Electrostatics 2019 – Questions and Answers

Session: Nature and Biology

Bumblebee hair motion in electric fields
K L Koh, C Montgomery, D Clarke, E L Morley and D Robert

Q1. Do you perceive there is any application of the electric field applied to insects or bees as a form of repellent? For example, could it be used to repel them from a building or campsite?

A1. Yes, definitely. One of our lines of inquiry is the spraying of insecticides for fertilizers and that there could be some electrostatic effects, which are putting bees off. Hence there could be a case of designing other types of fertilizers or insecticides that are more ecologically friendly. We are trying to understand how bees sense the environment around them to design better environmental policies. Bees are an agricultural commodity these days. Therefore, the information will be necessary for farmers.

Q2. How does the bee use the hair as a sensor? What is the bee feeling physiologically?

A2. They have measured the nerve on the base of the hair. Therefore, at the base of the hair of most insects, there is an intricate structure of nerves. The structure has been studied in much detail for acoustic field sensing, and the hairs move like an inverted pendulum, and the deflection at the base fires nerves. In the paper, they show the deflection of the hair by the electric field is large enough to make a nerve fire.

Measurement of electric charges on foraging bumblebees (Bombus terrestris)

C Montgomery, K Koh and D Robert

Q1. Are you aware of Prof. Low’s and Dr. Ganmore’s work on bee charging? They charged the bees at different polarities under different humidity so their work may be useful.

A1. Yes, their 1995 paper showed that bees charge up less in higher humidity, but they did not show a reversal of charges. I do not believe there has been a registered example of bees having a negative charge.

Q2. Do you believe the electric field could be used to control pollination, i.e., could you increase the level of pollination for agricultural applications?

A2. Yes, I believe others are looking into that. There are already charged polymer sprays that are used to spray pollen at flowers. A member of our lab is investigating how the plant physiology and how it affects the floral electric field, as this could highlight the types of flowers and conditions that could be optimal for that use.
Session: Triboelectrification

Experimental study of the triboelectric charging of a glass bead impacting against a polymer plate

U Lesprit, T Paillat, N Zouzou, A Paquier and M Yonger

Q1: When you perform repetitive tests, did the subsequent impact charges go down over time?
A1: Between two tests we do not have exactly the same point of impact, so we are not interacting with a previously charged part of the surface, so we do not see any relationship between what is built in one test and the following test.

Q2: Because it is a PTFE surface, is there a need to neutralise over time? Perhaps it has an effect on electric discharging so in the end there might be an accumulation of charge that is causing it.
A2: We have thought about it. Generally, what we can do pretty easily is remove the target emplacement inside of it, so that is what we do at the moment. We have thought about potential neutralisation of the surface, but some of the devices we have thought would generate a lot of charge inside the system and we are afraid it would interact with other parts of our very sensitive measurements. So that is why, so far, we have not gone into this area, and it does not appear that we see a dependence on further tests.

Q3: What is the size of your beads? Would you expect a size dependence on your charging?
A3: We have 4 mm diameter beads. We do expect a dependence on the size. It is already described in some literature that size of the spherical particles will impact this very aspect. We have not tried to vary this parameter, but we do expect to see an increase in charge with increase in diameter.

Q4: Does your video technique let you distinguish at all, or identify sliding and rolling contacts?
A4: We don't have much resolution so far, so we cannot distinguish the two at the moment.

Q5: That can actually be associated with whole different charging, and indeed, relaxation mechanisms.
A5: We will try to investigate this. We will first need to go to a faster acquisition rate because 5000 images per second is not enough to really distinguish what will happen on the surface, and we have thought about adding some coloured part to the bead in order to see if we have sliding or rolling or what happens alongside the target, but the problem we have is not enough resolution to gain comprehensive knowledge from those tests, so we are still looking into it.

Q6: What is the industrial relevance for your partner in this work?
A6: We are now more looking at the chemical conditions and to see how it impacts the build-up of charge and what solution there could be potentially to increase or decrease the amount of charge.

Q7: Is this blowing glass beads like pneumatic conveying? Is this what is driving the research?
A7: I am not allowed to say.

Comment: A tip also – humidity is probably affecting your glass bead more than the PTFE. Glass in high humidity likes to form a static dissipative surface; PTFE is not so impacted by humidity.
Contact electrification of adhesion films on flat panel displays

T Viheriäkoski, J Hillberg, J Smallwood and P Holdstock

Q1: What is the area of the charged surface?

A1: 10 cm × 10 cm.

Q2: Why is the charge density on the dissipative material higher than on the insulating material?

A2: If we think about two insulating materials in a triboelectric series, and when we touch them together and they are separated, one of them goes positive and one goes negative. If we have a little bit of conductivity on one side and it is connected to ground, we will see exactly the same charging effect, but because the other material stays at the earth level, we will exactly the same charging, but it goes … [interrupted]

Q3: Charge must be conserved.

A3: Agreed. It seems also we got different behaviour. We saw many time we can get higher charge with dissipative surfaces, but also the opposite observations.

Q4: What materials were earthed.

A4: At first we made tests with automated separation without earthing, and then we added earthing and saw the behaviour after that, but in manual separation, the sample was always earthed.

Surface treatment of granular materials by dielectric barrier discharge in view of triboelectric charging improvement

A Benabderrahmane, T Zeghloul, K Medles, A Tilmatine and L Dascalescu

Q1: Just wondering if we have got a chemical phenomenon here? In the plastic films industry, especially when we want to print onto films, we corona treat them. There is quite a high energy atmosphere created above the polymer and it tends to oxidise the film, so you could be having ether groups, carboxyl acids and things like this forming on the surface. When you come to do the charging, and we have seen some evidence here of static dissipative particle charging more in some cases, I think that is a mechanism you want to develop. And also, if you are looking for industrialisation, corona treatments are pretty developed over the past 30 years or so. I do not understand the end use application of charged particles in particular for polyethylene, but I am sure there are things we can learn for the printing industries, but they may already be doing things.

A1: We are interested in the electrostatic separation of waste electrical and electronic equipment. Polyethylene, we can find this type of plastic in waste, so we are trying to improve the charge in order to better separate from a mixture. And yes, there are some chemical interactions, but since the particles are very small, 2 – 4 mm, we can do some tests on them to see the chemical … [interrupted].

Q2: There is a time effect with corona treatment as well, if you have got additives in your plastic, and your recycled waste will not be pure polyethylene, there will be a lot of additives, and these effects can be lost after treatment.

A2: Yes, of course.
Session: Dielectrophoreses, Particle Control and Transport

Electrostatic formation of liquid marbles – statistical model

P M Ireland, C A Thomas, B T Lobel, G B Webber, S Fujii and E J Wanless

Q1. Have you tried checking how the applied electric field and the conductivity of the particles you are trying to lift and the minimum electric field required for them to lift off?

A1. We have qualitatively but not quantitatively with polystyrene, polypyrrole, and several other particles, and there seems to be a trend.

Analysis of the behaviour of charged particles in electrical relay devices

M Iida, K Koshimura, M Kaneko and M Saeki

Q1: Is the voltage applied AC or DC?

A1: We always use DC voltage.

Q2: You saw a small difference between the velocity of the particle you observed versus the model. Can you comment on the source of that difference?

A2: I think we did not measure the amount of charge precisely because we catch the particles with a tweezer and there might be some triboelectrification.

Q3: As an electrical/electronic engineer interloping in room full of physicists, I think this is really interesting. I have seen relay failures over time and wondered just how that happened. Also, I am very impressed with how you have treated it as an interconnected system and written your own code for the FEA, etc. rather than trying to put together multi-physics FEA to try to recreate that result.

A3: Thank you.

Session: Lightning Protection and Hazards

Case study to determinate the angle-dependence during the risk determination in lightning protection

Z Tóth, I Kiss and B Németh

Q1: Have you tried to use a simulation system to predict the e-field distribution around the scenario; do you have information that the e-field gradient would follow your curves and support you measurements?

A1: I made some simulation. We had a problem for this one, and we can calculate the value of the probability for the PMAS method and for the EGM method too and get similar. I used the PMAS method, but when we made measurements in the laboratory we can get different results, and a different field come out if the structure is higher than certain point. This means that for this 10 cm high rod, we get one result, but for the 55 cm structure we get something different.

Q2: Can you explain the approach in which you take large scale phenomena and model on, or do experiments on a much smaller scale when clearly there must be some limiting scale to the process? How valid is it to have a laboratory model to model something that is one hundred times larger?

A2: It is a really good question. We cannot say that it is a one-to-one model. We have some measured values from nature and we can compare it to our values measured in the laboratory. We also have some data from Russia and we can say the data is similar.

Q3: Does the fact that there is this equivalence tell you something about the basic processes involved?
A3: This value is dependent on a lot of other points – how big was our model, the pressure, the temperature and many other things. It is not so easy to compare one-to-one, but it can say something similar.

Q4: I think your work is very valuable since we don’t have a complete model description of a lightning discharge as big as we may hope it to be. How big is your rod and apparatus?

A4: My model was 55 cm high and I made 50 impulses for positive and negative polarity for each grid point.

A kinetic model for the electrostatic spark discharge in atmospheric-pressure air

A Ohsawa

Q1: How long does it take for the gas temperature after the discharge to go back to equilibrium?

A1: I have to consider the diffusion of all the species and heat conduction loss, which is a long calculation.

Q2: I was a little surprised that you have not mentioned the flame quenching work that was done a long time ago by Lewis and von Elbe and various other people, looking at flame kernels that will propagate. Is this something that you think you will do in the future?

A2: I did not worry about quenching. I calculated the discharge current from the resistance obtained from the electron properties. Quenching can then be found from the discharge current waveform, otherwise from the decay of electron density.

Q3: How did you obtain the values for $V_{OPT}$ and $C_{OPT}$, the optimum conditions? Were they derived from ignition experiments?

A3: First of all, I calculated the capacitance between the sphere and the frame. The other values were derived from the data on ignition experiments published by von Pidoll.

Session: ESD and Hazards

Hospital flooring – why is that an issue today?

D E Swenson

Note: this paper was not presented by the author, who was unable to attend the conference.

Q1: I understood that the electrical charge carried by a person wearing insulating footwear or walking on an insulating floor could not exceed 30 mJ, and that when that person touches a metal object that is grounded, two thirds of the energy would be dissipated such that the spark discharge it generates only had an energy of 10 mJ. So, I am surprised to hear that a person can be knocked over by a spark discharge from these causes, and so maybe it is another type of discharge. Would you care to comment on that?

A1: Having not been personally involved in that study, I cannot say for sure, but what very commonly happens is that people fall over when they get a shock. It is not that they have a massive physiological reaction; it is just that they are surprised. I suspect it is that, rather than a massive electric shock that has knocked them over.

Post conference note from the author: The nurse was pushing a surgical bed and holding the metal frame. She was otherwise isolated from ground because of plastic shoes. Her overall capacitance increased significantly due to the metal frame of the bed. The accumulated charge was discharged when she reached for a door push button. So she received a very large discharge - and of course was
startled so the involuntary reaction caused her stumble and fall. My estimate was that the discharge was on the order of 25kV from around 1000 pF so a very large shock.

Q2: Do you know anything about electrical shocks to people with pacemakers?

A2: It is not something I know a lot about. There is an IEC Technical Committee that is concerned with electric shocks to people, mainly from mains electricity rather than static electricity and they do publish some standards that include guidance for pacemakers. My understanding is that the body voltages required to cause damage are above the levels required for shocks, so if someone feels a shock, it does not necessarily mean disruption to a pacemaker. But if the body voltage rises to 15 or 20 kV, which it can do at low humidity, there might be a risk there.

Q3: On these discharges to human beings, it is very much dependent on the capacitance. For example, when rolling a person in a bed along a corridor for a long distance, there was an incident in Sweden were a women was knocked over when touching the bottom of the bed.

A3: Thank you.

Energy released by brush discharges from the fabric with conductive fibres

R Kacprzyk, J Król and A Pelesz

Q1: Did you look at how your areas compare to the areas in the standards? In the explosive atmosphere standards there are some tables that say you cannot have insulating surfaces of a certain size for a certain type of gas. That could be a really useful comparison to see where you are against that. Some people put the conductive grid on one side of a material and if the charge goes on to the other side you form a more capacitive structure, which changes the energy and could in certain high charging circumstances push you into in a propagating brush discharge. And also, if you were to put this conducting grid on both sides of your material does this change your results?

A1: I do not think right now we compare with the standards. Now we are focussed on developing the analytical model and calculating the energy. There are lots of things we could try, but what we want to do next is compare this energy from the numerical simulation and analytical model in an empirical way by measuring the energy. If the model works in this way, we want to further develop it to account for other factors.

Q2: You are modelling the cell as being near zero potential around the perimeter, but when we talk about conductive fibres in a fabric, they are not really conductive; they typically have a resistance of one megaohm to 10⁸ ohm or higher, so in this situation the boundary is not necessarily at zero potential.

A2: Of course the fibres are not at earth potential, but we have to simplify to make the calculation. If when we make a comparison between the analytical model and empirical results, we might have to consider other factors, but right now we just assumed the simplest way, so the mesh is grounded and at earth potential.

Q3: Another thing I found quite extraordinary is the charge density you say you measured on the centre of the cell. I think you measured or calculated 40 µC/m², which is close to the maximum charge density that can be assumed for a large planar surface with uniform field. You have a small cell with a near zero potential boundary. I would imagine it is very difficult to sustain that level of charge density without exceeding the breakdown field between the centre of the cell and the boundary.

A3: 40 µC/m² is a threshold value, but I think it is not uniform over the whole surface but confined to a small area near the boundary. If we put that value into the calculation we obtain the potential distribution that we measured. And we wanted to check the maximum energy, so we put in our model some quite large charge density.

Q4: What material do you use for the sphere electrode and the samples?

A4: Our samples are polypropylene fabrics and the ball electrode is stainless steel.
Can ElectroStatic Discharge Sensitive electronic devices be damaged by electrostatic fields?

J Smallwood

Q1: What practical conclusions can we draw from this?

A1: The very practical conclusion is that if you are handling voltage sensitive devices or circuits with very high impedance nodes, one should be careful to avoid electrostatic field changes that could damage components. This is really about how we package components against ESD damage and it informs people who design ESD packaging that there should be shielding against electrostatic fields as well as shielding against direct electrostatic discharges.

Q2: Not audible.

A2: The study shows that it is not a constant field that is the risk, but a collapsing field or a fast changing field. One way this might occur is if something is charged, but then discharges near by a circuit, which creates a collapsing field in that way, for example.

Q3: In response to your last question you mentioned a collapsing electrostatic field. Does that mean an electromagnetic field? Because a collapsing electrostatic field creates and electromagnetic field.

A3: Yes, of course it is an electromagnetic field, but a collapsing E-field rather than a H-field.

Q4: That is really interesting and so is the capacitive coupling. It is interesting thinking about standard electrostatic packaging, which is really high impedance, and if that starts to give some shielding at the levels of capacitance, impedance and discharges you are talking about?

A4: Firstly, I going to talk about what you mean by standard electrostatic packaging because there are many, many different sorts of ESD protective packaging, and there are different functionalities that they might have. Some of them have maybe one of those functionalities; some of them have a lot. But if we restrict ourselves to a metalized ESD shielding bag, those have the functions of not charging up very much, so they do not cause ESD risk; they also have electrostatic field shielding built in, but they also have a barrier against ESD from outside the bags to inside. It is the latter that is thought to be the most important for most ordinary ESD sensitive devices when they go out into the real world, and the debate has been do we really need this field shielding. So going back to the previous question, yes we might do, at least for certain situations with certain types of circuit, such as those with very high impedance and high sensitivity to ESD.

Charge distribution and discharge current analysis with charged connector pins

P Tamminen

Q1: I have dabbled in some similar work and I am very interested in what software you used to do the co-simulation for FEM to SPICE with the S-parameters?

A1: The main software is Ansys HFSS, it calculates high frequency events. In addition, I used Ansys Maxwell to get static charges and source capacitances. SPICE co-simulations were done with Simplorer and with Nexxim. All these are Ansys Software. HFSS calculated 3D model frequency response and this is then used in SPICE to calculate time domain currents.

Ignition risks associated with migratory antistatic liners at the point of use

C Newlands, I Pavey, S Shepherdson and W Azizi

Q1: In a previous IEC standard, 61340 I think, there was a requirement for relaxation time, but about 10 years ago it was cancelled. Do you know why?

A1: (from the floor) The requirement was in the first edition of IEC 61340-5-1, which was based on the old European standard EN 100015-1. With the second edition, the structure was changed to follow
the American standard ANSI/ESD S20.20. At that time the decay time requirement was dropped, basically because there was no consensus on the correct way to measure it, or on the appropriate performance requirement.

Q2: Is there and argument for using paper bags instead of plastic so there is not the same build-up of charge?

A2: The drug regulators would argue against that because paper bags can shed particles, fibres, etc., which can cause contamination. We do get some raw materials in paper sacks lined with a vapour barrier type of plastic, which are quite good and quite robust, but we do not like bringing them into manufacturing areas because they can harbour things like fungi and bacteria.

Q3: What causes the difference in the surface resistances between the fresh and conditioned samples?

A3: We believe there is no monolayer of additive in the surface when it is fresh. When the bags are blown, the additive is evenly distributed in the polymer matrix and it will stay like that while it is sat in a stack of bags. We receive bags in stacks or maybe 100 or 200, so there is quite a lot of pressure. We think there is some interaction with the blocking agents that are used to reduce the tendency for the bags to stick together, such that the monolayer of additive is not present at the time the bags are first used, and it takes some time to develop.

Q4: I think the difference that you are seeing between the charge transfer results and the actual ignition tests is because charge transfer values are only a guide. It is not charge transfer that causes ignition. There are temporal factors that influence ignition.

A4: Yes, and it is through discussions like this that we start to understand what it behind IEC standards, recommendations and all of that. The key take away that I am getting is that you have to be very knowledgeable about these things in order to apply them correctly.

Q5: A comment that is to do with terminology. The words antistatic, conductive, static dissipative mean a lot of different things to different people. I do not know where your definitions come from, but there can be a lot of misunderstanding about this, and in IEC/TS 60079-32-1 we define insulative materials as being above $10^{11} \Omega$.

A5: I left the term antistatic in there because I think that lubricant effect is quite interesting. For me static dissipative is about loss of charge and antistatic is about not charging up much. So, you can have the additives that prevent charge generation, and we have seen a lot of work here where humidity has had huge effects on whether particles charge and how they charge and all that.

**Session: Industrial Applications and Charge Control**

**Study on charge neutralization effect by electron cyclotron resonance plasma source in high vacuum**

T Morishita, D Koda, S Hosoda, T Mogami, K Minemura, N Nomura and H Kuninaka

Q1: What is the pressure of the ECR reactor?

A1: About 5 Pa in the ECR reactor.

Q2: You are using one of the noble gases, xenon. Can you explain why you are using xenon and not helium or argon, and what would happen if you used helium or argon, for example?

A2: This ECR reactor has been researched and developed for space use, and its performance has been optimized with xenon. Since this experiment was conducted for the initial examination of charge neutralization capability, xenon was used. If we use argon, the charge neutralization capability is reduced by an order of magnitude compared to xenon.
Q3: Do you use xenon because in the application of rocket propulsion it is preferable to expel heavier ions?

A3: Yes, we use xenon because it is heavy and its ionization energy is low.

**Measurement of electric fields of charged spray clouds of conductive liquids in free space and in a conductive vessel**

F Baumann, J Esslinger, D Möckel, M Thedens and O Losert

Q1: Does this mean that the previous guidance given in TRGS and IEC/TS 60079-32-1 that 12 bar water jetting in quite big tanks is perfectly safe needs to be changed?

A1: No, that is not the objective of this work; in fact it is quite the opposite. We have data from one set of experiments that date from the 1980’s relating to supertanker operations in the 1970’s. We do not have any other data. So, for example, the guidance given in TRGS 727 for the pressure of water washing tells us that 500 bar is safe, but we do not know about higher pressures, 600 bar or even 1000 or 1500 bar, which are quite common cleaning pressures and have to be done under inerting. As we do not know how far we are from the hazardous range, we started this research, and I presented at Southampton four years ago preliminary results for a small vessel. We now have the opportunity to do more fundamental research to understand the underlying physics; we do not know if charging takes places at the nozzle or when the spray jet hits the wall. There is no danger from using the values specified in the standards.

Q2: You measured 400 kV/m electric field. Did you observe any corona or spark like discharges from the fine edges of your measuring system, that can occur when you introduce a measuring system into the jet of charged droplets?

A2: No, we did not observe any discharges.

**Session: Measurements**

**Electrostatic risk and specification of field and voltage limits for insulating web materials**

K Robinson and J Smallwood

Q1: Does this mean that we have to run this equipment slowly? This feels that the limits we are trying to run to for safety seem very low.

A1: This doesn’t make a comment on how fast you are running the machine. I would usually do this at the process speed, usually without any flammable materials present – for safety obviously. This is basically a way of evaluating where the risk lies and how you approach the risk – and how you evaluate using your meter.

Q1 continued: It doesn’t seem like a good idea to have insulating materials near flammable materials. If you do have to have it then you have to run it really slowly.

A1 continued: I agree not a good idea to have flammable materials near where insulating materials are being charge up – but quite often this is the prevailing case – and yes they do get fires.

Q2: This kind of process generates charges on both sides. They could be positive on one side and negative on the other or positive on both sides. You must use a nanocoulombmeter as the voltage is not important if you have counter tension on the other side.

A2: I would argue another approach to doing so. You can evaluate net charge by doing field meter measurement in mid span. You can evaluate charge on both sides by doing an electrostatic voltmeter
measurement at a metal roller – you have to do two measurements, one for each side and that will give you the charge density.

Q2 continued: But if you have 4.5 kV negative on one side and 5.0 kV negative on the other side and you approach with a piece of metal, you will have a discharge of 0.5 kV or 5kV on the touched side.

A2 continued: Are you talking about measuring in free span or near a roller?

Q2 continued: Free span – away from the roller.

A2 continued: The measurement is going to be kV – but one can’t distinguish between either side – so you don’t get enough info from that. But you can evaluate the risk in terms of limiting charge densities as described in paper.

**Measurement of total electric charge of submicrometer particles using a DBD charger coupled with a capacitive sensor**

D Aouimeur, N Zouzou, F Miloua and A Zouaghi

Q1: I notice the aerosol size range you used starts at about 200 nm. From about 300 nm upwards, there are devices available that are relatively inexpensive, but when you go down to 100 – 200 nm, that’s when it starts to get very difficult to measure the particles. Have you done any work at the sort of size range, down at 100 nm range?

A1: The process of charging is completely different. The most difficult size to charge is here (pointing to slide). For small particles we can use a different charging mechanism. For larger particles, we can use (indistinct) charging.

Q1 continued: From a practical point of view, 100 nm is the hardest size range to measure, so if this is a solution where it is easy to charge up at that size and easy to get a measurement in that size range, relatively efficiently and relatively cheaply, then it is something I would be very interested in.

A1 continued: It would be very interesting to move the peak to smaller sizes, I agree with that.

Q2: In a lot of industrial processes, the particle number concentration is not $10^5$, it is $10^7$, $10^8$ or even up to $10^9$. How does your system operate with higher particle number concentrations?

A2: We expect when the concentration increases, the response of the equipment is better, so big concentrations are not a problem.

Q3: You are working now with solid particles. What would happen if you had some liquid particles and collected liquid material in your DBD system; how would this influence the stability of your DBD system?

A3: Contamination could be a problem. We would have to make some improvement to the fluid dynamics inside the sensor in order to avoid contact with the sensor.

**Characterization of ESD shielding materials with novel test methods**

T Viheriäkoski, R Wong, R Fung and P Tamminen

Q1: Is there any value in doing radio frequency shielding measurements on ESD shielding materials?

A1: We did that measurement because there is an existing standard test method: 50 ohm transmission line test method for shielding. So we decided to check how it behaves with a continuous signal because we would like to compare the results with ESD energy attenuation values; that is the only reason.
Session: Environment and Agriculture

Optimization of parameters of designed and developed handheld electrostatic sprayer and its performance evaluation for herbal pesticides

M K Patel, A Kumar, P Kumar, A Jangra and A Kumar

Q1: What is particle size versus charge distribution?

A1: No fixed formula for particle size versus applied high voltage but when applied high voltage is increased the particle size reduces and there is a certain limitation in induction charging; you cannot get below 5-10 micron. In our application, 40-80 micron are sufficient for crop spraying.

Q2: Why is only negative charge in the sprays?

A2: In the working environment negative charge is more. If positively charged, the spray gets discharged in environment. There are studies that positively charged sprays get fully neutralized after 5-10 kilometres. For crop spraying it is not a concern but for tree or object spraying it is a concern.

Q3: Do the droplets cover both sides of leaves?

A3: Yes. In electrostatic charging, they covered in their own electric field lines and get uniformly sprayed onto leafs; because once a droplet is on the leaf, it will not allow more droplets to get closer to it.

Influence of ESP collector configuration on reduction of particulate emissions from biomass combustion facility

A Bologa, H P Rheinheimer and H P Paur

Q1: A question concerning the loading of the power plant. At 100% the fly ash is not similar to that at 10% or 20% where the particles can stick on the electrodes. Also, what about the particle number not mass – is there something in Germany about this question?

A1: In Germany we have regulations controlling the emissions in particle mass not in number. There are quite of lot of discussions about this in Switzerland and to promote a new law considering particle number concentration taking into consideration the health effects. But this is in a stage of discussion. EU regulations are based on particle mass concentration. The new law relating to particle number concentration will not apply in less than 5 to 7 years. Regarding the fly ash – if I correctly understood – yes there is a big discrepancy between the ash which you find in the bottom of the boiler (this ash is coming directly from the wood) and the ash which is going into the clean air. In the clean air you have partly re-entrainment of the larger particles (2 – 5 µm) but the rest is formed due to the chemical reaction and the condensation of the inorganic and organic materials. Here we have quite a lot of polycyclic aromatics. We have also found in the finer fly ash, there is a high concentration of hard metals. If you take the fly ash which is coming from the ESP, I would never recommend this for your garden. This ash should either be disposed of or for the retrieving the metals. There is a high concentration of these metals emanating from the condensation of the inorganic salts in the heat exchanger of the boiler.

Q2: How much energy is required for this cleaning system? What do I do with the metals that are retrieved?

A2: For the delivery of the wood chips you need a special system. These require motors. You also have an extracting system for the ash. You have primary and secondary air blowers. For a boiler, the power consumption [=of these ancillary systems] is more than 1kW. For a 100kW boiler, the ESP needs only 60W. For 1500 hours of operation over 1 year, the ESP running cost is about €12 - €15 (two coffees in Starbucks!). The ash remains are a question for the legislation. Currently it is disposed
of, not recycled. In the future, in a large-scale operation, there should be a periphery system that would allow collection of the ash for recycling the hard metals. This is still under discussion.

Q3: Your application is just for automatic boilers?

A3: Our investigations are concentrated on the boilers that are automatic. There is an appetite for the next generation of ESPs for small scale (<20 kW) boilers and “stoves”. This could be useful for manual boilers - but the cost of the unit is greatly reduced. Regarding the boilers – one of these units was made in Eastern countries -= used for cleaning of gas from coal combustion – quite good results.

Q4: In this next generation of these products – how do you plan to account for the different volume flow rate of the gases – the velocity of the gas will dramatically change during the operation of the boiler?

A4: We over-specify our ESP by 20% - i.e. 20% reserve. Otherwise it’s difficult to design an ESP for all types of boiler. Collection efficiency is less important than the pressure drop.

Q5: Do you think this could be applied to automotive exhaust treatment?

A5: It could be done – it could be used for engines – but this is not certificated – only for bio-mass at the moment.

Session: Modelling and Simulation

Modelling the agglomeration of electrostatically charged particles

E Klahn and H Grosshans

Q1: If you go back to the pictures of the particles in the boxes, when the particles are charged, they obviously repelling each other so they are congregating around the periphery of the box. Interestingly, if you go back to the uncharged particles, where Van der Waals forces dominant, for example in the top view there, in these cases they are congregating around periphery of the box. Do you have any idea what is going on?

A1: We chose the parameters so that electrostatic forces are much larger that Van de Waals forces. For this simulation we chose very high value for the particle charge. They are very fast and they repelled each other and went to walls and that is why we can see the effect much stronger here.

Q2: Not audible, but continuation to the first question by the same person.

A2: That’s correct. We kind of cheated here for both electrostatic case and Van der Waals case. We increased artificially the forces because we wanted to see faster and stronger effect.

Q3: In you formulation, the forces are summed, is it possible to add any interactions to this, for example can you add thermal motions to the particles?

A3: That is the nice thing when I go into this formulation, so everything I showed to you is about the formulations of the prediction of the particles trajectories. Then to add a force is very simple. Because we collect all the external forces and I can add them to there and everything will be happy equation. This is not going to change the rest of the algorithm I have.

Q4: Not audible. However, the question is related to including external forces into the model.

A4: This is correct. The focus here in developing this algorithm is that the forces here are not physically correct and also, for example, when we learn about charged particle interactions, we have induced charges on other particle surfaces and forces. But we did not look into these in this study, but it is rather simple to add the equations of the external forces and reflect on all of them.

Q5: You are solving the equations for the motions of each of the particles. So that mean actually you are free to also treat non-homo disperse decisive solutions. How much would that increase of
computational efforts. For me, it sounds huge. The other question is; it is a beautiful algorithm. How do you include all the material properties that you need into the algorithm? Because all the forces requires characterization of your particles.

A5: For the first question. Now we only look only monodisperse particles. I cannot see anything that would cause problems with using any particle size distribution. For the numerical algorithm we tracked a rate use of each single particle anyhow. So it will not change anything in the algorithm. Again, for each particle, we have material properties, density and whatever. The question is only how well do know these properties and how much you trust these equations, which you put for the external forces. It depends, how well you know these forces. Everything you know, you can input there.

Q6: I could not find the boundary conditions of the box. I would like to know the boundary conditions.

A6: In this case, when we solved for the electrostatics forces we solved coulomb’s law. So we computed electric force of all particles on each other. This means we do not compute electric field or electric potential that we need to impose boundary conditions. In other words, we assume that boundary conditions have no influence on electric field.

Q7: Not audible.

A7: Because they repel each other. If we put particles of same charge in a box they repel each other and they move away from each other. In this case, the electrostatic force is so high and hence they drag the particles to the walls. So they are not in contact each other. If I look on the side view they distribute on the box sides.

Monte-Carlo simulations of electrostatic self-charging of tritiated tungsten and beryllium particles

G Dougniaux, M Sow, S Peillon, C Grisolia and F Gensdarmes

Q1: You used Monte-Carlo simulations. I could not find how you have used Monte-Carlo simulations. The rest of the questions can be constructed as it was breaking in between.

A1: My colleague, who is a nuclear physicist did the simulations. He would have given more precise answers than I can do. We used a part of Monte-Carlo simulation; so it is not the simulation we developed in the lab. We used to get the calculations done very quickly and should be able to get some results within weeks. We just looked at the extreme conditions. If the particles get very small then the exit probability should be close to 100% and if the particles are very large then the exit probability will be very low. We tried to be bit comfortable with it. But I cannot go deep inside the model.

Q2: What will happen if your particles are not in a shell of a tritium, but even the shell of a helium or deuterium; how does your calculations change in your results?

A2: Tritium is a radioactive isotope that we are looking at. Deuterium is not radioactive; helium is not radioactive. As far as we don’t have radio activity we are not concerned about the self-charging. Because self-charging is due to radioactive decay. Tritium is only our radioactive partner.

Q3: is it possible to build metastable helium? Let us say atoms or agglomerate molecules metastable, which have additionally 2+ charges. These 2+ charges can make their over going of their charges from the helium, metastable helium, to the particles and provoking the particle charging in this situation of metastable helium.

A3: You are perfectly right. We are not looking at that far in the self-charging. This is a very first set of results we are running on these kind calculations; for now, we just try to keep it simple so that we can see if it make sense or not to do these kind of calculations. After we can go deeper inside and see for the kind of charging mechanism out of different from the Tritium absorption charging mechanism.
Session: Atmospheric and Lightning

Lightning in other planets

C Helling

Q1: If I understand for correctly, I seen this as market for lighting; what are you looking for is transient rather than simply the present. So it occurs to me it would actually be able to resolve those events that need to be much rarer and much larger than, for instance, what we see on earth. Is that correct?

A1: The problem here is that if you look at the observation of transients than the photons or amount of information we are going to get is actually very low. My argument would have been that we have been thinking about high energy and gamma rays and what so ever and everything that comes out of the atmosphere is so low in number count; that is almost impossible to really make that argument in exoplanets. Therefore in order to have a real signal, it has to be chemical or it has to be very rare typical to what the stars are doing. We are talking, for example, about radio emission. Radio emission needs to be really specific, like sporadic and stochastic wide of the star it sitting there and emitting radio flux continuously.

Q2: We need two conductive layers. Are we sure we have those layers in exoplanet?

A2: Yes. This is what exactly we are trying to make with this figure. It depends on what objects do we have. If it is a rocket planet, then we do. If we have gaseous planet, we have so high temperature and so much ionisation that allow that part make it extremely conductive. This is where people start to think about aerodynamic simulation, so that there is another way of heating the part of the atmosphere. Purely because they are easily so many ionising.

Q3: Is lightning dependent on the diameter of the planet? Because there is same charge.

A3: There is no such thing as same charge. It is depending on what planet you are looking at, depending on how big it is, it has difference hydrodynamic. So you have different conductive strength or difference issues of strengths. So it may be a big planet but may be very close in, so it has strong winds circulating the planets basically tribo-electrically charging the entire cloud all the time. You really see that you get really charging the cloud particle and you expect to see lightening.

Atmospheric potential gradient measurements from a rooftop in Bangkok

J C Matthews, M D Wrighta, P Navasumritb, M Ruchirawatb and D E Shallcross

Q1: Very fundamental question. What is it that charged the particles of the cloud?

A1: We weren’t measuring anything in the cloud; just be the normal cloud electrification process. There may be some charged particles that are coming from traffic. But that would be a guess. Mostly it is natural charges within the cloud. We don’t have any direct measurements of that other than potential gradient.

Q2: How does the polarity change?

A2: That is usually through thunderstorms. The clouds have a couple of things. The cloud tend to change its polarity in different areas. You might see a positive region and negative region in the clouds. When clouds pass overhead, you might well see the field rises, drops and rises again. The other thing is more rapid change. Then that could be a thunder strike, where the charge in the cloud discharges to the ground. The very large change moving along are due to the cloud process.

Q3: Would you expect that the aerosols are different to what usually you measure in Bristol or Reading? Does the charge load change depending on where we are on the globe.
A3: I don’t know the charging will change. Certainly there will be more in numbers in Bangkok compare to UK, for example. I am also expecting to see difference, depending on aerosols property, like high viscosity, that could be, depending on the sources, will have an electrical effect. Different effect on the growth of the particles; therefore, attachments to the ions of the particles. I still need to do more work on actual chemical analysis of some of the particles around. To what little we have done, we see difference properties in terms of metal contents from that we can infer different properties in terms of size contents and in terms of shape as well. All of those will have different effect on ion aerosols attachment and therefore you may see this relationship. Possibly it is a good idea to do separate analysis in wind direction. Each wind direction will have slightly different aerosol content due to source. By separating by the wind directions and looking at the various relationships between different weather parameters such as potential gradient and aerosols size distribution; you might see different to aerosol properties such as contents, shape and size. That is something that I have to look into. I don’t know I will find anything yet, but it will be anything interesting to know.

Examination of electric and magnetic fields around high voltage equipment

G Göcsei, B Németh and I Kiss

Q1: The geometry of the 3 conductors make a big difference – should this be triangular to reduce the field? Is that correct?

A1: I showed you a program for a 3-phase arrangement – the field density distribution can be calculated from this program. In this case you cannot take into consideration the field modified by the object. However now it is possible to take into account the sag of the conductors – this requires a long calculation time. In our calculations, the critical part of the school was near a grounded pole so we could consider the closest phase conductor – that other two conductors would modify this but not very significantly. We therefore neglected the other conductors.

Q2: Values of the voltages and current. Presumably the voltages are fixed but the current varies depending on the load – did you use nominal or worst case of current?

A2: These values came from the company – they measured the current as a function of time. We were able to make calculations based on the time so we could estimate the current. The calculations were therefore not based on direct measurements, but they were based on knowing the time at which the currents were made.

Q3: You mentioned public concern about lines. Are the public worried about emission of ions from lines of they only interested only in fields?

A3: At Southampton conference, there were consideration of ions. The public are not so aware of this situation – but it is interesting to examine distribution of ions as well as the field.

Session: Energy and Environment Applications

Study of electrohydrodynamic phenomena in high temperature high pressure nitrogen

A Bologa, H P Paur, K Woletz and D Stapf

Q1: Do you know why nitrogen has this large hysteresis?

A1: One of the explanations is that there is so-called meta-stable nitrogen. You have seen in one of the presentations today that this is N++ and these ions have this so-called memory effect. These meta-stable nitrogen ions, which are formed during corona discharge, exhibit this memory effect and give another curve for the current-voltage. This is only my proposal, which I have found from internet research.
Electrostatic charging of water spray by induction

A Marchewicz, A T Sobecky, A Krupa and A Jaworek

Q1: You had a negative figure for the distance to the charging ring, does it mean the charging ring was entirely above the opening of the nozzle?

A1: Yes, that is exactly it. The top of the cylindrical part is higher than the exit of the nozzle. This way we could change the magnitude of the electric field on the liquid film.

Q2: If you have an electric field or no field is there a difference in particle size and flow?

A2: We did not measure the droplet size distribution with the induction electrode on because our apparatus is stainless steel and all the droplets would attach to the probe. But, I remember from literature that it changes slightly towards the smaller droplets.

Q3: You obtained values of $Q/m$ up to 200 $\mu$C/kg. Is this enough to improve the process, because in agriculture it is more like 2 mC/kg?

A3: It is sufficient to improve the process. It would be better to use higher charge, but we would have to use smaller nozzles or pneumatic nozzles, which produce much smaller droplets. Such small droplets are not useful for scrubbing because they flow with the flue gas and so exit the scrubber without many interactions with the particles.

Session: Dielectrics & Electrostatics I

Influence of electrode spacing on a symmetrical washer type electrohydrodynamic conduction pump

M Daaboul, P Traoré, S Modh and C Louste

Q1: You mainly use steady-state data. Why did you not check the exponential decrease of the current and the pressure? It would be interesting to do it.

A1: I agree with you; it is very interesting to understand the behaviour, especially in the first seconds after the application of the high voltage. In this work, only the steady-state was investigated. However, it is very complicated and the reasons for the behaviour you mention are not very clear. It is a possible perspective for future work; we have many ideas of what might be the possible source for this increase or decrease, but at the moment we did not study this.

Q2: Several peaks appear of the current and pressure. What causes that? Maybe the current includes a component of the displacement current?

A2: One thought is that maybe the flow is decreasing the hetero-charge layer density. It is just a thought that needs to be proved; we are not sure about that. Another thing is that after a few seconds the electric field is getting lower because of charging at the electrodes. I am not able to state now that this sudden increase then exponential decrease is caused by something I am sure about. It needs to be investigated.

Time resolved measurement of dielectric particles velocity on standing wave electric conveyor using PTV technique

A Zouaghi, N Zouzou and P Braud

Q1: A few days ago, similar work was presented in which a square wave was used. What waveform did you use?

A1: We use a sine wave. If we change the waveform, we add some harmonics that can contribute to things that we do not understand. By using a sine wave we can clearly analyse the effects.
Q2: Does collision of the particles with the electrode affect the conveying velocity?

A2: What we have seen is that the initial charge on the particle is low and after a few tens of milliseconds the charge goes up, so there is interaction between particle-particle and particle-surface and particle with the electrode.

**Dielectric measurements for the examination of electrostatic charging of powders**

I Kiss, Z Á Tamus, T Iváncsy, B Németh, G Ujfalussy and I Berta

Q1: In the previous slide you have compared the characteristic of the powders and you have mentioned the water vapour adsorption. Did you make any correlation between charge accumulation and this adsorption?

A1: You can see in this slide that the water vapour sorption is higher for samples 3 and 4, and practically these were the better samples from the electrostatic behaviour. But, if the water vapour sorption is high, it has to be reflected in the dielectric properties too, not just the charge accumulation.