Final Year Project Showcase Batch 2022
Year 2026

Department: Petroleum Engineering Programme: Petroleum Engineering	
1	**Project Title** Nano-Enhanced Smart Drilling Fluids: A Novel Approach of Carbon-Zinc Oxide Synergy For Improved Mud Properties and Acid Solubility Insights of Weighting Materials
2	**Project Idea:** Conventional water-based drilling fluids (WBDFs) frequently cause operational challenges while drilling shale formations because reactive clay minerals absorb water and swell, leading to wellbore instability, stuck pipe incidents, excessive fluid loss, and increased non-productive time. Additionally, conventional weighting materials such as barite may invade pore spaces and reduce formation permeability, resulting in formation damage. This project proposes a Nano-Enhanced Smart Drilling Fluid system utilizing Zinc Oxide (ZnO) nanoparticles supported by Activated Carbon (AC) and Multi-Walled Carbon Nanotubes (MWCNTs). The synergistic effect of carbon-based nanomaterials and zinc oxide aims to enhance rheological and filtration properties, improve shale inhibition performance, reduce swelling behavior, and investigate acid-soluble weighting materials for minimizing formation damage while preserving reservoir productivity.
3	The project followed a multi-stage experimental methodology: 1. Collection of Raw Materials: Collection of ZnO nanoparticles, Activated Carbon (AC), MWCNTs, shale samples from Ranikot Formation, and drilling fluid additives. 2.Synthesis of Nanocomposites: Preparation of AC/ZnO and MWCNT/ZnO nanocomposites through synthesis techniques. 3. Characterization of Shale and Nanocomposites: • X-Ray Diffraction (XRD) • Scanning Electron Microscopy (SEM) • Fourier Transform Infrared Spectroscopy (FTIR) • Energy Dispersive Spectroscopy (EDS) • Cation Exchange Capacity (CEC) 4. Drilling Fluid Formulation: Preparation of water-based mud systems incorporating synthesized nanocomposites. 5. Performance Evaluation: • Rheological analysis • LPLT and HPHT filtration testing • Mud cake thickness and permeability measurements • Linear Dynamic Swell Meter (LDSM) testing • Acid solubility analysis of weighting materials

4	**Outcome:** • Nano-enhanced drilling fluids demonstrated improved rheological properties and filtration control. • MWCNT/ZnO formulation showed superior performance compared with AC/ZnO in terms of viscosity behavior and fluid loss reduction. • Shale swelling behavior was significantly reduced through enhanced shale inhibition. • Thin and less permeable mud cakes were produced, minimizing formation damage risks. • Micromax exhibited higher acid solubility than Microdense and Barite, indicating reduced permeability impairment potential. • Results demonstrated strong potential for improved drilling efficiency and wellbore stability.
5	**Evidence (Theoretical Basis):** The project is grounded in established petroleum engineering principles and validated through laboratory testing and analytical characterization: • Shale inhibition theory involving clay hydration and swelling mechanisms. • Nanotechnology principles utilizing ZnO nanoparticles and carbon-based nanomaterials. • Drilling fluid rheology and filtration concepts according to API standards. • Formation damage theory and acid-soluble weighting material evaluation. • Experimental validation through SEM, XRD, FTIR, EDS, CEC analysis, LDSM testing, HPHT and LPLT filtration testing and rheological measurements. • Findings validated through published literature and SPE-based studies on nano-enhanced drilling fluids.
6	**Impact on Sustainability of Urban Regions or SDG-11 "Sustainable Cities and Communities":** The project supports sustainable development through improved drilling efficiency and environmentally responsible fluid systems: • Reduced drilling complications decrease operational waste and energy consumption.

	• Water-based systems offer environmentally safer alternatives compared to oil-based mud systems. • Reduced formation damage improves reservoir productivity and minimizes resource wastage. • Supports Pakistan's energy sustainability by improving domestic hydrocarbon production efficiency.
7	**Competitive Advantage or Unique Selling Proposition** (Cost Reduction, Process improvement, Attainment of any SDG (Sustainable Development Goal), increase of market share or capturing new market or having superior performance over a competitor. In summary, any striking aspect of the project that compels the industry to invest in FYP or purchase it. Some detailed description is required in terms of how, why when what. You can select one or more from the following dropdown and delete the rest of them). Please keep relevant options, delete the rest of them, and correct the sequence .
a	**Attainment of any SDG** (e.g. How it is achieved and why it is necessary for the region) SDG-7 (Affordable and Clean Energy): Improved drilling efficiency and reservoir productivity help sustain domestic energy production. SDG-9 (Industry, Innovation and Infrastructure): Introduces nanotechnology-based smart drilling fluid systems for upstream petroleum applications. SDG-13 (Climate Action): Reduction in drilling time and operational inefficiencies lowers energy consumption and carbon emissions.
b	**Environmental Aspect:** • Water-based drilling fluids reduce environmental risks compared with oil-based systems. • Lower fluid loss minimizes contamination and formation damage. • Acid-soluble weighting materials reduce long-term reservoir impairment.
c	**Cost Reduction of Existing Product:** The enhanced rheological and filtration properties reduce drilling-related issues such as stuck pipe, wellbore instability, and non-productive time, ultimately lowering operational costs.
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency** Current Issue: Conventional drilling fluids face challenges such as shale swelling, fluid invasion, and excessive filtration losses.

	Improvement: Nano-enhanced smart drilling fluids significantly improve shale inhibition, fluid stability, filtration performance, and wellbore integrity through ZnO-carbon nanocomposite synergy.	
8	**Target Market:** • National oil and gas companies operating in shale and complex formations in Pakistan. • International exploration and production companies working in unconventional shale reservoirs (Middle East and other regions). • Oilfield service companies providing drilling fluid and mud engineering services (e.g., Halliburton, SLB, Baker Hughes, Weatherford). • Drilling fluid formulation and chemical additive manufacturers. • Research and development institutions in petroleum engineering and nanotechnology. • Universities and petroleum training institutes focusing on advanced drilling fluid systems. • Drilling engineers, mud engineers, and reservoir engineers involved in well planning and drilling operations.	
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11	**Video (If any)**	-