Continuous Electrokinetic Dewatering System for Use in Phosphate Mining Cleanup

Efficiently Removes Water from Phosphorus Clay to Speed the Disposal of Waste Clay Suspensions Resulting from Phosphate Mining

Background

This device continuously dewaters phosphatic clay suspensions through electrokinetics. A typical Florida phosphate mining operation produces more than 100,000 gallons per minute of phosphatic clay, which is pumped into large ponds known as clay settling areas, or CSAs. The current separation method of this mining waste product uses gravity settling and vast amounts of land. More than 150 squre miles of CSAs currently cover central Florida, representing 30 percent of the mined land. Consolidation of the clay can take 25 years to complete and still leaves clay too soft to build upon. The need both to reduce the land area required for clay suspension storage and to reduce the water usage in the mining operations has led researchers to search for an inexpensive method that can enhance the process of dewatering.

Researchers at the University of Florida have created a device that effectively separates water from phosophate mine clay solids and by applying an electric field. This design creates a 10-fold reduction in the electrode area, as compared to previous designs, which reduces efficiency and the cost to perform the continuous electrokinetic dewatering process. By utilizing electrical fields, this system also eliminates the need for chemical additives to aid the separation process, unlike its competitors.

Application

An electrokinetic dewatering system for extracting water from phosphatic clay suspensions

Advantages

- Reduces land, power and time required for dewatering process, improving the economic viability
- Requires no flocculation agents, reducing reclamation costs
- Applicable to other mining operations that generate a clay-rich suspensions, broadening its field of use

Technology Detail

This device continually dewaters phosphatic clay using an electrokinetic method. It feeds phosphatic clay suspensions between two conveyor belts and allows the clay to come into contact with electrodes that apply an electric field. As it passes the electrodes, water drains freely away from the phosphatic clay solids and forms a dewatered cake solid, or thickened layer of clay, with a solids content of 31-38 weight percent, surpassing available dewatering methods. Additionally, this system allows for a 10-fold reduction in the required electrode area compared to a previous design, improving clay-water separation efficiency and reducing the operational cost, making this the ideal system for dewatering of phosphate mine tailings.

Electronic Contact Lens for Therapeutic Drug Delivery

Incorporates an Electronic Circuit for Delivery of Ocular Medications to the Posterior Eye

Background

This electronic contact lens uses iontophoresis, a process incorporating electronic stimulation, to deliver ophthalmic drugs to the eye's posterior segment, for back-of-eye disease treatment. Macular degeneration and other forms of posterior eye disease affect over 8.5 million Americans. These retinal-area diseases can result in blindness and retinal detachment if left untreated. Treatment typically consists of eye drops for aqueous medication delivery to the eye's vitreous tissues. However, ophthalmic drops fail to effectively deliver medication to the back of the eye, making this therapy unable to treat retinal and macular disorders. Ocular implants and intravitreal injections allow prolonged drug delivery to the eye's posterior. However, patients often find these non-aqueous therapies uncomfortable for prolonged wear and direct eye injection can create insertion complications, patient discomfort and low efficacy. Other available treatments incorporating iontophoresis use reservoirs and electrodes placed onto the forehead or ear, making a bulky, uncomfortable device and a need for large voltage to operate.

Researchers at the University of Florida have developed a self-contained electronic contact lens incorporating the drug treatment, a power supply and built-in electrodes to iontophoretically deliver the therapeutic to the posterior eye with minimal patient discomfort.

Application

Soft contact lens containing electrodes, a power supply and ophthalmic drugs to treat posterior eye disease

Advantages

- Contains both an anode and cathode, creating an electronic gradient for non-invasive medication transport to the back of the eye
- Generates a weak electric field, avoiding interference with other electronic medical devices
- Rests on the surface of the eye with minimal discomfort, allowing for longer use than available therapies

Technology Detail

A layer of positively charged ocular medication located above the eye's anterior chamber rests adjacent to electrodes on the contact's surface. When worn on the surface of the eye, a paired anode and cathode included inside the contact lens generates an electrochemical gradient when the contact's power source is activated. The created voltage gradient extends across the eye's anterior vitreous tissues. The continuous current from each end of the anterior eye drives the migration of positively charged drug particles from the cathodic electrode to the anodic electrode. This electric field allows the medication to penetrate the epithelial cell layer and travel towards the back of the eye while evenly distributing medication throughout tissues in the posterior eye.

Smart Mosquito Trap to Automate Detection, Counting and Data Reporting for More Efficient Flying Insect Control and Disease Research

Captures Mosquitoes and Remotely Reports Population Data

Background

This mosquito trap incorporates software and computing processors that enable detection and counting of captured insects and also establishes a communication network between traps, providing remote reporting and access to the real-time data. Mosquitoes are notorious carriers of many diseases which kill over 1 million people worldwide every year. As such, the global market for mosquito control efforts is projected to exceed $350 million by 2021. Whether for targeting the application of insecticide by mosquito control district teams, for entomological research or for disease research programs, effective mosquito monitoring involves recording accurate censuses of flying insect populations through the deployment and subsequent inspection of traps. The monitoring and maintenance of these traps is both costly and labor intensive, especially when the project includes many traps deployed in remote locations. Available mosquito trap designs do not support potential smart features such as controllable gas attractant release or identification and selective capture of a particular sex or species.

Researchers at the University of Florida have designed a smart mosquito trap capable of recording and reporting captured insect population data over a wired or wireless network to provide researchers and technicians remote accessibility. The traps are highly configurable and can integrate a range of visual, audio, or proximity sensors to enable advanced detection and identification functionality, enabling more efficient disease research and insect control.

Application

Smart mosquito trap that counts captured insect populations and transmits the data across a trap-to-trap network to increase mosquito monitoring efficiency

Advantages

- Enables insect population data recording and reporting over a multi-trap network, increasing the efficiency of mosquito monitoring
- Utilizes a flexible computing device that can integrate various attraction mechanisms and detection sensors, facilitating species-, sex-, or type-specific detection and capture
- Works with various wired and wireless protocols, simplifying implementation into local mosquito control efforts
- Allows remote control of trap functions, including gas locking and releasing or chamber emptying, saving time and effort on maintenance
- Installs underground, underwater, or floating on water, permitting mosquito control in diverse environmental settings
- Operates using a solar charging system, ensuring trap station longevity
- Supports GPS tagging, preventing potential trap theft

Technology Detail

These mosquito traps augment traditional CDC trap designs with smart capabilities to improve mosquito monitoring for disease research and insect population control efforts. Flying insects drawn into the traps pass through a narrow, extended path, allowing various sensors to detect the captured insects by recognizing audio or visual patterns or analyzing wing-beat frequencies. A processor keeps count of the population in the basket. The computing devices integrated into the traps can establish a wired or wireless communications network between the traps, providing researchers and technicians with remote access to device data and remote control over device functionalities.

Coatings to Minimize Artifact Scattering on Industrial X-ray and CT Scan Images

Improves Resolution and Precision of X-ray and CT Imaging Using Mitigating Materials

Background

These coatings minimize scatter that arises most strongly during an X-ray or computed tomography (CT) scan of an object, where the object interfaces with the surrounding air. In dentistry, for instance, scatter occurs from existing fillings and crowns, which can distort X-ray images used in diagnosis. The automotive and aviation industries also use X-ray and CT frequently because imaging can help manufacturers inspect and analyze complex manufactured parts and systems without destroying them. Estimates value the global market for industrial X-ray inspection systems to grow to about $350 million by 2022. While available imaging techniques are useful, scattering artifacts can obscure images, causing misinterpretation. X-ray photons beam through an object and generate an image on an X-ray detector on the other side of the object. The density of the various parts of the object determines the amount of photos absorbed or scattered. Greater density areas absorb more photos to show the true shape of the object while lower density areas scatter photos, which produces a fog or feature on the image that doesn't exist on the object. Some imaging instrument manufacturers provide hardware and software solutions to resolve this issue, but they are often expensive and imperfect.

Researchers at the University of Florida have developed scatter mitigation methods using a variety of coatings that improve the fidelity of X-ray images by reducing scattering at the surface of an object. The coatings can mitigate scattering by absorbing scattered photons, which provides a simple and cost-effective strategy for improving clarity of X-rayed and CT scanned objects.

Application

Coatings to reduce scattering artifacts in X-ray and CT scan images

Advantages

- Provides a range of low-cost coating options, creating solutions for a variety of industrial X-rayed objects
- Absorbs scattered photons, improving fidelity defect identification on images

Technology Detail

In X-ray and CT imaging, the most scattering occurs at the boundary between the surface of an object and the surrounding air because photons here have a low chance of absorption before reaching the detector. Four major types of coatings mitigate scattering. Various coatings consisting of materials including alkali, metals, oil or clay applied to the surface of an object can mitigate either Compton or Rayleigh radiation scattering.

Fuel Injection System for Improved Fuel Mixing and Distribution into Hypersonic Jet Engines

Injects Fuel into a Jet Engine's Airflow Upstream of the Combustion Chamber to Improve Fuel Modulation and Combustion Efficiency

Introduction

This fuel injection system places a porous injection strut near the engine's airflow inlet to inject fuel into the center of the airflow upstream from the combustion chamber. This positioning improves fuel distribution throughout the airflow, achieves better fuel mixing, and increases combustion efficiency, all of which makes fuel injection for an engine in hypersonic flight possible. Jet engines function by forcing incoming air through an increasingly narrow chamber, compressing it to increase its temperature. Fuel injectors squirt fuel into the compressed air then they mix together and burn inside of a combustion chamber. The hot exhaust then exits through a tapered nozzle at the rear of the engine, traveling more than twice the speed of the cold air entering the front, propelling the aircraft forward.

Fuel injection is an essential and delicate part of this process that involves introducing fuel into the compressed air prior to its entry into the combustion chamber. Mixing too much or too little fuel with the air hampers engine efficiency and can cause engine failure. In hypersonic jets, fuel injection is particularly complex. Properly mixing the fuel with the large amount of air entering the engine at very high speeds is difficult, because the air traverses through the combustion chamber within a fraction of a second. Fuel mixing at transonic speeds is therefore often incomplete, resulting in too much or too little fuel entering the combustion chamber, which decreases engine performance.

Researchers at the University of Florida have developed a fuel injection system that increases the fuel residence time within the engine's intake airflow, leading to better fuel and air mixing prior to combustion. A porous strut extending across the center of the engine's inlet, upstream of the combustion chamber, evenly injects fuel into the incoming airflow, providing greater control over fuel distribution throughout the entire flight duration of hypersonic aircraft.

Application

Fuel Injection system for hypersonic jet engines that introduces fuel into the airflow at the inlet to improve fuel mixing and provide greater control of fuel distribution at the combustion chamber entrance

Advantages

- Increases residence time of fuel in the airflow, improving premixed air/fuel conditions
- Adds a location for upstream fuel injection, improving fuel modulation along the flight path for better energy management
- Incorporates fuel injectors into the structural design of the propulsion system, reducing overall weight for better engine performance
- Allows for a smaller combustion chamber as a result of improved fuel mixing, reducing system weight and thermal stresses to further enhance engine performance
- Injects fuel into the core of the airstream, avoiding the inlet walls to minimize the risk of flashback

Technology

The primary component of this fuel injection system is a fuel injection strut extending between the opposing walls of the engine's inlet. A porous material forms the surface of this strut, injecting fuel into the incoming airstream as it flows through the porous surface. The strut has about 100 pores per square inch, which are evenly spaced across the surface of the strut, providing a wider and more effective distribution of fuel within the airflow. Furthermore, the structure of the strut ensures that injected liquid fuel breaks up rapidly. This, coupled with the improved residence time, produces a large degree of premixed fuel within the airflow prior to its entrance into the combustion chamber. The fuel injection strut is also oxidation and corrosion resistant, employing a partial composition of Inconel metals.

Unclonable, Chipless RFID Tags to Improve Tracking and Tracing of Pharmaceuticals

Tracks Pharmaceutical Tablets at Pill Level to Enhance Traceability and Prevent Counterfeit Drug Replacement

Background

This unclonable chipless RFID (UCR) tag enables pharmaceutical companies to trace products at the pill level through their supply chains. Today's pharmaceutical industry suffers from product theft and counterfeiting. These issues not only damage the profit and reputation of pharmaceutical companies, but also cause a serious threat to public health. Counterfeit drugs alone generate an estimated $75 billion in revenue each year and have caused over 100,000 deaths across the globe. Available track-and-trace techniques, such as barcodes and QR codes, require individual scanning via direct line of sight and are easy to duplicate. RFID track-and-trace systems, on the other hand, are much more effective because they do not require direct line-of-sight scanning, they can accommodate batch scanning, and they are more difficult to duplicate. However, available chip-based RFID tags are expensive to manufacture, making them impractical for tracking low-cost items. Alternatively, chipless RFID tags offer several benefits including low-cost manufacturing, ability to print directly onto the packaging, and insusceptibility to ambient temperature changes. While these benefits improve pharmaceutical tracking, available chipless RFID tags are both complex to manufacture and vulnerable to cloning.

Researchers at the University of Florida have developed an unclonable chipless RFID tag that traces pharmaceutical products at the pill level. This UCR tag utilizes a layered track-and-trace system to improve product security and quality assurance. The system includes an external tag on each cavity of a tablet blister pack and another tag inside the pill itself. This pill-level tag creates an inseparable connection between RFID tags and the products, eliminating the effectiveness of attempted counterfeit drug substitutions. This UCR technology can be adapted to track other small valuable products, such as microprocessors and fully programmed FPGA's.

Application

Unclonable, chipless RFID tags to track and trace pharmaceuticals at the pill level

Advantages

- Tracks pills individually, making an inseparable connection between the product and tracking system
- Layers two separate track-and-trace systems, providing amplified protection against illegal pill replacement
- Randomizes the tag fabrication process, creating a unique unclonable ID for every pill
- Employs chipless RFID technology, making tags easy to manufacture and utilize

Technology Detail

These pill-level, chipless, unclonable RFID tags comprise a cross-registration approach to ensure greater security. The tags secure to both a product and its packaging, generating a unique ID from multiple entropic sources that can't be removed. One component distributes a specific number of concentric-ring-slot resonators onto the exterior surface of each pill cavity in a blister pack. When the RFID reader

transmits a plane wave to the packaged product, the copper concentric-ring-slot resonators introduce a number of resonance points into the response spectrum equal to the number of rings present. The second component works with a random quantity of nontoxic silver particles inserted into each pharmaceutical tablet. The randomness of the silver particles affects the electromagnetic field distribution when the plane wave is transmitted, further altering the frequency signature. The combined effects of the two components create unique IDs for each package and pill it contains.