The appendage of the human body engineering essay

Engineering

The limb can be described as the appendage of the human body used in grasping and locomotion. It consists of the upper and lower limbs which are usually called the arms and the legs respectively. The limb comprises of several bones and joints which are covered by the skin, subcutaneous tissue containing vessels and nerves, and by deep fascia [1]. These biological tissues have electrical properties (e. g. conductivity) that determine the pathways of current flow through the body and thus are very important in the analysis of a wide range of biomedical application such as non-invasive electromagnetic blood flow monitor, functional electrical stimulation etc [2]. The electrical properties of any material including biological tissues can be broken down into two categories; conducting and insulating. In a conductor, the electric charges move freely in response to the application of an electric field, whereas an insulator, the charges are fixed and not free to move. On a more basic level, knowledge of these electrical properties will lead to an understanding of using a compound containing bentonite to model the human limb. Bentonite is a group or series of clay-like materials characterized by an alkaline oxide and alkaline earth content of 5 to 10 percent, fine grain size, high adsorptive powers, and usually very strong colloidal properties [3]. It is a type of clay that consist predominantly smectite minerals usually montmorillonite and beidelite. These minerals are very soft phyllosilicate group of minerals that typically form in microscopic crystals, forming clay. Bentonite is highly plastic, highly weathering resistance material and highly swelling in the presence of moisture [4]. Because of its mineral composition, ion exchange takes place when an electric field is applied to it. This ion exchange definitely influences the passage of electric current. Bentonite has good electrical properties, which when composition of the minerals are varied, the electrical properties changes. This implies that the distinctive engineering properties of bentonite are directly related to the mineralogical structure of the clay. The importance of bentonite cannot be overemphasized. It is used efficiently in everything from hazardous waste treatment to cosmetics and pharmaceuticals. Also it is profitably used in civil engineering and construction, drilling operations and many other environmental retention applications. The main focus of this report is on designing and construction of phantom limbs that have same internal electrical conductivity as real human limbs using compounds containing bentonite.

ELECTRICAL PROPERTIES OF LIMB

When viewed in cross section, the human limb consists of skin and subcutaneous tissues containing nerves and veins. These tissues have different electric properties and these differences to a large extent are determined by the fluid content of the tissue. For instance, blood conduct current relatively well; muscle and spleen are intermediate in conductivity; skin and bone are relatively poor conductors [2]. Blood has a conductivity of, bone, muscle, and skin [2].

1. 2 AIMS AND OBJECTIVES OF THE STUDY

The aim of this study is to design and construct a phantom limb that has same electrical conductivity of a real human limb with compounds containing bentonite for use in non-invasive electromagnetic blood flow monitor. In order to achieve this aim, the following objectives are set out; Mix bentonite compound to give a sample that has precisely controlled conductivity. Design a test cell to enable the conductivity measurement of bentonite. Determine how reliably/repeatedly the sample can be made. Attachment of electrode to the simulated limb.

2. 0 LITERATURE REVIEW

2. 1 HISTORICAL REVIEW AND COMPOSITION OF BENTONITE

The term bentonite was used first by Knight W. C. for clay found in about 1890 in upper cretaceous tuff near Fort Benton, Wyoming and two general types are known; northern or true bentonite (discovered in the region of the Black Hills of Wyoming and South Dakota) and the southern or so-called metabentonites found primarily in California and Texas; but the deposits of both types occur in many other parts of the United States [5] [6]. There are deposits of bentonite in several part of the world and it is produced normally from alteration of volcanic ash. To be economically extractable, deposits of bentonite are near the surface. The material overlying the bentonite must first be removed with a bulldozer or excavator. The surface of the bentonite's bed must be carefully scraped to remove the impurities. Depending on the thickness and the extent of variation, the bentonite can be scraped one layer at a time or dug with bucket loaders. Bentonite is processed by drying, grinding and bagging. The core constituent, which is the determinant factor in the clays properties, is the clay mineral montmorillonite [5]. The name ' montmorillonite' has its origin from the town of Montmorillon in Southern France. Montmorillonite belongs to the smectite group of clay minerals. Smectite clay minerals are made up of individual crystallites that are mostly less than in largest dimension. Smectite crystallites themselves are three-layer clay minerals. They are made up of two tetrahedral layers and one octahedral layer. The montmorillonite tetrahedral layers consist of Silicates [SiO_4] - tetrahedrons enclosed by the [M(O_5, OH)]-octahedron layer (M is majorly Aluminum (Al), Magnesium (Mg), but Iron (Fe) is also often found). The silicate layers have a slight negative charge that is balanced by the exchangeable ions that are in the intercrystallite region. The charge is so weak that the cations primarily Calcium ion Ca^{2+} or Sodium ion Na^{+} can be adsorbed in this region with their hydrate shell. The degree of hydration produces intercrystalline swelling. Montmorillonite are generally classified as Sodium (Na) or Calcium (Ca) types, based on the exchangeable ion that is dominant. The mineralogical composition of bentonite varies extensively depending on the origin and contains a variety of accessory minerals like quartz, feldspar, calcite and gypsum in addition to montmorillonite [5][7]. The special properties of bentonite (hydration, swelling, water absorption, viscosity, thixotropic, conductivity) make it a valuable material for a wide range of uses and applications. Quan Chen and his group in Singapore Institute of Manufacture Technology used bentonite to develop a latent finger print. Intercalation which involves insertion of molecule between two other molecules was used. Two types of cationic dye, Rhodamine 6G (R6G) and Methylene Blue (MB) were first absorbed on bentonite particles by an ion exchange process and the particle surface was subsequently modified by phenyltrimethoxysilane (PTMOS) [8]. The resultant particles had combined dye with good affinity and their surfaces depicted organophilic due to the planar aromatic ring of PTMOS grafted on the surface and edges of layered bentonite particles. The organophilic property promotes the attachment of particles to finger mark residues. Particles were produced as a powder and applied as a dusting agent using brushes. Kadir Esmer (1998) measured the electrical conductivity of bentonite when treated with organic molecule (benzidine–, pyrazine– and 1, 4-diamino benzene–). Dc and ac measurement techniques were applied to ribbon and sandwich type samples. Measurements were made under standard pressure, humidity and room temperature. It was observed that conductivity of ion exchanged Ag–, Cu–bentonite and benzidine–bentonite complexes increased [9]. M. B Kostic et al (1999) used bentonite and waste drilling mud to improve the electrical properties of grounding loop. Transmission line tower footings needs low grounding resistance so as to ensure proper operation of high speed protective relaying. Also, low grounding resistance results in a considerable reduction in the transmission outages caused by lightning strokes. The use of these materials showed a significant reduction in the grounding resistance and maximum touch voltage, especially during drought periods [10]. More so, Ana T. Lima et al (2010) determined the conductivity of bentonite using a model based on series-parallel transport. The total electrical conductivity of the bentonite plug was established to be dependent upon density of the clay [11]. The variation was expected to be due to surface conductivity. For modeling total conductivities, several assumptions were made: diffusivity of Na+ and Cl- are equal; solid conductivity was considered zero; high tortuosity.

2. 2 AREAS OF APPLICATION OF BENTONITE

Bentonite is used in several practical applications. This includes the industry, medicine/science, academics etc.

2. 2. 1 APPLICATION OF BENTONITE IN INDUSTRY

Bentonite is used in the industry for its inherent physical properties or the properties it can develop in other materials. Combinations of water and bentonite performs multitude of work in industry because the physical properties of the mixtures change as water-to-clay ratio changes [12]. The mixture of bentonite and water is used for bonding, plasticizing, and suspending. This bonding behavior is useful in foundry molding sand, as a binder for rock wool and asbestos fiber in producing industrial insulation products, as an ingredient to create pellets of animal feed from coarse ground components, and in the pelleting of finely divided magnetite concentrates recovered from taconite ore. Another good application is in drilling where it is used as mud constituents for oil and water well drilling. Its roles are mainly to seal the borehole walls, to remove drill cuttings and to lubricate the cutting head [5]. Also, bentonite is used in construction/civil engineering where the swelling and thixotropic capabilities are utilized in support and lubricant agent in diaphragm walls and foundations, in tunneling, in horizontal directional drilling and pipe jacking.

2. 2. 2 APPLICATION OF BENTONITE IN MEDICINE/SCIENCE

Bentonite is used as ingredients in pharmaceutical and cosmetic preparations. It allows paste formation due to the inherent absorption/adsorption properties. It is used as base for salves and ointments and as a diluent for powerful drugs, antidote in heavy metal poisoning, as well an adsorbent or carrier of vitamins. Cleansing and healing power plastic are produced when bentonites are mixed with various liquids. This disallows moisture, salts, and poisonous substance from the surface of the body. Such applications include industrial protective creams, calamine lotion, wet compresses, and antiirritants for eczema. Personal care products such as mud packs, sunburn paint, baby and facepowders, and face creams contain bentonite.

2. 2. 3 APPLICATION OF BENTONITE IN ACADEMICS

Bentonite is used by researchers and tutors for different educational purposes. Tutors use it for demonstration on clay mineralogy whereas researchers use it for carrying out researches on several field of study.

2. 3 METHODS FOR MEASURING RESISTIVITY AND CONDUCTIVITY OF SOLIDS

The electrical resistivity of a material is a number describing how much that material resists the flow of electricity and it varies from one substance to another [13][14]. In solids, it gives the clearest indication of their ability to conduct electricity. The unit of resistivity is ohm-meters (Ω-m) and is represented by the Greek letter ρ. If electricity can flow easily through a material, that material has low resistivity. If electricity has great difficulty flowing through a material, that material has high resistivity. Electrical conductivity is defined as the inverse of the resistivity. The unit of conductivity is Siemens-per-meter (S/m) and is represented by the Greek letter σ. K: My DocumentsMy Picturesimg001. jpgFig. 2. 1 Simple model of electricity flowing through a material under an applied voltage [14]There are two types of charged particle capable of transporting electricity through a material; electrons and ions. Electrons are charged particles, characterized by their charge –e and their inertial mass in the free sate me whereas ions are atoms which have lost or gained a small number of electrons, have a positive or negative electric charge of the same order as that of electrons [13]. Figure 2. 1 shows a simple model of electricity flowing through a material under an applied voltage. The white circle represent electron moving from left to right of the material and the black circles represent the stationary atoms of the material. Many electrons flow simultaneously from the left side of the material to the right side of the material due to the applied voltage. As the electron moves through the material, it collides with the stationary atoms of the material. These collisions slow down the electron. A material that produces lots of collisions is a high resistivity material. A material that produces few collisions is a low resistivity material. The resistivity of a material can vary greatly at different temperature and can also depend on the applied magnetic field [14].

2. 3. 1 TWO-POINT TECHNIQUE FOR MEASURING RESISTIVITY

C: UsersPa RayDesktopThesisDrg3. pngFig. 2. 2 Two point technique [15]The resistivity of a material can be obtained by measuring the resistance and physical dimensions of a bar of material as shown in Figure 2. 2. The bar of material has a cross sectional area A and a length l. Copper wires are attached at both ends of the bar. This is called two –point technique in that wires are attached to the material at two points. The battery E supplies a voltage V across the bar, causing current I to flow through the bar (in through probe 1 and out through probe 2). The amount of current I that flows through the bar is measured by the ammeter which is connected in series with the bar and voltage source. The potential difference between the two contacts is measured by the voltmeter. The resistance R of the bar is given by equation 2. 12. 1Where R = Resistance in ΩV = Voltage in voltsI = Current in ampsThe physical dimensions can be measured with ruler or other appropriate measuring instrument. The two-point resistivity of the material will be; 2. 2Where R = Resistance in ΩA = Cross-sectional area in m2l = length in mIn practice, measuring resistivity with a two-point technique is often not reliable [14]. It has some drawbacks which include; error due to contact resistance between the wires and the material; contacts between the electrodes and the material have a tendency of other electrical properties that give wrong estimates for the actual sample resistivity. The four-point technique overcomes these problems.

2. 3. 2 FOUR-POINT TECHNIQUE FOR MEASURING RESISTIVITY

C: UsersPa RayDesktopThesisDrg1. pngFig. 2. 3 Four-point technique [15]C: UsersPa RayDesktopThesisDrg2. pngFig. 2. 4 Electric field in the materialFigure 2. 3 shows the four-point technique for measuring resistivity of a bar of material with a cross-sectional area A. It comprises of four equally spaced tungsten metal tips with fixed radius. The various tips are supported by springs on the end so as to eliminate any form of material damage during probing. The material has a total length l (probe 1 to 4) and length l1 (length between probes 2 and 3). A current source forces a constant current through the ends of the bar of material (probes 1 and 4). The ammeter measures the current I passing through the bar while the voltmeter measures the voltage V across the inner part of the bar (between probes 2 and 3). The inner part draws no current due to the high input impedance voltmeter in the circuit. In figure 2. 4, the electric current carried through the outer probes, sets up an electric field in the bar of material. The solid lines represent the electric field lines and broken lines represent the equipotential lines. The inner probes measures the potential difference between points B and C and the unwanted voltage drop at points B and C caused by contact resistance between probes and the bar of material is eliminated. K: My DocumentsMy Picturesimg020. jpg

RISK ASSESSMENT ASSOCIATED WITH THE STUDY

Risk assessment is the process of evaluating all the risk and possible dangers associated with the present study. It is targeted at specifying the risk, identifying the various causes and recommending ways of avoiding/mitigating the effect of such risk/danger.

S/N

Identified Risk

Causes

Recommendation

1Loss of experimental data and reportUnexpected personal computer failureRegular backup of experimental data and report2Health effectsInhalation of powder which will result to irritation of respiratory system or lungs. Ingestion if swallowedIrritation of skin when in contact with powderIrritation and smarting of the eyes when powder enters the eyeAdequate general and local exhaust ventilation should be providedRespiratory protection should be used when air contamination is muchRubber or plastic gloves should be wornDust resistant safety goggles should be wornAppropriate clothing to be worn e. g. lab coatFirst aid box should be handyC: UsersPa RayDesktopThesisDrg4. png