participants to continue their careers as aspiring petroleum engineers. Their presence enabled the fest to conclude successfully.



SPE WEEK 16.0

SPE PDEU Student Chapter organized SPE Week 16.0, themed Fresher's Week, from November 21st to December 1st, 2020. The week included a variety of technical and non-technical events designed specifically for freshmen. Among the many events that occurred included: Collide-O-Scope, a debate competition. The topic for the debate was "The Impact of Energy Transition on the Oil and Gas Industry in the upcoming years." The participants were divided into teams of two and had to present their motion. Diwali Decor categorized as Poster Making, Rangoli Making, and Diya Decoration Competition. Participants were allowed to participate in any of the above-mentioned categories; participants were given enough time to prepare and decorate their artwork and had to capture a picture of their artwork along with themselves to ensure the fairness of the competition. Learnapalooza: Alumni Interaction Event. The event was organized to fill up the intermediate gap between the industry and academia. The event was specifically designed for the freshmen who had several questions in their minds after making the decision of pursuing Petroleum Engineering. The event was highly insightful and correlative. Mr. Divyanshu Vyas, Data Analytics Consultant at Dicelytics Pvt. Ltd, was invited as the speaker for the event. Petroplexity: The Puzzle Solving Competition. The event was organized with the sole purpose to welcome and encourage the fresher's to work as a team and help them to be acquainted with the importance of teamwork.

12TH ANNIVERSARY

Participants were allowed to form a team of 2 members each for the event. Special Day Out event, the primary inspiration behind organizing the event was to give a glimpse of student life in the university to the freshmen. During the event, the freshmen got a clear overview of the academic life of the college along with the sensational and remarkable extracurricular facilities that are provided to the students at PDEU. Membership Drive was the last event of the SPE Week 16.0. Even though this drive was conducted on an online platform for the very first time but that did not make the spirit of the event become any lesser instead a very unique level of ardor was present in the air. Freshmen were briefed about the chapter and its various activities. Immense support was displayed by the committee members to assist the newly registered member complete their online registration to formally become a member of SPE PDEU Student Chapter.

GIVING TUESDAY

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SPE PDEU Student Chapter felt gratified on completing an illustrious journey of 12 years and organized the 12th Anniversary Celebration on 5 December 2020. In this due period, the student chapter worked vigorously on extending its horizons to cultivate and nurture budding petroleum enthusiasts and professionals with premier knowledge. In addition to that, we also organized startling events, workshops, and distinguished lectures were organized. The event started with an enlightening speech by Shri Rahul Bali, Sponsorship Chairperson, SPE New Delhi Section, and Ms. Sushma Bhan, SPE DSEA Advisory and Co-Chair DETS. The event was also encouraged by the presence of dignitaries from the SPE India Section which included Mr. Peyush Nene, Ms. Priyanka Panigrahi, and Ms. Pallavi Adhikari Chatterjee. Following which Dr. R.K. Vij, Director, SPT, PDEU delivered a speech describing the achievements the chapter achieved and appreciated the chapter members for working relentlessly throughout to elevate the stature of the chapter. Around 150 people joined from all over the world to celebrate the event. Later, the officers and the executive committee members shared a presentation about the journey so far and future goals to achieve as in what will be the strategy the chapter will follow to lead further. As the celebration saw its conclusion, all the previous office bearers of the Chapter came forward and shared their thoughts and experience on the working of the SPE PDEU Student Chapter. The chapter celebrated this auspicious moment with complete pleasure and congratulated its affiliated members for their hard work and dedication.



SPE WEEK 17.0

SPE PDEU Student Chapter hosted SPE Week 17.0 from the 8th to the 13th of February, 2021, as part of its ongoing efforts to bridge the gap between academia and industry. Among the various events that occurred included: '5MT': Rapid PowerPoint Presentation Competition, the event emphasized on enhancing the critical thinking and communication skills of the participants. In this event, the participants had to create a PowerPoint presentation on the topic assigned on the spot in the given time constraint. Maximum 2 participants were allowed in each participating team. SPE PDEU Student Chapter has embedded service to the society in its core values and in accordance to that organized a Social Initiative as part of the week, The students visited their homes adhering strictly to the protocols imposed in their areas and donated essential goods to the deprived sections. These essential

goods consisted of shawls, old clothes, masks sanitization products, food grains etc. Research Paper Workshop was conducted by Mr. Harsh Patel, alumni of School of Petroleum Technology '16 Batch. He currently works as Process Data Engineer at Shell Business Operations, Chennai. Workshop emphasized on the key points to be kept in mind while preparing a good research paper; correct methodology to be followed, importance and correct usage of references, reduction of plagiarism, and concluding a research paper. Treasure Hunt event was held on the online platform Microsoft Teams and was invigilated by the core committee members of SPE PDEU SC. The competition fostered the analytical and creative thinking skills of the participants within limited time frame. The event was outlined in such a way that in the first-round participants were tested with basic Aptitude Based questions and the second round focused fundamentally on the technical aspects of the Oil & Gas Industries. The fervor and enthusiasm displayed by the competing teams kept the liveliness high throughout the event. Decoding the Disaster, a Problem Solving Competition was based on real-life problems faced in the oil and gas industry history. Teams were asked to make a PowerPoint presentation one day before the event based on the industrial accidents which have occurred in oil and gas industry including the likes of Deepwater Horizon Oil Spill and Piper Alpha platform disaster. RetroSPEct: Alumni Interaction Session was the final event of SPE Week 17.0. The event witnessed the alumni being reconnected with the juniors and celebrated their success and achievements. The alumni provided their guidance and interacted with their juniors as well as the freshmen. They provided insight into the petroleum industry and motivated the students for their future career life.



Guest Lecture on “Transition of India towards a Gas Based Economy”

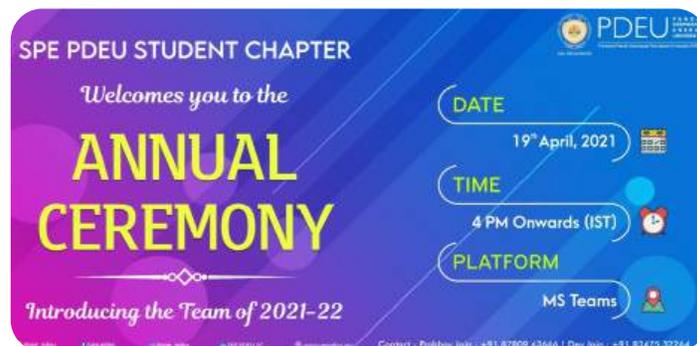
SPE PDEU Student Chapter hosted a guest lecture on ‘Transition of India towards a Gas based Economy’ on 27th March, 2021 which was delivered by Shri Rahul Bali. He presently works as General Manager at ONGC and has an illustrious experience of over 31 years in the oil and gas industry, as well as strategic communications, project management, finance, and the automotive industry. He also serves as the Section Chair at the SPE New Delhi Section.

Shri Rahul Bali began the lecture by recounting his previous experiences in the industry, accompanied by a thorough clarification of the nature of energy transformation and India’s current energy consumption situation. The data depicted the various resources as well as the amount of energy produced by them. The data revealed that there was much potential for meeting the energy demand through Natural gas. He then went on to discuss the different challenges that India faces in transitioning to a gas-based economy, as well as discussed, the potential solutions. The cost of natural gas output, pipeline structure, and storage facilities were the main issues addressed. He explained that the dilemma can be solved by decentralizing monopoly power which covers both the right to manufacture and the export of natural gas. Shri Rahul Bali concluded his presentation with a quote by J F Kennedy, “It is not our wealth that built our roads, but it is our roads that built our wealth”, wherein he cleverly compared the transportation of fuel resulting in an increasing economy.



SPE 12TH ANNUAL CEREMONY

SPE PDEU organized its 12th Annual ceremony on 19th April. This ceremony saw the passing of the baton to the new office bearers for the year 2021-22. The event was graced by Shri Pankaj Kumar, Executive Director, Ahmedabad Asset, Ms Pallavi Adhikari Chatterjee, Communication Chairperson, SPE India Section, Dr. Asish Thaplyal, Secretary, SPE India Section, Dr. R.K. Vij, Director, SPT, PDEU, and Dr. Bhawanisingh Desai, Founding member & Advisor, SPE PDEU Student Chapter, Dr. Amit Verma, Mentor, SPE PDEU Student Chapter. The outgoing committee shared their experiences before assigning the responsibilities to the new office bearers.

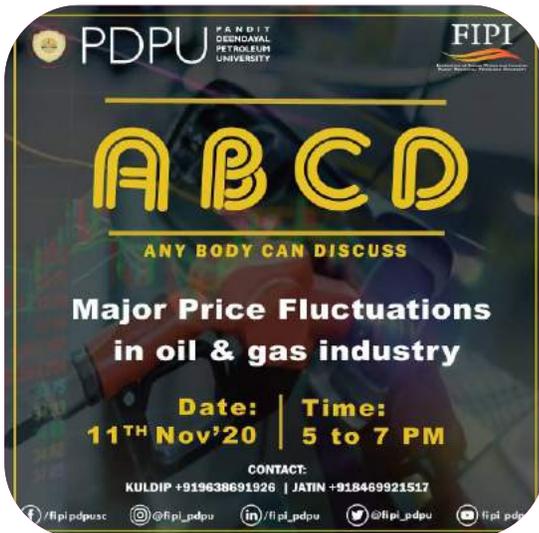




PDEU STUDENT CHAPTER

ABCD - ANY BODY CAN DISCUSS

The stylemark event of the Chapter named ABCD- Any Body Can Discuss was formulated to enhance the capacity to construct reasoned arguments as well as consider the arguments of the other side on a given topic, generally related to the Oil and Gas Industry. In this event a discussion on “Major Price Fluctuations in the Oil and Gas Industry” was conducted. The participants took a few minutes to write down everything they know about the topic of the discussion.



WEBINAR : USE OF PYTHON AND MACHINE LEARNING IN OIL AND GAS INDUSTRY

By looking importance of python in the oil and gas industry, FIPI PDEU SC organized a very Illuminating 3-day workshop on Use of Python and Machine Learning in Oil and Gas Industry by Mr. Jayesh Chahar Reservoir Engineer (data analyst) at Dicylectics.



VIRTUAL PANEL DISCUSSION ON PATHWAYS AFTER B.TECH

To give the students a superior comprehension of the multitude of various fields after BTech and to assist understudies with arranging their vocations in a particular way, FIPI PDEU SC organized an exemplary event named Panel discussion on Pathways after BTech. Throughout the session, panelists discussed Campus Placements, further studies with Specialization (i.e., MTech, Business and Management, MBA, etc.), Abroad study, Civil Services Examination, etc.



10TH ANNUAL CONVENTION

FIPI India organized the 10th Annual Convention on Meeting Energy Demands Amidst Climate Changes, and wherein FIPI PDEU SC also presented their views by giving the message that a true conservationist is a man who knows that his father does not give the world but borrowed from his children.

TECHNOALTAR 5.0

This was followed by the launch the specialized fest, “TechnoAltar 5.0”. The Theme of TechnoAltar was Revolution in “Indigenous Energy Transition”. TechnoAltar consisted of 12 events, including 3 pre-fest online events, viz., Portraire – Meme Making Competition with the Theme of Online Classes, Petroculture- Photography Competition with the Theme of Down the Streets of Indian Traditional Market, and the Aggrandize – Essay Writing Competition with the Theme of Revolution in Indigenous Energy Technology. The fest was of 3 days, and on the first day, the fest was started with the Inauguration Ceremony in the presence of our Guest of Honor Dr. Rakesh Kumar Vij and Mr. Sudhir Kumar, and Chief Guest Dr. Anand Gupta. There was a guest lecture on Indias Future Hydrocarbon Outlook by Mr. Sudhir Kumar. We also had another event called Emblazon-Poster Presentation Competition, and we had conducted the second round of Gollums Riddle and the final round of Countougeo. On the following day, there was a final round of Gollums riddle, loggers hunt, and the Guest lecture by Dr. Rakesh Kumar Vij on AI, ML, and DL in Oil and Gas Industry and Bid-2-win- Virtual Block bidding competition. On the last day, there was an event called Solvier- Case study Solving Competition, Virtual Field Trip, Prastutikaran- Paper Presentation Competition. There was an Award Ceremony where students were given prizes for their fabulous performances in respective events.

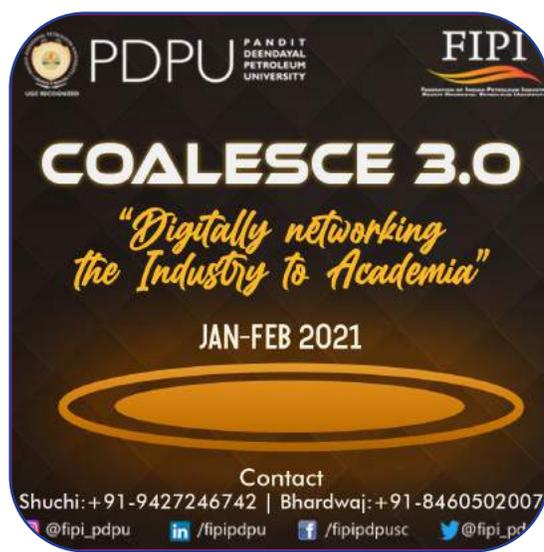


WORKSHOP ON EOR

A virtual workshop on Enhanced Oil Recovery (EOR) with the theme EOR Enablers -Technology &Policy Framework to leverage EOR Potential in India was organized by the Federation of Indian Petroleum Industry (FIPI). The Workshop was organised to refresh the latest technology developments, academic researches, and policy support required in the space of EOR.

COALESCE 3.0

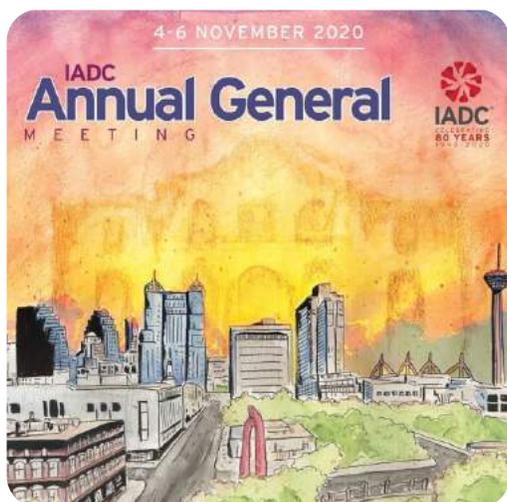
After the tremendous success of the first two editions of Coalesce, FIPI PDEU SC had launched 3rd edition of its name as Coalesce 3.0, which includes eight events like Paheli, Aptacon, Ecoscribe 2.0, Webinar, Workshop, Lecture series, Petrospect, and Social initiative. Wherein Aptacon was an aptitude test and a seminar on “Set your sights on doing masters abroad in association with Renaissance”. Ecoscribe 2.0, which was an online Blogging competition on the Impact of the net-zero carbon challenge. Then 3-day lecture series on the topic Importance of Geology in Petroleum Engineering by Dr. Ashish Sarkar (Master of Science and Ph.D., IIT Kharagpur). An essential part of logical reasoning there was a coding-decoding competition whose name was Paheli 3.0. As a part of the social initiative, FIPI PDEU SC had visited Aarti School to guide the future after class X. To check technical knowledge, there was a technical quiz competition whose name was Petrospect. There was a 3-day workshop on Use of Python and Machine Learning in the oil and gas industry. The Coalesce 3.0 was appreciated by the participants, and they also found it fascinating and informative.





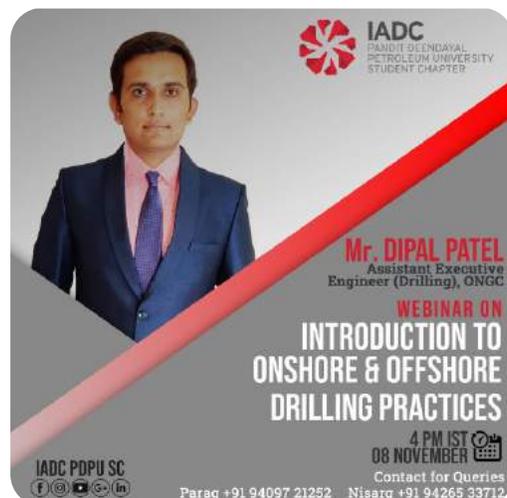
IADC ANNUAL GENERAL MEETING

Between the 4th and the 6th of November'2020, 20 students of our university had got the privilege of attending the IADC 80th Annual General Meeting (AGM) and witness the celebration of the achievements of the industry and the Association. Eminent persons like Dale W. Bradford, VP of Global HSE at Murphy Exploration and Production Company; and Clay Williams, Chairman, President & CEO at National Oilwell Varco, shared their invaluable insight and outlooks with the attendees. In a series of keynotes and panel discussions, IADC's 2020 AGM covered a variety of topics like health, safety, and competency initiatives during the downturn to ensure that they are navigating this market slump the best way they can. It was a great exposure for the participants to explore about the ongoing in the drilling industry and hearing from drilling experts. Virtual presentations from industry stalwarts were really helpful and inspiring.



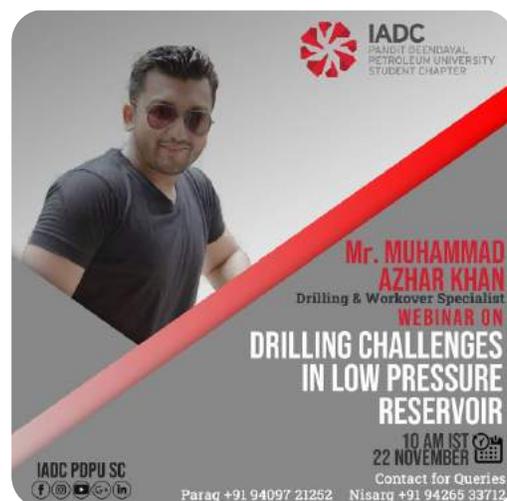
WEBINAR : INTRODUCTION TO ONSHORE AND OFFSHORE DRILLING PRACTICES

On the 8th of November' 2020, IADC PDPU SC had hosted Mr Dival Patel, a PDPU alumnus and an Assistant Drilling Engineer at ONCG, to hold a webinar titled, "Introduction to Onshore & Offshore Drilling Practices". The topics covered during the session were Onshore and offshore drilling Rigs, Types of drilling equipments used, and Various Stages of Drilling Operations.



WEBINAR : DRILLING CHALLENGES IN LOW PRESSURE RESERVOIR

A webinar titled, "Drilling Challenges in low Pressure Reservoir" was organized on the 22nd of November' 2020. In this webinar Mr Muhammad Azhar Khan, Drilling & Workover Specialist, lectured the students about the ways to overcome specific challenges in different wells; challenges in HPHT wells; factors affecting during low pressure reservoir drilling; and important aspects while dealing with such reservoirs. The session was followed by a Case study which helped the participants in gaining a practical understanding of the topic.



WEBINAR : EMERGING E&P CHALLENGES IN OIL & GAS INDUSTRY

Mr Pramod Kumar Sharma (Ex-Director-Operations, IOL) had been invited to lecture the students on “Emerging E&P challenges in oil and gas industry”. The lecture had educated the students about challenges in exploration activities, hydrocarbon resources of India, hydrocarbon potential sources of the Indian sedimentary basin with opportunities and challenges faced during E&P activities of oil and gas resources, along with the solution. The impact of Electrical vehicles and Covid – 19 on the demand of oil was also touched upon.



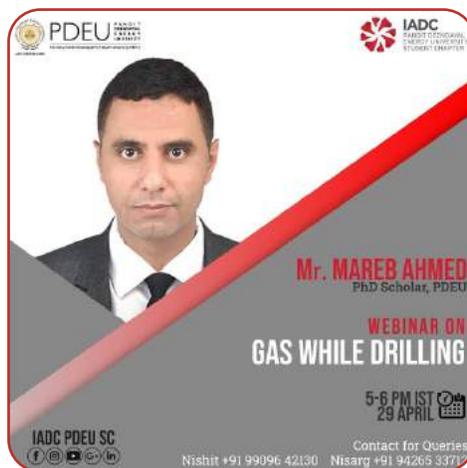
WEBINAR: MWD A PRACTICAL APPROACH

Mr Khalid Karajagi, a then MWD/LWD/RPS Field Engineer at Baker Hughes, on the 27th of March' 2021, to speak on “MWD – A Practical Approach”. Mr Karajagi had touched upon ways of formation evaluation, both onshore and offshore, and data analysis along with some logging tools.



WEBINAR: GAS WHILE DRILLING

In a webinar titled, “Gas While Drilling”, Dr Mareb Ahmed, a PhD scholar from our University and a former Well site and Reservoir Geologist in TOTAL E&P, shared his knowledge and industrialized thoughts on Gas System Components. Major topics covered during the session were: Types of gases while Drilling (GWD), GWD Interpretations which was to be full of various methods like Fluid Differentiation, Gas ratio method, Log Diagram method, Triangular Plots method, Vertical fluid evaluation and Biodegradation.



WEBINAR : HOW TO WRITE A TECHNICAL PAPER

A webinar on ‘How to write a Technical Paper’ received the highest number of registrations for any of our events so far. The webinar was mentored by Dr. Pawan Gupta, an assistant professor at School of Petroleum Technology – PDEU and an author to more than 20 publications till then. From the importance to the craft, every aspect of technical writing was covered during the session. Terms like Plagiarism, Reproducibility, Falsification were explained in detail and ways were suggested to do away with it during the webinar.





SEG-SPG-EAGE PDEU STUDENT CHAPTER

INTRODUCTORY SESSION

SEG-SPG-EAGE PDEU Student Chapters had successfully organized the INTRODUCTORY SESSION for SPT'20 on 4th November 2020, 11:30 A.M. onwards on MS Teams Platform. The session was organized so that students can learn more about our student chapter. This session aimed to demonstrate the significant aspects of petroleum engineering and geophysical science and how the Student chapter plays an important role in shaping one's life growth. Our speakers Mr. Sachin Nambiar, Ms. Nahid Shaikh and Mr. Karan Patel mentioned the various activities of the chapter to give a better idea about our chapter. We also arranged the quiz at the end of the session and exciting prizes for the winners. Lots of students attended the session and introduced themselves. It was a very interesting session as junior students got a chance to introduce themselves and to know more about our chapter. We sincerely appreciate the students of SPT'20 for joining the session and making it marvelous.



FRESHER'S WEEK

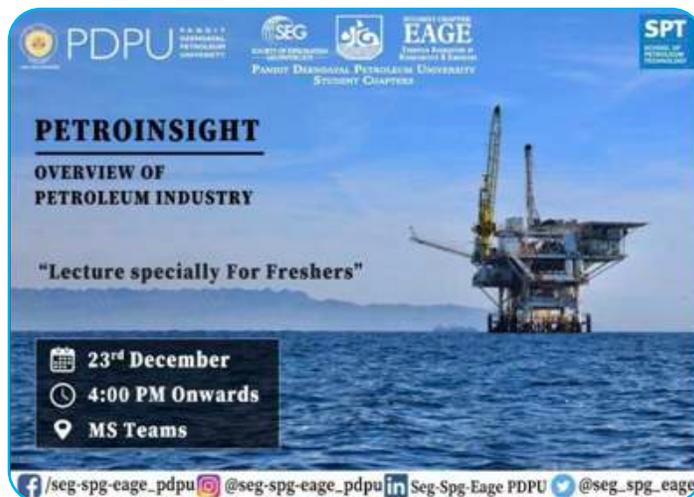
The COVID-19 pandemic is an unexpected ordeal that we are facing together. All the sectors have been adversely affected during this tough time with education being an exception. After organizing successful Introductory Session for SPT'20, we had organized the "Fresher's Week", to give an opportunity to young minds with intense technical excellence and an abreast practical application to showcase their knowledge. It was conducted from 23rd November to 27th November 2020. Fresher's Week consisted of 5 events; Emoji Dumb Charades, Quiznetics, Webinar on GROW - Get Ready for Opportunities at Work, Petrohunt, Webinar on Mathematics in Oil & Gas Industry: A Comparative Approach.



PETROINSIGHT

GATE is an integral aptitude examination for engineering students for earning better prospects after the Bachelor's degree. It becomes very important to prepare for the same with dedication, perseverance, regularity and in a planned way.

We were elated to host Mr. Raunak Gupta (AIR - 4, GATE 2019) to deliver a talk on "Road to GATE". He guided the students with salient requirements to score a good rank in GATE. His principles and guidance helped everyone to ignite a spark of excellence in their preparations. It was really an informative quest for the students.



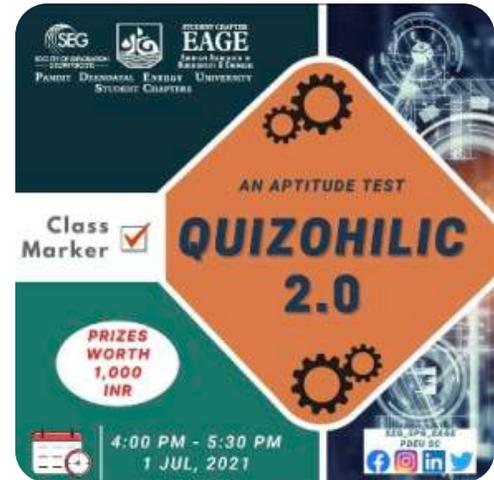
DIALOGUE SESSION ON ENGINEERING

In today's world, everybody has a technical degree but few of them have employment. To understand this situation, we organized webinar a on "Engineering Employability and Beyond" on 27th February 2020 through MS Teams from 3 pm onwards. The session was delivered by Mr. Soham Pathak (Financial Modelling & Valuation Analyst (FMVA); Certified Six Sigma Executive (CSSE)). First of all, Mr. Soham Pathak begun the lecture by giving us a brief introduction about key agenda and after we discussed many topics like Common skillset of Engineer, Career Pathways, Myth Busters, Employability, Capability Development Framework. He had solved all questions raised by participants and also cleared all their doubts. The session was very encouraging, inspiring, and informative. We anticipate the participants had clear mind-set of the topic after attending the session.



QUIZOHOLIC 2.0 - AN APTITUDE TEST

To succeed in any of your future career alternatives, you must have a high aptitude to get past the preliminary stage and meet the screening criteria. We, the SEG SPG EAGE PDEU Student Chapters, held an outstanding event called "QUIZOHILIC 2.0 - An Aptitude Test" on July 1, 2021, from 4:00 to 5:30 P.M, using the online platform ClassMarker. It was a fantastic opportunity to put your eligibility and aptitude skills to the test in preparation for job interviews and any other exam. Numerous talents were tested, including arithmetic reasoning, verbal reasoning, abstract reasoning, speed accuracy, and others. 250+ students from 14 different universities representing various engineering areas attended the event to display their abilities and talent. Finally, the winner received a monetary prize of Rs.1,000 as well as a Certificate of Appreciation. All of the winners are congratulated by the Student Chapters. We praised all of the participants for their excitement and look forward to seeing them at future events.



WEBINAR ON "OUTLOOK & OPPORTUNITIES IN VARIOUS SECTORS FOR ENGINEERING EDUCATION AMIDST & POST COVID -19"

The webinar was held with to inform future engineers about the prospects that exist in the current pandemic situation, as well as the skills that must be developed to establish career chances. A total of 65+ students from various universities and engineering branches participated in the webinar. Mr. Rajendra Singh Sisodia's talk was very informative, and the Student Chapter would like to thank him for it and hope to have more lectures with him in the future.



PLACEMENT TALK

SPT takes pride in her meritorious students. Having spent four years with us, students not only get well-versed with their technical lessons but also hold a good command over their soft skills. Even in the toughest times of the pandemic, our students had had themselves placed in reputed companies.



Recruiters like Shell, Infosys, Cognizant, Ernst and Young, Excel, Wipro, Adani Gas, ExxonMobil, Infosys, Sabarmati Gas and Torrent Gas, had taken many of our students.

IADC PDEU SC had organised the “Placement Talk” event, on the 27th of June’ 2021, in alliance with the other Student Chapters of SPT, like, FIPI, SPE and SEG-AEG-EAGE. The event was meant to showcase the success of our fourth-year students and to guide the upcoming batch about the challenges that might pose a hurdle in the way. The event was hosted by Mr Eshaan Verma, a then sophomore student of our School. Guest speakers in the event were Dharti Patel, Yogini Lakhani, Dixit Sabhani, Het Patel, Smeet Patel, Parth Patel, Gairik Chakroborty, Jenisgiri Goswami, Pranay Patel, Pal Pandya, Anish Singhi, Brijesh Gondiya and Dhyan Rathod. The host invited the speakers one by one to share their experiences and the audience paid keen attention to whatever they said. Even the minutest doubt was tried to be clarified. Finally Mr Eshaan ended the event with the vote of thanks.

INTERN TALK

School of Petroleum Technology, Pandit Deendayal Energy University in collaboration with SPE PDEU, FIPI PDEU, SEG-SPG-EAGE PDEU, and IADC PDEU Student Chapters organized Intern Talk on 18th January 2021, an interactive session wherein the final year student interacted with the pre-final, sophomores, and freshers.

The final year students provided insights into the process of selecting a proper internship and then reap maximum benefits from the same. They then elucidated on the prerequisites and qualifications which we require to have in place for that particular intern role. They emphasized the importance of their study and practical tasks. They also addressed the operating atmosphere and situations per the company's requirements. They also discussed the significance of internships in terms of campus placements.

The session helped the attendees comprehend both offline and online internship experiences, how to approach different industries for internships through different speakers. The insightful and interactive discussion concluded with a Q&A session.



INTERNATIONAL WEBINAR SERIES FOR THE BRANCH OF RUSSIAN STATE UNIVERSITY OF OIL AND GAS NAMED AFTER I.M. GUBKIN IN TASHKENT, REPUBLIC OF UZBEKISTAN

In accordance with the signed memorandum of understanding between PDEU and Russian State University of Oil and Gas, SPT, in conjunction with FIPI PDEU and OIR PDEU organized a 5-day International Webinar Series on the oil and gas sector for the branch of the Russian State University of Oil and Gas named after I.M Gubkin in the city of Tashkent, during 20th -24th September 2021. The event began with introducing the esteemed faculties of Pandit Deendayal Energy University, followed by an ardent interaction with the faculties and students of the Russian State University. The objectives of this webinar were highlighted by the Director of Pandit Deendayal Energy University in the program induction. Then, Dr. R.K. Vij began his lecture at 11 UZT Time and addressed how oil companies are building more prominent supercomputer centers to analyze seismic and drilling data quickly. Then, at 1:00 UZT time, Dr. Shanker Krishna began by elucidating the Role of Geo-Mechanics in the Oil and Gas Industry. At 3:00 UZT time, Dr. Shanker Krishna and Dr. R.K. Vij concluded the session, leading to a great end to day 1 of the webinar.

On 21st September 2021, Mr. SSP Singh delivered the first webinar on industrial oil & gas field production operation. He started his lecture with a brief introduction to the petroleum asset value chain and the life cycle of petroleum engineering. Throughout the session, he covered many topics like well connection configuration, well manifold, wellhead and well fluids, simplified well head fitting and piping, Christmas tree components, etc. The interactive session lasted over 2 hours. Mr. Santosh Rampilla delivered the second webinar on Advanced logging techniques for reservoir characterization. The plenary began with an introduction about the use of Advanced well logging tools and approaches towards Improved reservoir characterization and their value to reservoir engineering. He briefly explained different well log techniques and tools. Mr. Gaurav Hazarika delivered the last webinar on the Matrix Acidization. Throughout his session, he discussed about field procedure for matrix acidization. He introduced the participants to the Injectivity test. Also, he explained three case studies that he practically encountered during his career. His remarkable depth of understanding of the subject made the session an exceptionally stimulating and informative one. With this session, the second day of the International Webinar series concluded.

On the Third Day, Mr. B.B. Ray started the session with a brief description of Geological aspects in oil and gas field development. He explained how petroleum geology is concerned with the structural configuration of the crust of the earth. Mr. B.B concluded the session by briefing about Proven Reserves and how Stochastic Model works.

The last webinar of the third day of the International Webinar series was on Offshore Operations & Technology. The session was presided over by Dr. Hari S., who firstly discussed how the development of welding design philosophies for deepwater offshore structures took place over time. In his session, he discussed environmental loads acting on an Offshore platform, Floating production storage and offloading, Mooring systems, and different types of Marine risers.

On 23rd September 2021, the fourth day of the International Webinar Series commenced at 10:10 UZT Time with the webinar on Redevelopment of Offshore Oil Field by Dr. R.K. Vij. He started the session by explaining how



two-thirds of the world's daily oil production comes from mature fields. The session also included the history of the production of crude oil in India from 2006 to 2016, along with the field details and generalized stratigraphy. The session also contained information regarding the reasons for production decline and what short-term actions were taken for it. The session was concluded with a briefing on the Management field. The next Webinar was on Machine Learning for Petroleum Engineer's which was delivered by Dr. R.V. Marathe. It was intended to make participants aware of the importance of Machine learning and big data in the oil and gas industry. In his session, he discussed about deep learning, Linear and Non-Linear classification problems, Building Predictive Machine Learning Models, and Application of Typical Data Categories models in Reservoir Engineering. With this session, the fourth day of the International Webinar series concluded.

On 24th September 2021, the Fifth Day of the International Webinar Series commenced at 10:10 UZT Time with the webinar on Gas Hydrate Technology by Dr. Pawan Gupta. He started the session by explaining how accurate, consistent and timely energy data are fundamental to developing effective and efficient national energy policies. The session was concluded with the topic of methane recovery from hydrate reservoirs. The next Webinar was on Coal Bed Methane Recovery, which was delivered by Dr. Paul Naveen. The session commenced with a statistical review of world energy. He projected a clear understanding of the importance of unconventional energy resources technology in context with world energy demand and why Coal Bed Methane (CBM) gas has gained its prominence at the commercial scale in different countries. The overall session discussion benefitted the faculties and research scholars. To maintain the enthusiasm of the webinar series and check the knowledge gained by the students, a quiz was conducted on the last day based on the topics discussed in the lectures. After the quiz ended, a valedictory ceremony was organized to celebrate the accomplishment of the 5 Day International Webinar Series and bid a final goodbye to the students and faculty members of the partnered university. The occasion was graced by the presence of our guests of honor, Professor S. Sundaram, Director General, PDEU, and Professor Abdulla Magrupov, Deputy Director-executive director, Russian Stage University. The ceremony ended with a vote of thanks by Mr. Gaurav Hazarika.

1ST ANNIVERSARY OF IADC PDEU STUDENT CHAPTER



The date of 28th September, IADC PDEU Student Chapter marked one glorious and amazing year since its establishment in Pandit Deendayal Energy University. This was just first destination, ahead of many milestones yet to come.

To look back and commemorate the achievements in the past year, IADC PDEU SC held the celebration of 1st anniversary at the campus. The chief guest of the day was Mr. Ved Prakash Mahawar, Ex- Director (Onshore), ONGC. He has an experience of 34 years in managing drilling and operational functions. He is the man behind controlling the recent Baghjan Blowout and more than 30 other blowouts across the world.

The celebration started with a video showcasing the journey of IADC PDEU SC and highlights of the various technical and non-technical events, initiatives, training and mentorship programs organized throughout the year. The training mentors, Mr. Anwar Momin (QHSE Manager, Shelf Drilling), Mr. Joachim Meulen (Secretary, DROPS Asia) and Mr. Randeep Gandhi (Former GM, Shell) shared their experiences with IADC PDEU SC and sent best wishes for the team.

The host of the day, Mr. Vaidik Chaudhari welcomed all the guests, faculties and the students. Dr. R. K. Vij, Director, School of Petroleum Technology felicitated the chief guest and delivered the welcome address. He praised and acknowledged the sincere efforts of team IADC PDEU. Then Prof. S. Sundar Manoharan, DG-PDEU shared his auspicious words and talked about the genesis and growth of IADC PDEU SC in front of his eyes in the past year. After that, Mr. Virag Poshiya, Chairman of IADC PDEU SC thanked everyone who played a part in the journey of IADC PDEU SC and extended his gratitude to all for gracing the occasion. With great enthusiasm, Mr. V. P. Mahawar shared his journey in the oil & gas industry. He spoke about the importance of safety, marvels and

innovations in drilling technologies found nowadays in the industry. He advised young minds to be confident and passionate in completing each task that we are assigned, no matter how small or big.

After a short tea break, Mr. N. K. Jain (Ex – ED, ONGC) gave a presentation named Rig- Zoo that certainly tickled the funny bone of the audience as he talked about how a lot of rig equipment and their nomenclature is related to animals and birds.

Mr. Vishnu Rawal (Head of Drilling Services, ONGC-Mehsana) shared his journey that motivated the students. Then, Mr. A. K. Gupta (Drilling Supervisor, Kuwait Oil Company) shared important tips to keep in mind for a successful career as a drilling engineer. Dr. Amit Verma (Assistant Professor- School of Petroleum Technology) gave a presentation on the overview of the drilling industry and how PDEU plays an important role in preparing the next generation of energy soldiers.

Dr. Hari S (Assistant Professor- School of Petroleum Technology) took the opportunity to share the news about the latest patents registered by the university. Mr. Arun Karle, in his virtual address advised the students to think out of the box and to never forget the importance of safety even in daily life. Mr. Mike Dubose (Vice President – IADC), who joined the celebration from Houston wished IADC PDEU SC for the milestone and talked about the role of student chapters in spreading the practical knowledge required in the industry.

Towards the end, Mr. Gaurav Hazarika (Assistant Professor- School of Petroleum Technology) delivered his closing remarks and a vote of thanks to everyone for being present on the occasion of the 1st anniversary of IADC PDEU SC. The celebration was ended with cake cutting.

DESIGNING CO₂ FLOOD

ABOUT THE AUTHOR

Ms. Aditi Trivedi, M.Tech (Petroleum Engineering) Graduate at SPT, is working on Heavy Crude Oil Characterization for her dissertation under Dr. Uttam K. Bhui, Associate Professor, SPT. In this article, she hopes to acquaint the readers with the possibilities of Spectroscopic Studies in understanding Crude behaviour at molecular level which ultimately opens a gateway for addressing many problems in Oil & Gas Industry.

GEOLOGY

Because of the high cost of CO₂ when compared with water, a much higher degree of reservoir description is required for CO₂ flooding than for waterflooding. This makes the preparation of a geologic picture of the greatest importance. Using cores, logs, tracer tests and well tests, the best possible description should be made of the formation, including: (1) cross-sections showing pay zones and tight sections; (2) formation rock descriptions; (3) structure maps, and (4) Isopachs.

A knowledge of the depositional environment is helpful in constructing such a model. The use of simulators to match prior performance is also helpful. The later may point out zones of anomalous performance which can be correlated with the geologic picture.

PETROPHYSICS

One of the most important items to determine is the oil saturation at the start of CO₂ flooding. Estimation from logs is not very accurate. Perhaps the best technique is pressure coring. A careful laboratory analysis

is then required to determine how the residual oil saturation varies as a function of rock type and rock properties.

In addition to oil saturation at start of flooding, the petrophysicist must arrive at a description of porosity and permeability throughout the reservoir.

This must be integrated with the geologic picture. Rock wettability is important, as discussed previously. To determine rock wettability it is usually necessary to core with a mud containing no surface-active agents and to test for wettability immediately on site. Wettability can change rapidly as evaporation and oxidation take place.

WETTABILITY

Determination of formation wettability is both important and difficult. Trapped oil is apparently more easily contacted by CO₂ after alternate water injection when the formation is partially oil-wet than when it is strongly water-wet. In strongly water-wet formations, CO₂ can only contact residual oil by diffusion through surrounding water.

The best method for determination of formation wettability is by use of native-state cores. Pressure coring is the most reliable method for retrieval of such cores. It allows their retrieval at near in-situ conditions. A proper mud system must be used, of course, to prevent changes in wettability during coring. The mud should be carefully designed to minimize flushing. An optimal penetration and mud circulation rate should be used.

Recommended coring fluids are: (1) synthetic formation brine, (2) unoxidized lease crude oil, and (3) water-base mud with minimum additives. Additives such as surfactants, caustic, and mud thinners should be avoided. De-aerated brine or formation water with an oxygen scavenger should be used in a water-base mud system.

The core must be protected against

loss of light components of the crude and against oxidation. It should be wrapped with a polyethylene film, then with aluminum foil, and then sealed in wax or plastic. In pressure coring, the cores are frozen before the pressure is bled off. They are then stored frozen. Samples from these cores may now be used for wettability studies.

Samples from these cores may also be used for flow and displacement studies. In choosing samples for analysis, X-ray tomography is helpful in identifying heterogeneities. In the case of sandstones, only small samples parallel to reservoir bedding planes should be chosen for flow experiments. These may be butted together with a capillary bridge such as facial tissue between them. The capillary discontinuity introduced in this manner should not be a problem in miscible flooding, if CO₂ enriched with enough intermediate hydrocarbons to be miscible with the residual oil is used for the displacement experiments.

MISCIBILITY CONDITIONS

CO₂ is a very powerful vaporizer of hydrocarbons. Hydrocarbon fractions as heavy as those in the gasoline and gas-oil range are vaporized into the injected CO₂. This enables CO₂ to develop miscibility even though there may be very little of the ethane through hexane components in the crude oil. The mechanism by which CO₂ miscibly displaces oil is through a multiple contact extraction of hydrocarbons in the C₅-C₃₀ range. Suitable oils are usually in the 25-45 API range and are present in the reservoirs deep enough so that displacement can take place above the minimum miscibility pressure. For 40 API oils, the minimum miscibility pressure ranges from 1200 psi at 100 F to 3000 psi at 250 F.

The multiple contact extraction required to achieve miscibility requires the CO₂ to move some distance through the reservoir.

As the bank forms and moves, it tends to be dispersed both transversely and longitudinally. Additional extraction by CO₂ re-establishes miscibility. Two wells drilled in the Mead-Strawn.

Field give some idea of the distance required to achieve miscibility in a reservoir. About four years after the CO₂ slug was injected, two wells were drilled and cored. In the well drilled 60 ft from the injector, the average oil saturation was 10% PV. In the second well drilled 400 ft from another injector, the average oil saturation was less than 5% PV. This was interpreted to mean that at a distance of 60ft from the injector the slug was partially effective, but that it was still being formed and became more effective at greater distances. The oil saturation prior to CO₂ flooding was estimated to be about 25% PV.

At temperature lower than about 120 F, the phase behaviour is more complicated than that just discussed. Two liquid phases can coexist. These two liquid phases can then be in equilibrium with a vapor phase. Dynamic miscibility, however, can still be achieved under these conditions.

RECOVERY PREDICTION

With the above basic data at hand, the engineer must now arrive at a process design and recovery prediction. He must choose the following: injection pressure, injection slug size, continuous CO₂ injection or alternate injection of water, well pattern, and zonal isolation (if required or feasible).

In a gravity-stable flood, the CO₂ is injected above the oil zone. Drive gas is then injected above the slug. In this case some additional design factors are: (1) critical rate for stable displacement, (2) initial placement of the CO₂, and (3) estimation of coning into the producing wells.

The critical rate, u_c , in ft/day may be calculated from the equation:

$$u_c = \frac{0.0439(\rho_o - \rho_c) \sin \alpha}{\mu_o/k_o - \mu_c/k_c}$$

where ρ_o and ρ_c are oil and CO₂ densities in lb/ft³, μ_o and μ_c are oil and CO₂ viscosities in cP, k_o and k_c are oil and CO₂ permeabilities in darcies, and α = dip angle, relative to horizontal.

Pressure transient data should be obtained

and analyzed to determine directional permeability and barriers to flow. Analysis of a previous waterflood is critical to the success of a CO₂ flood. Production history matching with a reservoir simulator will be of enormous aid in guiding performance prediction using CO₂.

Reservoir simulation of the CO₂ flood is the next step in recovery prediction. Numerical finite difference simulators are the commonly used tools for this purpose.

Although reservoir simulators can treat nearly all aspects of CO₂ flooding, they can treat them all simultaneously. It is here that engineering judgment becomes important. Is vertical permeability so limited that the reservoir can be treated as a stack of non-connected parallel layers? Can several representative areas and patterns be chosen? How can the complete reservoir behavior be modelled from those areas and patterns? Has a pilot been run? Can this be simulated and the results then scaled up to field scale?

Simulators for CO₂ flooding are basically of two types, black oil simulators and compositional simulators. In both, the difference equations which model the flow and other mechanisms are approximated by finite differences. The resulting finite difference equations are then solved on a high-speed computer. The reservoir is represented by a grid as shown in figure:

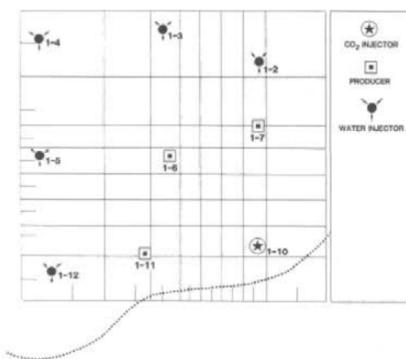


Figure : Areal grid for a Simulator (Courtesy of the Society of Petroleum Engineers)

The pressure and saturation changes are then calculated for a series of small time increments.

In black oil simulators, reservoir oil is represented by two components, stocktank (black) oil and gas. It was noted that black oil simulators could also be used for miscible

flooding by modifying the expressions for relative permeability and capillary pressure.

In compositional simulators, multicomponent mixtures are used to represent the oil and gas phases. Phase compositions are usually calculated using K-values. Phase properties are calculated either from correlations or from equations of state. Calibration of the K-values and of the equations for phase behavior with experimental P-V-T data is recommended. Slim-tube experimental results are another calibration point. Viscous fingering is often represented in compositional simulators by a mixing parameter.

The formulation of a Simulator which takes advantage of the best features of both the black oil and compositional simulators. Considerable experimental data is required to calibrate this system.

It is common practice with simulators to choose representative field patterns and to make the calculations for those patterns. This can be done for the different areas of the field, which have different physical properties and/or different patterns. Engineering judgement is required in choosing representative areas and patterns.

EXAMPLE SIMULATION

A miscible flood performance prediction was presented for CO₂ flooding in the San Andres Formation at Wasson by Bilhartz (1978). In this reservoir, there are a number of well-defined non-permeable anhydrite units which effectively limit vertical permeability. Thus, the reservoir simulation was limited to the flow in non-connected vertical layers.

The authors used a black oil simulator with a mixing parameter. They used 16 vertical cells and 20 horizontal cells. The model was calibrated by first matching previous waterflood performance for selected areas of the field. Permeability of the various layers was adjusted during this match.

The CO₂ flood predictions were then made for a 20% hydrocarbon pore volume slug injected alternately with water. The mixing parameter was determined by matching the saturation changes observed in the logging observation well in a small pilot test. The pilot test indicated that a mixing parameter of about 2/3 best represented CO₂ flooding in this reservoir.

OIL RECOVERY

Field tests conducted thus far showed that CO₂ can recover a significant fraction of the oil left as residual after a waterflood. Some of the highest recoveries have been reported for the San Andres carbonate reservoir in West Texas. The slaughter Estate tertiary recovery pilot test in that formation was projected to recover about 20% of original oil-in-place for a 26% hydrocarbon pore volume slug.

The little Creek pilot in the Tuscaloosa Sand in Mississippi reported a very high recovery of 30-35% of initial oil-in-place. The slug size in this case was very large (160% hydrocarbon pore volume). The Tuscaloosa Sand has a very high initial water saturation (56%) due to a network of very fine pores. The larger pores which contain oil are apparently very accessible to injected CO₂.

Lower oil recoveries than these have been reported at SACROC (3.5% of original oil-in-place) and Levelland (6% of original oil-in-place). This makes it imperative to conduct both laboratory flooding tests and pilot tests in a formation different than those already tested.

SLUG SIZE

A 40% hydrocarbon pore volume CO₂ slug was chosen by the National Petroleum Council(1984) in their estimation of U.S. oil recovery by CO₂ injection. They assumed

alternate injection of CO₂ and water in a ratio of 1.5 reservoir pore volumes of water per volume of CO₂. This was followed by water injection to the economic limit. Half the injected CO₂ was assumed to be purchased and half recycled. This reflects current practice in relatively homogeneous reservoirs such as the San Andres in West Texas.

Although the 40% slug size may be used for screening purposes, final selection should await a geological, petrophysical, and reservoir simulation study. More heterogeneous formations will require more CO₂ (possibly through recycling) and more water. This again points up the necessity of a thorough reservoir study prior to undertaking a field-scale flood.

Production of a significant fraction of the CO₂ slug should be anticipated. Again, reservoir simulation should give a good idea of when this should occur and how it will increase with time. In typical cases, 20-60% of the slug is expected to be produced.

SUMMARY OF DESIGN STEPS

The following list of design steps is from the recent paper by Holm and O'Brien(1986):

- (1) Measure gravity, molecular weight, C5-C30 content and type, and asphaltene content using oil sample from candidate reservoir.
- (2) If the reservoir flow paths are not primarily fractures and if the gravity of the oil is lighter than 12 API, it is likely to be a candidate for CO₂

flooding, either miscible or immiscible.

(3) Estimate minimum miscibility pressure (MMP) using correlation. Conduct slim-tube experiments to establish MMP more accurately and observe phase behavior of oil sample in visual cell as CO₂ is added. Measure volume and viscosity of oil as a function of the amount of CO₂ dissolved in the oil.

(4) Based upon the above data and taking into account the reservoir pressure and depth, decide whether oil displacement will be miscible or immiscible.

(5) Process core and well log data to establish a geological model of the reservoir. Conduct pressure transient and oil saturation measurements in the field. Determine rock wettability.

(6) Construct a computer model based upon the reservoir data and determine the well pattern, injection and production rates, and slug size that will maximize sweep efficiency. The model will also provide oil and CO₂ production predictions.

(7) For thick reservoirs, consider zonal injection techniques.

(8) Plan to inject 20-40% PV of CO₂, and be prepared to inject surfactant solution or water in alternate slugs in the event CO₂ production becomes excessive.

(9) Consider installation of a CO₂ recovery plant, because it could be a sound economic investment, particularly if hydrocarbon gas sales are a prominent factor in the operation of the field.



M. Tech. students of SPT ongoing hands-on training on Core Displacement Experiment

By Domain Experts Dr. AKS Rathor & Dr. S. Bateja (Ex-ONGCians)

It was a very enlightening session where we got hands-on experience on the handling of core flooding equipment which is the best setup present in academic institutions of the country. It will prove to be critical for our research activities and future endeavours. We are grateful to the management at SPT, PDEU for organizing this training session in such difficult times of a world-wide pandemic.

Nikhil Rajan (Student)

No other institutions in the country is striving so hard for the benefits of the student fraternity. The initiative has sparked a flame of encouragement in us after the long break of COVID-19. Such initiatives will increase our employability and deployability in industry and academia as a whole.

Uddeshya Sharma (Student)

OPTIMISATION OF SURFACTANT PRODUCTION IN TWO DIFFERENT STRAINS OF RHODOCOCUS SP. MICROBIAL ENHANCED OIL RECOVERY

ABOUT THE AUTHOR

Ms. Harshita Goyal, 2nd Year student of M.Tech (Petroleum Engineering) at SPT, has worked on MEOR for her dissertation under Dr. Sivakumar P., Associate Professor, SPT. In this article, she hopes to acquaint the readers with the efficiency of microbes in producing biosurfactant under various reservoir conditions.

ABSTRACT

Microbial Enhanced Oil Recovery (MEOR) is gaining interest because of its low-cost operation, environmental friendliness, biodegradability, and less toxic products. MEOR helps to recover a large volume of remaining oil after primary and secondary oil recovery operations. MEOR process involves microorganisms to produce a specific product or directly metabolize the organic compounds to enhance oil recovery in the reservoir. MEOR produces a variety of by-products such as Biosurfactant, biopolymer, acids, solvent, gases, and biomass. Biosurfactant is surface-active amphiphilic components that are produced by microorganisms. These are widely used to reduce surface tension, critical micelle concentration (CMC) and interfacial tension in both aqueous solutions and hydrocarbon mixtures. Numerous varieties of microorganism are proven to produce these useful by-products. One major class of microorganism that produces biosurfactant is robust *Rhodococcus* genus. Even though this species is vastly studied for surfactant production, but the two strains *Rhodococcus opacus* and *Rhodococcus ruber* are rarely studied. In this work, these two strains are studied at different growth conditions to induce maximum surfactant production. They are analysed at varying pH, constant

pH and at different temperatures to understand biosurfactant production in terms of total carbohydrates. Results of laboratory scale shows that both strains give maximum biosurfactant at pH 9 and at 30°C. Further, the optimized results are scaled up to 25 L to validate their performance in large scale cultivation. This results will help in comparing biosurfactant producing capability of two species and selecting the better one for optimum results.

Keywords: Microbial enhanced oil recovery; *Rhodococcus*; Biosurfactant; Interfacial tension reduction; Scale up study.

1. INTRODUCTION

Oil is an essential source of energy and one of the main factors driving the economic development of the world. It is important to recover the oil by suitable techniques from the reservoir. It comprises of a primary phase, which produces oil and gas using the natural pressure drive by the reservoir producing 5 to 10% of the original oil. Followed by secondary recovery in which water, steam, gas etc. were injected to supplement reservoir energy and to displace remaining oil. (Lazar et al. 2007). Recovery efficiencies in the secondary stage range from 10% to 40%. Therefore, crude oil remaining in the reservoirs after conventional oil recovery operations makes up to two-thirds of the total oil reserves (Youssef et al., 2007, 2009; Suthar et al., 2008; Brown, 2010). Enhanced Oil Recovery (EOR) or Tertiary oil recovery is the third and final stage implemented in recovering all the crude oil possible from an oil reservoir. EOR methods utilize physical, chemical and biotechnological approaches to economically recover hydrocarbons from mature fields. These methods decreasing viscosity and increasing flow their by assiststing in the movement of oil from the reservoir into the production well.

In recent decades, Microbial Enhanced Oil Recovery (MEOR) was developed as an alternative method for the secondary and tertiary extraction of oil from reservoirs. It is a new and developing technique in

which live microorganisms and nutrients or only nutrients if microorganisms are already reside in reservoirs are injected into a reservoir to mobilize the residual oil. The MEOR process of oil recovery offers more advantages than the conventional methods. The additional strength of these microbes makes it cost-efficient in the extraction of oil remained trapped in capillary pores of the formation rock and in areas not swept by the classical or modern EOR methods.

Microorganism have unique metabolic and physiological property to survive in extreme conditions and produce metabolites. Biosurfactant are amphiphilic compound that are produced by wide variety of microorganism possess structures of different chemical and surface properties (Martins and Martins,2018). These compounds can reduce surface and interfacial tensions in bot aqueous mixture and hydrocarbon mixture(219,227,234) Their biodegradable, biocompatible and less toxic nature (Nguyen et al. 2010; Franzetti et al. 2012; De Oliveira et al. 2017) makes them a more environmental friendly than chemical surfactant. Biosurfactant are stable in extreme conditions of salinity, temperature and pH (Khopade et al. 2012; Liwarska-Bizukojc et al. 2018).

Microbial enhanced oil recovery (MEOR) is an alternative method of advanced oil recovery that takes advantage of the ability of microorganisms to synthesize products that are useful for improving oil recovery, e.g., gases, acids or biosurfactants (Safdel et al., 2017). *Pseudomonas*, *Acinetobacter*, *Bacillus*, *Brevibacterium*, *Clostridium*, *Rhodococcus*, *Thiobacillus*, *Leuconostoc*, *Citrobacter*, *Candida*, *Corynebacterium*, *Penicillium*, *Ustilago*, *Aspergillus*, *Saccharomyces*, *Enterobacter* and *Lactobacillus* (Lietal.,2016;Shekharetal.,2015) are proven biosurfactant producing microorganisms. In the process of EOR a wide variety of microorganisms are used, in that attracted important interest on the *Rhodococcus* sp. that produce glycolipids with tensioactive properties have more advantages than others microbes. *Rhodococcus* sp. is a

well reported oleaginous microbe able to accumulate more biomass under nitrogen limiting conditions using a wide range of carbon sources (Kurosawa et al., 2015b).

The genus *Rhodococcus* sp. is as one of the most promising groups of organisms suitable for the MEOR. It produces biosurfactants at high enough levels to allow the use of whole broths in some oil industry applications (Abu Ruwaida et al. 1991). *Rhodococci* are more often isolated from environments where hydrocarbons are present, which suggest that these organism are able to grow and produce surfactants using waste oil or even gaseous hydrocarbon as a sole carbon source (Mercade et. al 1996) (Woods and Murrell 1990). Also it has an advantageous system owing to a relatively fast growth rate and simple developmental cycle.

In the *Rhodococcus* sp. there are many stains which produces biosurfactants which are already used in the field of oil recovery. These stains have their own characteristics which are effective in degradation of heavy hydrocarbon. A lot of research are conducted on these strains to find the perfect conditions required to match the perfect microbes to produce high yield. In this work, two genus *R. opacus* and *R. ruber* which are least studied for pilot scale production were investigation. The two strains were assimilated in different growth conditions like initial pH, varying pH and in different temperatures in laboratory condition to find the optimum yield of biosurfactants. Further, the results obtained were validated in a pilot scale fermenter having 25 L capacity and their results are discussed.

2. MATERIALS AND METHODS

2.1 Preparation of Growth Medium :

Culturing medium provides suitable nutrients needed for the growth of *Rhodococcus* sp. The medium used for culturing are Basal inorganic media A and B mixed together in an aseptic condition. The media A is prepared from the solutions 1 and 2 as shown in Table 1. Similarly for media B, the solution B (Table 2) and 10 mL L-1 of SL-6 solution (Table 3) with appropriate carbon source. The same was used for preparing solid medium by adding 20 g L-1 of agar.

2.2 Preparation of Primary Culture :

The strains of *R.opacus* (MTCC 6420) and *R.ruber* (MTCC 1827) were acquired from Institute of Microbial Technology, Chandigarh, India. Components used for preparing media and chemicals of analytical grade required for this study was purchased from Hi-Media and S.D Fine Chemicals, India respectively.

The stock culture was prepared by inoculating these two strains at 30 °C in agar plates for three days. When they reached the stationary phase, the pre-inoculum of 5 mL was prepared in test tubes from the slants and an inoculated for 24 h at 30 °C in a shaker incubator. Every time the same method is used for culturing the next generation of organism from the previous sample. 1 mL of this inoculum was transferred into 250 mL conical flasks having 100 mL of media with 3 mL of carbohydrate and was incubated at identical condition. All the tests were performed under aseptic conditions.

2.3 Experimental Methods :

Conical flask containing 100 mL of Medium B along with 5 mL of hexadecane as carbon source was sterilized in autoclave. Further, it was cooled to room temperature and 1 mL of inoculums was added. Then the flask incubated at 30 °C in a shaker incubator rotating at a speed of 150rpm. Samples were taken at regular intervals for analysing pH, Cell Density and phenol assay. Important parameter affecting the growth of the microorganism is pH. SevenCompact S220 (Mettler-Toledo GmbH, Switzerland) pH meter is used to determine the pH of the culture whenever required and it is calibrated regularly before starting a new reading to get accurate results. To study the effect of different pH, the required change was done by stepwise addition of either 0.1 N HCl or 0.1 N NaOH. Similarly, a controlled culture medium was maintained without inoculums for comparing their natural effect. All the parameters at different condition were studied at every 12 h time interval for 6 days. To check the reproducibility and repeatability of reported results, tests were conducted for three different samples cultured at same condition and their average was taken for investigation.

Optical Density (OD) of the culture is directly proportional to cell density. For this, UV5Bio spectrophotometer (Mettler-Toledo AG, Switzerland) is used. The cell density is measured at 600 nm in this spectrometer by taking 1 mL of sample in a cuvette.

Perhaps the biosurfactants produced by the bacteria are carbohydrates. Phenol Assay is an accurate method used to determine the total carbohydrate. 1.5 mL of the sample was ultrasonicated in a Sonorex Digiplus DL 102 H (BANDELIN electronic GmbH & Co. KG, Germany) sonicator to cleave the surfactants attached on the living cell surfaces. After that it is centrifuged at 10000 rpm for 30 min. During centrifugation, the heavier cells were settled at the bottom whereas lighter substances were separated at the top. From this, 1 mL of the middle layer of the supernatant containing biosurfactants was pipetted out and 3 mL of conc. H₂SO₄ was added. After cooling, 50 µL of phenol is added

and kept for 30 min to complete the reaction. From that 1 mL of sample is taken in a cuvette for measuring the total carbohydrate in a spectrometer at 480 nm.

3. RESULT AND DISCUSSION :

3.1 PH Studies :

In order to design an effective biosurfactants production scheme, the effect of initial pH in the system is important. To identify the optimal pH needed for growth of *Rhodococcus* sp., the culture was studied between 3 to 13 pH at 30 °C. With different pH and their effect on cell density and total carbohydrates were examined and their observations were shown in Figure 1 and 2.

The results for pH changes with the growth in different time period are given in Figure 1a. Separate measurement conducted for pH 13, the results are almost no change in pH for 15 days but, by visual appearance there is slight growth on the walls of the flasks. Initially the pH is started at 12.30 and on the fifth day the pH is 11.70 and then after 15th day the pH is 8.40. It shows that bacteria can survive in high pH for long time and, they are trying to change the environment very slowly according to their

Given below is the optical density value for the flask culture in different time period given in hours. The first reading is taken before the inoculation after few minutes it is inoculated and the results were given below.

The readings given below in the table are taken from phenol/sulphuric acid assay for measuring the weight of the total carbohydrates produced by the bacteria.

Initial decrease is observed within 12 - 24 h in the carbohydrate is due to the intake of the carbohydrate present in the media for log phase growth.

The first experiment on pH studies was conducted on *R.opacus* and the topic “varying acidic and salinity” is by the results found in the pH reading. In the initial the pH was set as start and then in the remaining days it started changing like the pH with saline condition are started reducing day by day due to the growth and by the product produced by the bacteria. We can see in the below graph of reducing pH. From the Graph of optical density vs time it shows that the pH 3 is in the same level because there is no growth of bacteria and the pH of 5, 7 and 9 are reduced to the pH in between 4 and 5 and the pH 11 was ended at around pH of 7.5 this is maybe, because of the biosurfactants produced by the Bacteria.

Figure 1b. shows graph of the optical density measured by the spectrometer, at the different pH.

From the graph of optical density it is very clear that the pH 11 was very high in the optical density result. So, the flask culture at the pH 11 is very high that all other. The pH 11 was not started growing until the around 60 hours after inoculation, but after reaching the pH around 11 it started growing very rapidly. And also proves in the below graph of total carbohydrates produced.

The graph of total hydrocarbon shows that... for the amount of biosurfactants produced was measured by the phenol/sulphuric assay also shows the first high growth in pH 11 and the second high growth in pH 9, the third high growth in pH 7 and the remaining where very lower than the saline condition.

3.2 Experiment with Ruber :

The inoculum sample is taken from the 7th generation of routine culture. Then after arranging the pH the media is sterilized and inoculated. The pH is corrected same like for R.opacus for Acidic pH H₂SO₄ (sulphuric acid) and for Alkaline condition NaOH (sodium hydroxide) is used. The same amount of sample is taken for the Cell density, pH Measurement and for finding biosurfactants. Readings are taken by the above mentioned methods of analysis.

The flask culture of R.ruber at different acidic and saline conditions of pH of 3, 5, 7, 9, 11 and 13 at different time period where taken and the results for the change in pH with different time scale and the increasing or decreasing optical density of growth and the amount of biosurfactants production by the total carbohydrates are given below. Also experiment on pH 13 is conducted for a long period of around 15 days and the results also given below. As the second strain used here is the R.ruber in the same way of the R.opacus. R.ruber also shows the same kind of symptoms as R.opacus. From the graph below shows the same kind of decreasing pH.

The same kind of pH reduction was happened for every pH level like, in pH 5, 7 and 9 it is reduced to around 4.5 on the 96 hours after inoculation and pH 11 was also dropped to around 7.5 on the same time.

In the graph above of the optical density measured for R.ruber was also high cell density in the pH of 11 but not that much high growth seems to be in the R.opacus, but still the pH 11 was high in the cell growth and following by pH 9 and pH 7 the remaining where very less. It is also same in the Below graph of total hydrocarbohydrates produced by the R.ruber also same as R.opacus.

3.3 Effect of Constant PH :

The inoculum sample is taken from the 7th generation of R.opacus and from 9th generation for R.ruber. The methods were similar as the varying pH, only thing is to maintain in the same pH for every day. When there is a change in the flask after inoculation due to the growth of bacteria and the biosurfactants, the pH is changed by adding the H₂SO₄ (sulphuric acid) for acidic and NaOH (sodium hydroxide) for Alkaline to maintain the previous pH.

R.opacus shows slightly linear and slow growth of microorganism. At pH 9 there is highest growth of microbes followed by pH 7, this is also same for total carbohydrate reading (figure 3b) which produces around 5000 ug/l. pH 11 lowest optical density and total carbohydrates production.

R.ruber (figure 4a) results shows that pH 9 and 7 are starting at the same time for log phase, but microbial growth in pH 9 is higher than pH 7. The graph (figure 4b) below for the reading of total biosurfactant is approximately 4500 ug/l which is very high than that produced by pH 7.

3.4 Temperature Studies :

The temperature studies were conducted on 25°C, 30°C, 35°C and 40°C with the both R.opacus and R.ruber separately and also one with combined in the temperature of 30°C. The different temperatures are controlled in the incubator. Each temperature studies are conducted on different time period on the same incubator.

The pH studies for the growth rate and other culture of bacteria is done at 25°C temperature. So, the temperature studies were done on the higher value than this.

Temperature 40°C, the samples for inoculation are taken from 10th generation. The culture were conducted in the 5 samples and each sample where taken in two flasks for error correction, so totally 10 flasks were used, in flask 1 and 2 for controls, in flask 3 and 4 R.opacus is used at pH around 9.5, in flasks 5 and 6 R.ruber is used at pH around 9.5, in flask 7 and 8 R.opacus is used at the pH around 11 and in flasks 9 and 10 R.ruber is used around pH 11. The pH changes are made once before inoculating and maintained in the same pH up to the end of the process.

At temperature 35°C, the samples of inoculation are taken from 13th generation. The culture were conducted in the 5 samples and each sample where taken in two flasks for error correction, so totally 10 flasks were used, in flask 1 and 2 for controls, in flask 3 and 4 R.opacus is used at pH around 7, in flasks 5 and 6 R.ruber is used at pH around 7, in flask 7 and 8 R.opacus is used at the pH around 9 and in flasks 9 and 10 R.ruber is used around pH 9. The pH changes are made

once before inoculating and maintained in the same pH up to the end of the process.

At temperature 30°C, the samples for inoculation are taken from 20th generation. As same like above temperature the method is same and the number of flasks used here is only eight so only 4 samples were used. In the flask 1 and 2 controls where kept, in flasks 2 and 3 there is a small test of mixed culture, the equal amount of mixed culture of R.opacus and R.ruber. same media and same amount of hexadecane where used the inoculation of bacteria 0.5ml of each in the same flask in the pH of around 9. In the flasks 4 and 5 R.opacus where used at the pH of 9, and in the flask 7 and 8 R.ruber were used in the pH of 9. But in this process the pH are not kept constant to see the changes along to the growth.

R.opacus and R.ruber where grown on a flask culture at different temperatures like 40°C, 35°C, and 30°C, for finding the growth and production biosurfactants in constant or varying pH, and also for temperature studies for 25°C where already conducted in the pH studies, all the reading conducted in the pH studies where at 25°C.

At temperature 40°C

The given below was the results for optical density and the amount of biosurfactants produced for R.opacus and R.ruber at pH of 7 and 9 in 40°C.

Table 17: Optical density for R.opacus and R.ruber on constant pH at 40°C

Total carbohydrates:

Table 18: Amount of biosurfactants produced by R.opacus and R.ruber at 40°C

At temperature 35°C:

The given below was the results for optical density and the amount of biosurfactants produced for R.opacus and R.ruber at pH of 7 and 9 in 35°C.

Table 19: Optical density for R.opacus and R.ruber on constant pH at 35°C

Total carbohydrates:

Table 20: Amount of biosurfactants produced by R.opacus and R.ruber at 35°C

At temperature 30°C:

The given below was the results for optical density and the amount of biosurfactants produced for R.opacus and R.ruber at pH 9 in 30°C. In this there is also an equal amount of R.opacus and R.ruber where grown on the same flask culture and the results for that also included in it.

Previous studies on pH is all done on the temperature of 25°C, and also it is not quite good in low temperatures so the temperature studies where conducted at higher

temperature on R.opacus and R.ruber and the temperature were taken on 40°C, 35°C and 30°C.

Temperature at 40°C:

The first temperature was taken at 40°C for both R.opacus and R.ruber in pH 7 and pH9, where the optimized pH is around 9 from the pH studies. So, in the growth condition at 40°C, there is a huge difference between the two bacterial strains in the given graph below.

From the graph, we can see the two major differences in the growth condition. The first difference is between the two bacterial strains, we can see only the growth and biosurfactant produced in only by R.ruber and not by R.opacus in different time period, where R.opacus is not good enough at 40°C. Then the second difference is at 40°C the high growth and the high biosurfactants where produced at pH7 and not in pH 9 as from the pH studies, it may be because of the constantly maintained pH also.

Temperature at 35°C:

The second temperature studies were carried at 35°C, as same as for 40°C on both strains and the graph for cell density and for total carbohydrates were given below.

At 35°C R.ruber was growing but still not as much as R.opacus, and also in 35°C where growth is more similar for pH 7 and pH 9 for R.ruber but for R.ruber the growth is higher in pH7 than 9 here the pH is maintained at the constant for the whole process. In the amount of biosurfactants produced also quite similar with the growth.

Temperature at 30°C:

In the temperature studies at 30°C the pH is not maintained throughout the process to find the difference with the other two temperatures and also the pH used here is around 9. And also here there is a mix of culture used to find the result and the growth, pH drop and biosurfactants produced where given in the graph below.

Graph16, 17 and 18: optical density, total carbohydrates produced and the pH at 30°C
In the above graph the mix culture where not as good as grown in separate cultures, and in this temperature both strains were quite similar in growth and biosurfactants produced. The pH dropped to around 7.5 from pH9 for all the cultures and strains.

3.5 Fermenter

The fermenter is used in large scale cultivation of R.opacus and R.ruber at 15L it was 30 litre capacity, with single phase induction motor

(Hitachi ltd) with capacity of 240volts for running the agitator, agitator as 6 blades in it and it rotates at the speed from 100 – 1000 RPM.

The fermenter used here is at a capacity of 20liters and made up of stainless steel. The fermenter is connected to motor for agitators, and heat transfer unit for heating it has steam pipe line and for cooling it is connected with a cooling water pipe line, it has sparger connect with air pump, it is totally fully fledged fermenter. The fermenter also contains agitator, baffle, pH meter, Thermometer, visible glass to see the flow and the things inside the fermenter and it is also have a light inside and also there is a separate water heating and pump is connected to the fermenter, so there is a heat exchanging process also takes place. First the medium is prepared for 15 litres, so the medium B used are in the amount of

Media B:

With the medium B it included the water of 15 litres and it is sterilized by autoclave for 10 minutes at 110°C. Before adding the media the fermenter is cleaned with biological cleaning agent and alcohol. Then the media is added to the fermenter after adding the agitator is started rotating at a speed of 250 rpm the agitator as a four blade and with one baffle is used in the fermenter. The externally fixed heater is also started for water circulation through the fermenter at the temperature of 30°C and then the fermenter is started maintaining at the temperature of 30°C, then the hexadecane as a carbon source is added to the media in the amount of 150ml. After that, 150 ml of inoculate is also added from the 18th generation of routine culture. For this high volume two flasks were used for the culturing of bacteria at each 100ml and from that one flask, it is used fully for the fermenter and another one is used around 50ml. This fermenter is also maintained at the pH of 9 for the high growth, so for increasing alkalinity NaOH (sodium hydroxide) is used. Then the process is left of around one week with the same temperature and also not modified in the pH. The samples for the tests were taken one in every day for about 7 days. Samples were taken for analysing pH, cell density, and for biosurfactants as total-carbohydrates and the amount of samples were taken is 2ml for optical density, 6ml was taken for pH measurements and 3ml for phenol assay so totally 11 ml is needed and the sample is collect around 20ml by a 50ml pipette by bulb connected for suction, the sample was collect at the time of running process through the opening in the top of the fermenter. On the first week R.opacus is used for the cultivation, once finished it is fully cleaned with the bio cleaner it is added in the fermenter of 5 teaspoon and mixed well left for 3 hours and drained it, then it is cleaned with water and wiped with

tissue and also cleaned with alcohol again wiped with tissue after that for the second run for R.ruber is done in the same method and same period with the same capacity of 15 litres once it finished it is also cleaned in the same method as for the method used in R.opacus.

4. CONCLUSION AND FUTURE SPEECH :

In the process for Microbial Enhanced Oil recovery (MEOR), different bacteria might suit for the conditions in the oil well. In this project obtained results shows that R.ruber is quite good in hot conditions of temperature around 40°C or less than that. R.opacus can be suit the condition of temperature around 30°C or less than that. The most promising one in the two strains are it grows in high alkaline range of more than pH11, the main important issue in the microorganism which can grow in high alkaline condition is used for MEOR, because of most oil wells in off shore and on shore are alkaline in nature, the bacteria which overcomes this problem is given more importance, so by this research both strains where producing biosurfactants good enough in this pH range but it still depends upon the temperature as well. Finally the R.opacus is concluded that it as high resistive than R.opacus, more or less both where good for Oil Recovery.

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SHELL SPONSERED RESEARCH PROJECTS

PDEU - SHELL ENERGY INDIA RESEARCH PROJECTS

BIO DIESEL

- Energy efficient Biodiesel production technology at industrial scale
- Improvement in yield and quality (fuel properties) of biodiesel

GREEN HYDROGEN

- Development of enable Catalytic Energy Reactor (CER) with Aluminum Strip and Sulfate for Production of Hydrogen
- Electric and Aluminium hydroxide
- Design and Development of Adsorbent Catalyst for Green Hydrogen Production and CO₂ reduction

CO₂ CAPTURE

- Development of CO₂ Injection Strategy for Enhanced Oil Recovery and Storage in Indian Oil Field
- Atmospheric CO₂ capture and its Efficient utilization in Green methanol and other Products. Feasibility Hydrogen and Bi-carbonate Salt of Aqueous Electrolyte Media

DIGITAL TECHNOLOGIES

- Digital twin for oil and gas pipeline monitoring and risk analysis

PROJECT ON BIO DIESEL

AUTHOR

Mr. Nirav Prajapati completed M.tech. (chemical engineering) from Pandit Deendayal Energy University, Gandhinagar. In M.tech., he researched on production of biodiesel from waste cooking oil using various process intensification techniques. He joined PhD (Chemical engineering) program in the department of chemical engineering of Pandit Deendayal Energy University in August 2021. Currently, he is working as Junior Research Fellow (JRF) in the Shell Energy sponsored biodiesel project under Prof. Surendra Singh Kachhwaha and Dr. Pravin Kodgire. His research interests are in the field of biofuel and bioenergy.

(a) Energy efficient Biodiesel production technology at industrial scale (b) improvement in yield and quality (fuel properties) of biodiesel

Design, Development, and Demonstration of an energy efficient, environmental friendly and cost effective hydrodynamic cavitation reactor for biodiesel production at industrial scale. Improvement in biodiesel yield as well as physicochemical properties of biodiesel through efficient pre-treatment methods and proper blending of low cost raw feedstock. A successfully operational biodiesel reactor facility will demonstrate energy efficient, environmental friendly and industrially viable facility for production of biodiesel at competitive cost..



PROJECT ON

DEVELOPMENT OF CO₂ INJECTION STRATEGY FOR ENHANCED OIL RECOVERY AND SEQUESTRATION IN INDIAN OIL FIELDS



DETAILS OF JRF :

PDPU has appointed a JRF for completion of this project.

Ms. Purna Prakash Kamdi, She pursued her Masters in Petroleum Engineering from MIT Pune and completed her master thesis from ONGC IRS Ahmedabad. She is having a background of mechanical engineering. On the basis of work done during master thesis, she had invited to ICAM 2019 conference for a short talk.

BACKGROUND AND MOTIVATION

With the dawn of floating oil prices, growing energy demand, declining oil field productivity and hard to discover new giant fields, the oil operators are now increasing its focus on the improvement of oil recovery from mature hydrocarbon fields. Innovative enhanced oil recovery (EOR) techniques are required to emerge and currently implemented ones need to be revisited and optimized to recover additional residual oil trapped in the reservoirs. Conventional EOR methods can increase the production of oil; however they cannot produce trapped oil inside the reservoirs. Trapped oil is referred to the oil which is trapped inside the reservoir due to capillary forces in pore space. Injection of CO₂ can help to produce that part as well taking advantages of miscibility feature of CO₂.

Therefore, the main advantages of CO₂ which make it a good choice for gas injection EOR are:

- Miscibility of CO₂ in crude oil decreases the viscosity of oil and

therefore, oil can flow easier than before which results in more oil production.

- It is less expensive compared to other choices for miscible flooding.
- It is an excellent method for CO₂ capture with its injecting into reservoirs for sequestration.

Hence basically CO₂ injection improves oil recovery and at the same time, greenhouse gas profile is improved as well. The available chemicals for EOR techniques are not very much economical and due to this the demands for environment friendly chemicals for industries are always a priority. Using CO₂ injection can be a probable solution to reduce the greenhouse gases from the environment. Therefore, this proposal will bring a new development of the CO₂ injection technique for the application in the oil industry emphasizing on CO₂ storage and EOR.

PDPU has appointed a JRF for completion of this project. .

Ms. Purna Prakash Kamdi, She pursued her Masters in Petroleum Engineering from MIT Pune and completed her master thesis from ONGC IRS Ahmedabad. She is having a background of mechanical engineering. On the basis of work done during master thesis, she had invited to ICAM 2019 conference for a short talk.

The key objectives of the project theme can be depicted as follows:

1. Characterization of reservoir rock and fluid (crude oil) samples.
2. Phase behavior study of the CO₂ with crude oil.
3. Investigation on the influencing factors responsible for CO₂ EOR.
4. Core flooding experiment to investigate the additional oil recovery by CO₂ injection.
5. Determine the amount of CO₂ stored in the core sample after flooding experiment.
6. Modeling study of laboratory result for the applications in Indian oil fields.

PROJECT ON

DIGITAL TWIN FOR OIL AND GAS PIPELINES FOR RISK ASSESSMENT



AUTHOR

Gurrula Laxmi Nandan completed his bachelor's degree from KL University. Recently, he completed his masters in Petroleum Engineering from PDEU. He was selected under the PDEU – Petrabytes energy analytics program and also has one research article published.

Digital twins can help oil & gas companies: detect early signs of equipment failure or degradation to move from reacting and responding to a failure to being proactive; which enables owner-operators to plan and implement corrective maintenance actions before failure occurs and often at much lower cost.

The objective of the project is to build a digital twin for an oil and gas pipeline network. Asset Duo™ is used for oil and gas pipeline monitoring and risk assessment. Risk analysis is carried out for improved safety and shall be beneficial for regulatory compliance.

PI: Dr. R.K. Vij

Co-PI: Prof S. Sundar Manoharan, Dr. Hari S

Industrial partner: Petrabytes Corp, USA

INDIAN PATENT GRANTED

Sr. No.	Patent Name	Patent Number	Inventor (s)
1.	Valve	3312082-001	Dr. Bhawanisingh G Desai
2.	sediment core sampling tool	336295001	Dr. Bhawanisingh G Desai
3.	Geologist Hammers list	338207001	Dr. Anirbid Sircar
4.	Hand Tool Set for Geologist	338207002	Dr. Anirbid Sircar
5.	Disc Spring for Oil Filter	338209002	Dr. Anirbid Sircar and Dr. Kriti Yadav
6.	Hexagon Pan support for industrial Burner	338211-001	Dr. Anirbid Sircar, Mrs Namrata Bist and Dr. Kriti Yadav
7.	Pressure vessel loking ring	338364-001	Dr. Anirbid Sircar and Dr. Kriti Yadav
8.	Portable proppant transport analyser	336494-001	Dr. RK Vij, Mr. Shiv Shambhu Kumar, Prof Subhash Shah, Dr. Jatin Agarwal
9.	internal metal bonded coating equipment for marine pipeline network	336605-001 Patent Certificate no: 95,030-2021/1/21	Hari S, Sankar Krishna, RK Vij
10.	Pipeline Internal Beveling machine	336605-003	Hari S, Sankar Krishna, RK Vij
11.	Pipeline Internal Beveling machine for industry	336605-004	Hari S, Sankar Krishna, RK Vij
12.	Tringular Shaped reflector For Solar Thermal Collector	The Patent Office Journal No. 08/2021 Dated 337201-001 Granted & Published	Dr. Anirbid Sircar
13.	Portable Automatic Sanitizer Dispenser (23-02)	The Patent Office Journal No. 06/2021 Dated 337090-001 Granted & Published	Dr. Anirbid Sircar
14.	Thermal Insulated Hot Water Storage Tank (23-03)	The Patent Office Journal No. 09/2021 Dated 337091-001 Granted & Published	Dr. Anirbid Sircar
15.	Honey Extractor	The Patent Office Journal No. 08/2021 Dated 337201-001 Granted & Published	Dr. Anirbid Sircar

Sr. No.	Patent Name	Venue	Inventor (s)
1.	Molecular architecture of coal of different rank for possible future applications: An Optical spectroscopic study.	36th International Geological Congress, to be held on August' 2021, New Delhi, India.	Uttam K. Bhui, Ria Ghosh, Archchi Sarkar, Samir Kumar Pal, Sudip Bhattacharya
2.	A multipronged approach for understanding macromolecular structure of Liptinite rich coal from Ib-River Coalfield, Odisha, India: its suitability for coal liquefaction.	36th International Geological Congress, to be held on August' 2021, New Delhi, India.	Archchi Sarkar, Sudip Bhattacharyya, C.P. Ramteke, K.G. Geethumol, Uttam K. Bhui
3.	Surfactant Flooding for Enhanced Oil Recovery: Understanding Molecular Level Mechanism with Optical Spectroscopic Study.	36th International Geological Congress, to be held on August' 2021, New Delhi, India.	Rincy Anto and Uttam K. Bhui
4.	Optimisation of surfactant production in two different strains of Rhododoccus sp. For microbial enhanced oil recovery -	India Drilling & Exploration Conference (IDEC) 2021 from 29-30 June & 1 July 2021. Mumbai	Dr. Rakesh Kumar Vij Harsita goyal and sivakumar
5.	Scenario of EOR Screening for Small Fields of Cambay Basin	India Drilling & Exploration Conference (IDEC) 2021 from 29-30 June & 1 July 2021. Mumbai	Hazarika G. & Vij R. K.

SPT ACHIEVEMENTS

- 2 students: Manav D Patel and Shreya Nikte from 3rd year went to Oklahoma Universities student exchange program. We wish for their success.

- 2 Students Shubham Patel and Anugrah Singla are selected for Exxonmobil Internships

-Harshita Goyal Presented a Paper entitled Optimisation of surfactant production in two different strains of Rhododoccus sp. microbial enhanced oil recovery in IDEC 2021(Mumbai)



STUDENT PUBLICATIONS

S. No.	Author (s)	Year of Publication	Title of Paper	Complete reference of Journal (APA reference style)
1	Palakbhai Patel	2021	A Study on conservation of reverse osmosis reject water by reclamation	Published Paper URL: - http://ijcrt.org/viewfull.php?&p_id=IJCRT2107507
2	Jayesh Bellani, Harsh Kumar Verma, Dhrumil Khatri, Dhruv Makwana & Manan Shah	April 17, 2021	Shale gas: a step toward sustainable energy future	Bellani, J., Verma, H.K., Khatri, D. et al. Shale gas: a step toward sustainable energy future. J Petrol Explor Prod Technol 11, 2127-2141 (2021). https://doi.org/10.1007/s13202-021-01157-7
3	Dhruv Makwana, Jayesh Bellani, Harsh Kumar Verma, Dhrumil Khatri & Manan Shah	June 01, 2021	Emergence of nano silica for oil and gas well cementing: application, challenges, and future scope	Makwana, D., Bellani, J., Verma, H.K. et al. Emergence of nano silica for oil and gas well cementing: application, challenges, and future scope. Environ Sci Pollut Res (2021). https://doi.org/10.1007/s11356-021-14633-8

ACCEPTED

S. No.	Author (s)	Year of Publication	Title of Paper	Complete reference of Journal (APA reference style)
1	Shubham Bhavin Patel, Manav Divyeshkumar Patel, Tirth Komalkumar Shah	2021	Role of Disruptive Technologies for long term Energy Sustainability - An overview of Indian Scenario	AIP Conference Proceedings, ICAMTAAI 2021.

GEOSCIENCE AND HYDROCARBON EXPLORATION

FIELD WORK (KUTCH BASIN)

This field trip was conducted from 18th August to 22nd August 2021 in Kutch, Gujarat. The aim of this field work was to explore real life experience as an exploration geologist for students of M.Tech petroleum Technology-Exploration (Batch 2020-2022).

Whole field trip conducted under the guidance of Dr. Bhawanisingh G Desai and Dr. N Madhavan and P.hD student Mrs. Anjali Chaudhary.

This field work was designed to have a detailed outlook of Kachchh Basin to comprehend the on land Mesozoic outcrops and put them into petroleum system prospective. The locations covered are Jara, Katesar, Guneri, Lakhat, Jumara, Mata-no-madh etc. The outcrops of Jurassic were observed with their sedimentary structure, dyke intrusions, Fossils such as bivalve, ammonite, belemnite and corals being the major attentions.

Day 1

Formation:-Bhuj (lower cretaceous)

Location: - Mata no Madh

23°32'18" N

68°56'58" E

The entire section is of sandstone lithology. EW (N 110) orientation. Sedimentary Structures such as cross-stratifications can be observed. There are two sandstone bodies. Both the sandstone bed have fining upward sequence the entire unit is cross-stratified. Lower unit contains thick coarser units and has angular grains. They were formed during spring tide. It was deposited in high energy condition. Upper unit consists of planar beds and thin smaller units and were formed during neap tide. Burrows were maintained by sea animals during incoming sedimentation.

Day 2

On this day we have taken a travers from jara village in west direction. Target was to take a cross tracking and reached to the core of jara dome.

Location: - Jhuran delta sequence

23°42'49" N

69°00'20" E

Formation:- Jhuran

It is around 4M cliff with shale and thin sand stone lithology. N 45° orientation with 16° dipping beds. Whole section consist of multiple cycle of fining upward sequence. Dark shale present there which indicates reach in organic matter. It can be potential source rock but it is immature. In sand stone we can observed concretion plane lamination (base), ripple lamination(top)

Day 3:-

Location 1:- Malkan wandh(Rudramata shale)

23°37'45" N

69°02'30" E

Formation :- Jhuran (kimbrigian age)

Altitude: 70m above mean sea level.

Environment: Infra-littoral.

This section belongs to Rudramata Shale member of Jhuran formation. Whole section is about 55m in height and consists grey shales with thin sandstones and silt bands. This black coloured shale is very rich in organic matter and the middle part of the section is bioturbated. The grains are very well sorted and have decent porosity in sand layers. In



between the shale layers the mature organic matter was converted into bitumen. Load cast structures precisely ball and pillow structure are observed in the section. The sandstone present is well sorted and has good porosity. The entire formation is dipping in N 2900 with a dip of 80.

Location 2:- Malkan wandh waterfall section

23°37'08" N

69°03'19" E

Day 4

On this day our main object is to identify major and minor faults as well as trace them and search their extension in the area.

Location 1:-Near Meghpar

23°37'36" N

69°00'45" E

Section orientation is EW and we can see that Fault zone got secondary mineralization which can act as a sealing fault.

Location 2:-Siyot section

23°44'09" N

68°54'05" E

Day 5

Location:-Jumara Dome(Upper Jurassic)

23°40' 47"

68°04' 14"

Jhumara Dome is a classical locality for Middle Jurassic Ammonite biostratigraphy, the dome exposes low dipping strata of jhumara formation and jhurio formation.

On this day we have taken two traverses. First one is from one end of dome to other end and second traverse taken on almost half periphery by tracking one particular bed until we got same bed in opposite direction. Micritic limestone were deposited as Tempestites deposits on carbonate ramp environment Jhumara Formation is rich in fossils like ammonite, gastropod, brachiopods, bivalve and trace fossils Zoophycos.

During our traverse, director Dr.R K vij sir and Gaurav Hazarika sir also join us and we had enjoyed our lunch with amazing conversation. This day is memorable for all of the students as well as faculties present there.

Parmar Parthkumar Sureshbhai

Parmar Parthkumar Sureshbhai is a Research scholar of SPT working under the guidance of our reassuring faculty mentor Dr. Achinta Bera has done magnificent work in the field of Petroleum Engineering (Enhanced Oil Recovery).

Parth Parmar has completed Bachelors of Engineering from Chandigarh University, Punjab in June 2017. During 2013-2017 he got opportunity to do vocational training in IOCL Refinery Vadodara and ONGC Ankleshwar. Afterwards, He has completed Master's in Technology from Pandit Deendayal Petroleum University, Gandhinagar in June 2020. During M.Tech he got opportunity to do vocational training in ONGC Mehsana Asset and 6 months dissertation work in KDMIPE, ONGC Dehradun. In ONGC he has worked on "Design of Suitable Resin Based Polymer Gel for water shut-off job in Reservoir". He presented that work on 3rd International Oil & Gas Chemistry, Chemicals and Additives Conference (IOGCA 2020)". After completion of postgraduation he has successfully completed 3 months internship in SNF Flopam India which is located in Gandhidham. In December 2020, He has joined SPT PDEU for doing full time Ph.D. for work on "Development and Characterization of Biomaterial-Based Nanofluids for EOR."



Vishal Chauhan

Vishal Chauhan is Ph.D. Research Scholar at School of Petroleum Technology, Pandit Deendayal Energy University (PDEU), Gandhinagar since December 2020 under the guidance of Dr. J. Brahma (Assistant Professor). He holds 5 years Integrated Master of Science(M.Sc.) in Physics, Applied Physics Department from National Institute of Technology (SVNIT), Surat, Gujarat. During his master's thesis he work on "Advance Quantum Mechanics" & "Particle Physics". His research area in PhD is "Reservoir Modelling & Stimulation". He is currently working on "Reservoir Models & Flow through Porous media" in Reservoir Studies.

Sneha Lavate

Sneha Lavate, PhD Scholar, School of Petroleum Technology, PDEU

I have done B.Sc.-M.Sc. Nano Science and Technology (Integrated) from School of Nano Science and Technology, Shivaji University, Kolhapur. For my master's project work I worked as a Research Internship Trainee under the guidance of Dr. Rohit Srivastava. During internship period, I worked on the project entitled Research Synthesis and electrochemical characterizations of g-C₃N₄ based nanohybrid materials. of Nanocomposites as photo-electrocatalysts for hydrogen generation and CO₂ reduction into green fuels. After internship, I joined as a PhD scholar under Dr. Rohit. Currently I am working on synthesis of nanomaterials as photo/electro-catalyst for energy applications.



Chintan Mistry

Chintan Mistry is a Ph.D. student at School of Petroleum Technology, PDEU Gandhinagar. Currently he is working with Dr. Sivakumar Pandian on project “Catalytic cracking of mixed plastics to produce fuel and high value petroleum products”. He pursued his Masters in chemical engineering with specialization in chemical process and plant design from Nirma University, Ahmedabad in 2012. His M.Tech. project work on “Catalytic

oxidative dehydrogenation of 1-butene to 1,3-butadiene” was patented by Reliance Industries. He has rich experience of eight years and has worked as lead engineer piping for companies like Reliance Industries Ltd., Mott Macdonald India Pvt. Ltd., IBI-Chematur Ltd., Conex Refinery Liberia. Some of the major projects accomplished by him are as below:

- 10,000 BPD CDU unit for Conex Petroleum Refining Company., Monrovia, Liberia.
- Petroleum storage Terminal for Vihama Energy Ghana Ltd., Ghana.
- Fatty acid & Oleo chemical plant., Godrej Industries, Gujarat.
- DHDS-II, DCU BS-VI capacity enhancement., RIL Jamnagar.
- DTA Aromatics Revamp., RIL Jamnagar.
- IB Plant Facilities., Vinati Organics Pvt. Ltd.
- Hazira Terminal Expansion., Adani Ports Pvt. Ltd.
- ETP Plant & GGS Stations., ONGC Ankleshwar.
- LPG & Propylene Mounded Bullets., IOCL Haldia.
- LPG storage & Bitumen handling facilities at port Beira, Mozambique.

He is also an active member with various magazine publications like Hydrocarbon Processing, Hydrocarbon Technology, Pipeline and Gas Journal, LNG Industry, Decarbonization Technology, World Oil, World Pipelines, Plastics Recycling Technology



Rahul Sirvi

Rahul Sirvi, a Junior Research Fellow (JRF) and a PhD scholar of SPT, PDEU, is currently working in a Project funded by Board of Research in Nuclear Sciences (BRNS) with Dr. Uttam Kumar Bhui. His research area lies in the field of Deep Geological Repository (DGR) for disposal of Nuclear Waste. DGR is the most acceptable option for the isolation of the radioactive waste, necessitates the identification of site-specific potential host rocks and buffer materials. He aimed to characterize and investigate the sorption behavior of the Shale rock samples which can act as a barrier for migration of the toxic radionuclides. The outcome of this research will help in the advancement of the nuclear power generation with clean and green environment.

Rahul Sirvi holds Master’s degree in Geology from Fergusson College, Pune. He qualified CSIR-NET-Dec.-2019 with AIR-115 before joining SPT-PDEU. He previously worked on the interpretation of the correct lithological sequence using petrography of the rock samples. He has also completed a UGC project during his Post Graduation on the Study of fossil Turritellids from a new locality in Miocene of Kachchh. He has internship experiences with prestigious government organizations viz. AMD (Atomic Minerals Directorate) and GSI (Geological Survey of India) respectively.

SCAL COURSE

Understanding of Petroleum Reservoir through SCAL



Special Core Analysis, often abbreviated SCAL, is a laboratory diagnosis of petroleum reservoir samples to understand the reservoir characteristics for tailored applications. Special core analysis is distinguished from “routine (RCAL) or conventional (CCAL) core analysis” by the addition of more experiments, in particular including measurements of two-phase flow properties, determining relative permeability, capillary pressure, wettability, and electrical properties. School of Petroleum Technology (SPT) values the importance of such knowledge for its students and organized a 15 hours special lecture course by renowned reservoir engineer Mr. Dinesh Chandra Tewari,



Ex-GM, ONGC for developing skills and expertise of the talented bunch of B.Tech., M.Tech., and Ph.D. students. Mr. Tewari sailed through the key-spheres of Wettability measurements and the role of wettability in the nature of SCAL results, Capillary pressure measurements, initial water saturation distribution and reconciliation of Swi data, Relative permeability lab procedures, averaging, refining, and integrating lab results, Residual oil saturation lab results review, its relationship with rock types and deriving representative Sor data for use in engineering calculations and Assignment of Relative permeability and capillary

BARC PROJECT

Collaborative Research with Bhabha Atomic Research Centre(BARC)

Growing population demands increasing number of clean and sustainable energy resources. Nuclear energy is one such source for power generation which is sustainable, carbon free in nature and hence environmental friendly. In the present scenario of advancement in nuclear power generation, nuclear waste of various concentration level (low, intermediate and high) and types (short half-lives, long half-lives) are generated almost at every stages of open and/or closed nuclear fuel cycle. In order to protect human culture and its surrounding environment from contamination, safe long term disposal of radioactive waste is very much mandatory. There is international consensus that, using available technology, deep geological disposal is the only option to meet necessary safety requirements without leaving potential risks and burdens to future generations. It has now been accepted by international regulatory bodies and safety authorities that deep geological disposal are the safest and most secured waste management routes for long-term storage/disposal of spent nuclear fuel. Disposal of radioactive waste in engineered facilities or repositories, located underground in suitable geological formations,

is being investigated worldwide as a long-term management solution. It is necessary to identify suitable natural/synthetic materials which could restrict the migration of toxic radionuclides and retain them over a long-time scale. With an aim to contribute in this segment of nuclear fuel cycle, School of Petroleum Technology, PDEU, in collaboration with Bhabha Atomic Research Centre (BARC), with financial support from Board of Research in Nuclear Sciences, extended their research scope to identify suitable shale rocks, which could be used as barrier materials for restricting the migration of different radioactive elements within near surface zone. SPT researcher working in this area aimed to build the analytical sorption database, for different shale rock samples hailed from Gujarat and nearby areas which could be used as the prospective buffer materials at the Near Surface Disposal Facility (NSDF). This research project can be substantial for development of data base with respect to radionuclides sorption and performance assessment of candidate natural rock formation as buffer materials for deep geological repositories in near field areas.

PHOTO GALLERY





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