Book Review

Title: Handbook of Electrostatic Processes

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This is a very sizable book concerning the study of Electrostatic Discharge (ESD) processes. The book covers fundamentals of ESD and many other subjects related to ESD. The handbook is made up of thirty-three (33) chapters, but in reality it can be said the book contains thirty-three papers from a variety of sources (authors). As is customary each paper has an abundant number of references for further consultations if necessary.

The first chapter in the book is known as Electrostatic Fundamentals. Electrostatic is used in a wide range of applications ranging from the calculation of atomic forces to wrapping of leftover food items. All of these applications can be understood by the application of a few principles based on numerous observations. This chapter describes these principles and gives the formulas used to calculate the magnitude of the effects. The ideas presented here will be used repeatedly in the later chapters to discuss particular aspects of electrostatics. Chapter 2 discusses the Electrification of Solid Materials. It provides a brief over view of physical aspects related to the electrification mechanism of solid materials. With the exception of lightning, frictional electrification of material objects is probably the earliest electrophysical phenomenon known to people from their direct experience. This chapter emphasizes the present development of new and important links between electrification phenomena and certain fundamental aspects of quantum physics and other key areas of modern science, technology, and engineering. Chapter 3 covers Electrostatic Charging of Particles. When particles flow through an ionized zone, some ions will be deposited to the particle's surface and become charged particles. The amount of ion deposition on the particle surface depends on resident time, particle radius and shape, external electric and magnetic fields, particle velocity, etc. In this chapter, the effect of these parameters is discussed in detail. Chapter 4 is known as Electrical Phenomena of Dielectric Materials. If we exclude all metals, all remaining material are dielectric, whatever the state of the matter in question (solid, liquid, gas), and a permittivity can be ascribed to any substance, with vacuum as the reference dielectric. Dielectric can be employed either as passive devices (capacitors, cables) or in active devices (electrets, electrostatic motors), and they are required to function in our near or far environment (air seawater, soil, and space). Generally, materials are subjected to a voltage (dc, ac, and impulse), and, in exceptional cases, to an electromagnetic field produced by, for example, an intense laser beam. The spatiotemporal distribution of the field inside the matter not only is imposed by the geometry of the electrodes and the shape of the voltage wave but also depends on space charges: charge carriers can be generated or blocked at interfaces when different dielectric substances come into contact with each other. Chapter 5 is titled: Flow Electrification of Liquids. When a dielectric liquid flows through a pipe from one vessel to another, the potential difference that appears in the collecting vessel is due to the accumulation of charges. These charges result from the convection of a part of the electric double layer existing in the tube at the contact between the liquid and the inner wall. Indeed, at the liquid/solid interface, the electrochemical reaction induces an electrical double layer composed of two layers in the liquid: the compact layer very close to the wall (unaffected by the flow), and a diffuse layer that can be convected. Then the space charge density Q convected in a pipe by a flow is given by the ratio of the charge convected to the flow rate.

In Chapter 8 we see the subject of Injection Induced Electrohydrodynamic Flows. Electrohydrodynamic (EHD) is the study of the motion of liquids subjected to electric fields. The forces that are exerted by an electric field on free or polarization charges present in a liquid are transmitted by collisions on the neutral molecules. Typically, the liquid will be set in motion, thus changing the distribution of charges that in turn modify the electric field. This coupling makes EHD a difficult subject. The liquid state is chemically very reactive compared to the gas or solid state. Trace impurities undergo chemical reactions giving as end products ionic pairs. This chapter is organized as follows. In Sections II and III the equations of electrodynamics are deduced and then cast in nondimensional form to put in evidence the scales that appear frequently in EHD. Sections IV and V are dedicated to the problems of unipolar injection induced instability and convection. Chapter 9 addresses Gas Discharge Phenomena. The object of this chapter is to provide a brief overview of the fundamental aspects governing plasmas found in gas discharges, with particular emphasis on glow, arc, corona, and spark discharges. Gas discharge phenomena can generally be divided into those that occur at low pressures (<100 torr) such as glow discharges and those that occur at high pressure (< 760 torr) such as corona or spark discharges. Although arc discharges can occur under both low and high-pressure conditions, they have been included under discharges that occur at high pressure in this case. High voltage generation is addressed in Chapter 10. High voltage is widely used in equipment and in the testing of power apparatus. The types of high voltage in used can be classified as AC, DC and pulses. Some examples discussed in this chapter such as single transformer, cascade transformer, series resonance circuit, and Tesla coils (for AC) and half/full wave rectifier, voltage doubler, voltage multiplier, deltatron, and Van de Graff generator (for DC). Measurements of Electrostatic Fields, voltages and charges are described in Chapter 11. Examples of electrostatic environments in which measurements are important include electrostatic precipitators, static control systems for manufacturing, electrophotography, electrostatic flow systems, electrostatic spraying, atmospheric studies, and EOS/ESD hazard identification. This chapter outlines the basic principles and techniques of electrostatic measurement. The reader is assumed to have a working knowledge of field theory fundamentals as outlined in Chapter 1. Chapter 12 discusses the measurements of wind velocity using electrostatic flow measurement techniques.

The study of multiphase gas-liquid-solid flow requires accurate measurement of each phase velocity and phase fraction. Electrostatic multiphase flow measurement techniques are discussed in Chapter 13. Electrostatic principles can be used in the detection of multiphase flow measurement techniques. For example, piezoelectric transducers can be used to measure ultrasonic waveforms that have interacted with multiphase flow. Another example uses ionization (charge) chambers for the detection of radiation attenuation. The various techniques for measurements of two-phase flow parameters such as void fraction, phase distribution, and phase velocity will be discussed for gas-liquid and gas-solid two-phase flow applications. Several techniques are mentioned to ensure a fairly complete list with particular strengths and weaknesses addressed. In chapter 14 printer technology is discussed. Modern printing systems for computer output and office applications are generally divided into impact and nonimpact technologies. Most nonimpact printing technologies either were developed from the electrophotographic process or use one of many varieties of in jet printing. Hence electrostatic plays an important role in modern nonimpact printing systems. This chapter reviews the fundamental performance issues in document and graphics printers. Chapter 15 covers electrophotography. Copiers and laser printers, which use the electrophotography technology, represent one of the successful commercial applications of electrostatic phenomena. These devices, unknown to the general public, before 1959, have become indispensable office equipment today. Electrophotography is one of the most successful commercial applications of electrostatic phenomena. In most embodiments it requires six process steps to produce a copy: charge, expose, develop, transfer, fuse and clean. Electrostatic plays key roles in almost all these steps. Discussed in this chapter are the role of electrostatic in the charge, expose, develop, and transfer steps. During charge and transfer, the photoreceptor and the back of the paper, respectively, are uniform charged by extracting ions with an electric field from a gas breakdown, initiated by applying a high potential on this wire. Chapter 16 covers Electrostatics in Flat Panel Displays. Electrostatics plays a vital role in a variety of display technologies. These include the cathode ray tube (CRT), plasma displays (PD), liquid crystal displays (LCD), and high field electroluminescent displays (HFEL). This chapter will focus on display technologies that have application for flat panels, which are expected to make significant inroads into CRT dominated areas. The use of electric fields in PD, LCD, and HFEL will be described in conjunction with device operation and materials used in the active region of the device. However, another potential candidate for flat panels is a flat CRT. Chapter 17 addresses the Application of the Electrostatic Separation Technique. Separation and classification are very important manufacturing processes in many industries such as the mining and chemical industries. Equipment using many different methods of separation is applied in these processes. Electrostatic separation (including electrostatic classification) in one separation method. This method, relying on the differences of electrostatic characteristics inherent in different materials, has a long history. After an initial overview of the electrostatic technique, this chapter discusses a number of interesting applications of the techniques in the fields of ore, coal, food, and scrap processing. Finally, a few new applications are discussed. Chapter 18 considers Electrostatic Coalescence in Liquid-Liquid Systems. Phase coalescence may be defined as the aggregation of dispersed droplets that are suspended in another immiscible or partially miscible liquid, to form a heterogeneous dense packed zone at the main interface between the two bulk liquid phases. The coalescence phenomenon is associated with and important to some processing industrial operations, e.g. in the liquid-liquid extraction process. Indeed, liquid-liquid separation is not only restricted to extraction processes; it is also of considerable importance in effluent treatment plants and in any processes where liquid-liquid dispersions are present. Electrorheology is the title of Chapter 19. The electrorheological effect is a phenomenon in which the resistance to flow or to deformation of certain types of fluid can be changed by the application of an electric field. Chapter 20 is interested in Electrostatic Atomization and spraying. Electrostatic atomization and spraying in agriculture has found widest usage as the basis for incorporating electric force fields into the application of crop protection pesticides. Twofold improvements of droplets mass transfer efficiency onto plant surfaces are routinely achieved with corresponding environmental and economic benefits. Electrostatic induction has proven most satisfactory for charging water based sprays in the field, while electrohydrodynamic serves well for charging low conductivity, non aqueous liquids. Electrostatic Precipitation is outlined in Chapter 21. The electrostatic precipitator is a device for removing particulate pollutants in the form of either a solid (dust or fumes) or a liquid (mist) from a gas using an electrostatic force. Electrostatic precipitation (ESP) has been widely used for cleaning gas from almost all industrial processes with a medium to large gas volume (> 2000 m3/mim), including utility boilers, blast furnaces, and cement kilns. ESP is also in wide use for air cleaning in living environments and work places. ESP has large advantages over other particulate control devices: a lower operating cost, because of its low corona power and the low power needed in its blower due to a low pressure drop; a high collection performance even for submicron particles; and ease of maintenance.

The electrostatic precipitator (ESP) is a real challenge to the modeler. It requires knowledge of many fields: electrostatic, physics, fluid mechanics, mechanical and electrical engineering, adhesion, cohesion, and aerosol behavior. A model can be simple enough to describe with a few equations but can also require the capacity of a large computer to in details. The ESP is primarily an electrical device and must be characterized by its electrical parameters first. It is designed to collect aerosol particles, that is, particles small enough to remain suspended in a still gas for up to ten seconds. The characteristics of the aerosol are next most important. The removal of the particles from a flowing gas must be accomplished in a relatively short treatment time to minimize the size and cost of the ESP. Chapter 23 covers transducers. A transducer is a device that changes certain physical values to other physical values. There are many kinds of transducers related to electrostatics. They include electrostatic sensors, electric energy converters, and electric actuators. Typical examples are acoustic transducers made of electrets. One of which is called an electret microphone and is widely used in the compact cassette tape recorder. Other transducers include electromechanical converters, electrostatic sensors, and capacitive converters. Chapter 24 reviews EHD Enhanced Mass Transfer Operations and Chemical Reactions. The majority of conventional chemical processing operations applies mechanical or thermal energy in combination with pressure and gravity forces. The ability to superimpose electric fields to improve several separation processes has been well known and widely used for many years. The familiar industrial applications range from solid-liquid separation in the beneficiation of ores in the mining industry and cleaning of exhaust gases from solid particles in the energy and other industries. Chapter 25 (Heat Engineering) outlines the characteristics of active heat transfer enhancement techniques by applying electric fields.

Chapter 26 considers the usage of passing air or oxygen through a special s special electrical gas discharge to produce ozone. Ozone has any applications outlined in the chapter. Chapter 27 lists several methodologies for removing gaseous noxious emissions with a pulse electrostatic technology. Chapter 28 covers the very interesting subject of atmospheric electricity. The atmosphere is ionized by radioactivity, mainly alpha rays from the earth's crust, and by cosmic rays from space. Both electrons and primary positive ions thus produced react with atmospheric gases. The reactions continue until reaching the terminal negative and positive ions, respectively, within a few microseconds. Biomedical Engineering and electrostatic is discussed in Chapter 29. There are needs in biotechnology for the manipulation of small objects, such as cells, chromosomes, biological membranes, and nucleic acid and protein molecules. Biological cells range in size from less than a micrometer to several hundred micrometers, and molecules are even smaller, measured in nanometers Electrical forces are highly suitable for handling, characterization, and separation of these find particles. With the use of electrostatic effects , these objects can be manipulated collectively or even individually. In addition, because electrostatic force is "surface force" distributed around the surfaces of objects, it enables gentle manipulation, without applying too much stress to the objects. Finally chapters 30 through 33 addresses the negative aspects (or hazards) of electrostatic discharges.