A new Approach to Obtain Data about the Charge Decay in Samples of Textiles for ESD Garments

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Abstract: **The preliminary results of a research work concerning a special charge decay characterisation of carefully tribocharged samples of composite textiles are reported. The output evidences that the adopted automated set-up can offer a very small data scatter, that the adopted grounding paths can offer information about the charge release behaviour of these types of fabric and that the obtained output is consistent with common experience on the field.**

INTRODUCTION

Several types of electrostatic protective clothing, here named ESD garments, are in use, nowadays, within electronic industries. Composite fabrics are forming the structure of such garments. As sometimes the available measurement procedures to assess the performance of such garments are not satisfactory, improved testing procedures are being studied. For instance, a study of this kind is carried out by the EU Project "ESTAT-Garments" [1], which is aimed at gathering information about the performance of ESD garments [2] made by different composite textiles. Such studies require further knowledge about the charge formation, retention and decay mechanisms on composite textile samples.

Within the frame of the above EU project, an investigation aimed at focussing the electrostatic behaviour of samples of composite textiles after tribocharging has been implemented. A two-step approach was devised: the initial experimental step regarded the control of the factors influencing the generation of tribocharge on samples of composite textiles. This step required measurements of surface voltage (SV) after rubbing the fabric surface by means of a special stick. The relevant output evidenced that several factors (e.g. leakage current, stray capacitances et al.) could affect the repeatability of charge decay results, in terms of SV curves vs. time.

The second step of this approach was guided by the latter output: another experimental set-up was realised. All the testing operations were fully automated and the experiments were performed, after suitable samples conditioning, in very stable relative humidity (r.h.) and temperature conditions.

The relevant output had to supply information about the composite textiles samples capability of releasing/dissipating a controlled tribocharge, so to offer a useful basis for future measuring procedures/standards concerning modern ESD garments.

The present work will detail the latter experiments.

SAMPLES, TEST SET-UP AND TESTING PROCEDURE

The whole study will regard several composite fabrics of different kinds and geometries. However an initial stage of the investigation, hereby reported, concerned two fabrics, representative of two families of composite textiles: samples of fabric (50% polyester and 50% cotton) hosting a surface conductive 10 x 10 mm grid (named SC samples) and samples of fabric (100% polyester) hosting a core conductive "grid" made by 10 x 10 mm squares (named CC samples) were tested.

Some details of the measuring set-up and of the testing procedure to get the surface voltage (SV) vs. time curves in different conditions/ways are here described.

The picture in figure 1 reports an overall view of the set-up: a 120 x 120 mm square sample is suspended by means of 4 insulating threads: the relevant pulling force is set (e.g. in this test campaign a 5 N pulling force was applied) and controlled by 2 dynamometers.

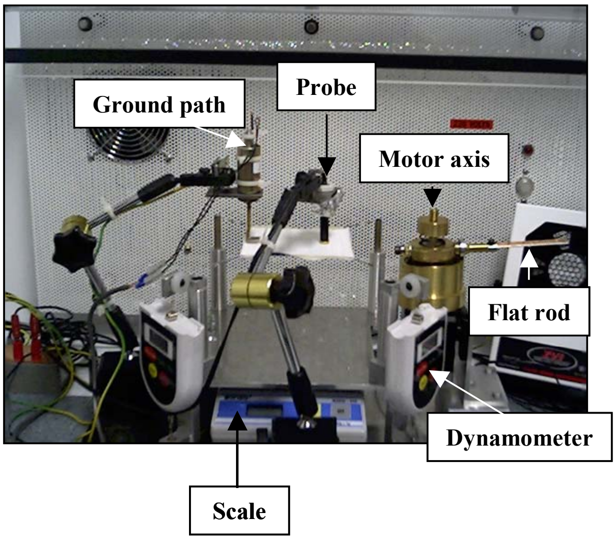


Figure 1 : A view of the experimental set-up

Both flat stick vs. sample surface velocity and pressure (between flat stick and composite fabric), which are the main influence parameters of this friction mechanism are set and controlled (e.g. during the present test campaign the velocity was 1 rotation per s and the pressure was about 980 Pa).

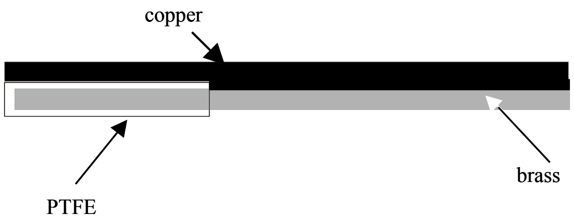


Figure 2 - Flat stick section. The stick is made by PTFE/brass and is covered by a copper strip, which is permanently connected to ground.

Besides, figure 2 reports a sketch of the special flat stick: PTFE faces the textile sample, while copper – permanently connected to ground – faces the SV probe.

The tests are performed at two standard conditions: (23 +/- 2 °C ; 12+/- 3 % r.h.) and (23 +/- 2 °C ; 50 +/- 3 % r.h.). The samples are kept 48 h at the above conditions (in an environmental chamber) before each test.

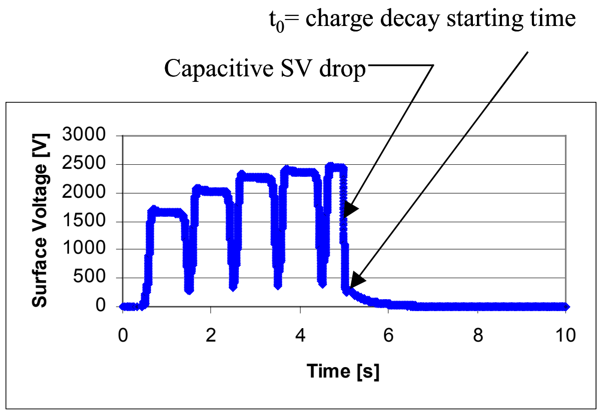
The testing procedure is completely driven via an "ad hoc" software. It starts at t_{in}, with a rotation of the stick due to a step-motor (in order to generate controlled tribocharge on the fabric), followed either by a charge decay "forced" by an automatic "ground contact" of a metallic micro-spherical electrode to the center of a non-rubbed square (gsc mode) or by a charge decay "forced" by an automatic "ground contact" of a metallic plate, 14 x 14 mm horizontal electrode, to the threads of a non-rubbed square (gth mode). In all cases the surface charge (i.e. the SV) over a rubbed 10 x 10 mm square was monitored since the initial rubbing period, through the probe of a non contact voltmeter (digital measurements = 4 k samples/s), which was set over a "rubbed" square (at 2 mm distance from the fabric).

The starting instant (t_o) of the all the above decay curves was determined by the change in slope of the SV curves, as visible in figure 3.

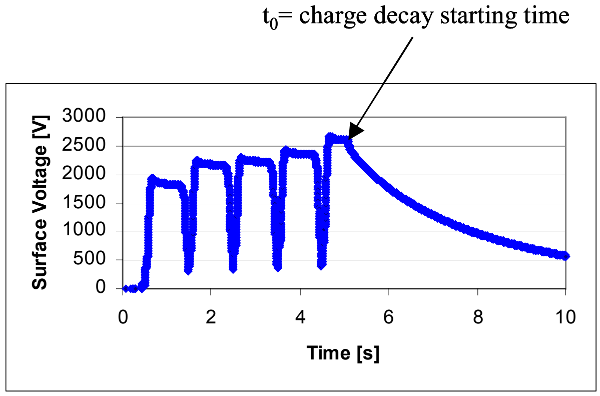
Figure 3 illustrates two examples of the obtained SV(t) curves, starting with t_{in} and reaching a time $t_{end} >> t_o$, in terms of absolute values. In fact, the attention is focused on the charge decay curves, therefore on the evolution of the SV curve starting from t_o.

It is of particular importance to evidence, here, the role played by the capacitive effects when the small metal plate electrode is brought near to the SC textile: the capacitance increase, when the plate is nearing the sample, originates a drop of the SV till a contact between the threads (gth mode) and the electrode is established. In the case of the microspherical electrode (gsc mode) this capacitance variation is negligible, therefore the initial SV drop is not recorded.

Besides it is worth to recall that in all explored cases the data scatter was definitely low (max 5%), so the average of just three curves was considered and a normalised plot of the average SV(t) was studied.



a) gth



a) gsc

Figure 3 - Example of surface voltage vs. time plot: a) gth mode ; b) gsc mode

RESULTS

Among the many SV(t) curves so far obtained, the following ones, regarding the two composite textiles SC and CC, two humidity values and two grounding modes (gsc and gth) appear to bring some preliminary information which is worth to report even before the end of the whole investigation.

At first the SV(t) plots for the CC textile (100% polyester) obtained in dry and at humid conditions both adopting the gth mode, that is forcing a grounding path which involves the borders of a square and acting in the gsc mode (the grounding path involves exactly the center of a square) are reported in figure 4 (gth mode) and in figure 5 (gsc mode).

Then the SV(t) plots for the SC textile (mix = 50% cotton + 50% polyester) obtained in dry and at humid conditions both adopting the gsc mode and introducing the gth mode are here reported in figure 6 (gth mode) and in figure 7 (gsc mode).

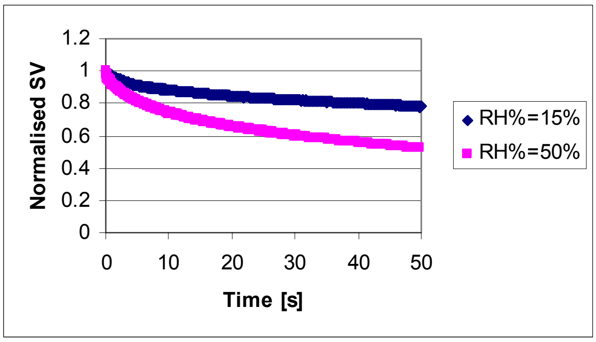


Figure 4 - Charge decay plot on CC textile: gth mode at 15% and 50 % r.h. conditions

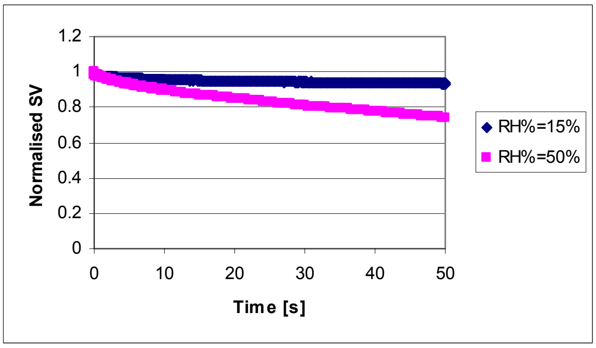


Figure 5 - Charge decay plot on CC textile: gsc mode at 15% and 50 %r.h. conditions

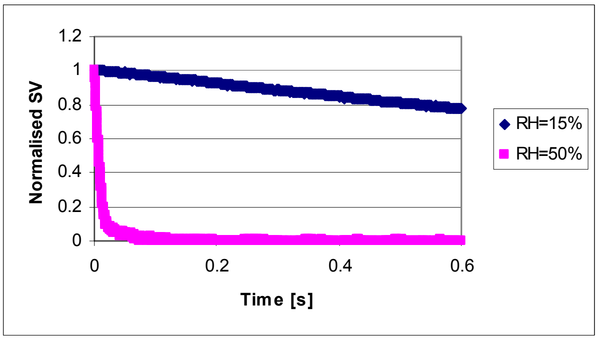


Figure 6 - Charge decay plot on SC textile: gth mode at 15% and 50 % r.h. conditions

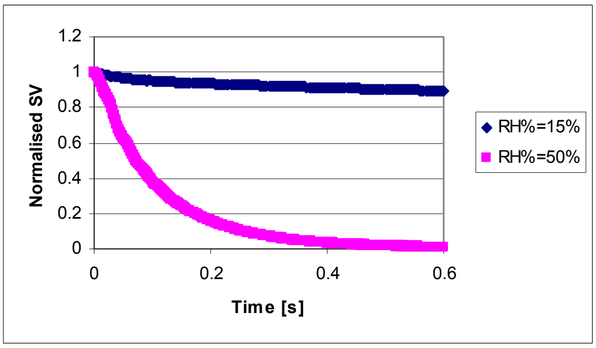


Figure 7 - Charge decay plot on SC textile: gsc mode at 15% and 50 % r.h. conditions

COMMENTS

While the general meaning of the present tests output is to be confirmed by further tests on different textiles, nevertheless these preliminary data appear to offer interesting information. In fact the experiments with CC textiles (polyester fabric) would evidence a similar though modest effect (figures 4 and 5) of the humidity in gth mode and in gsc mode. This output appears consistent with the operating experience, but the relevant data offer much higher repeatability.

When exposed to different humidities, a 50% cotton/polyester mix composite fabric, like the SC textile, as expected, behaved differently. In dry conditions this textile shows a trend to behave like an insulating fabric. In humid conditions, both in gth mode (figure 6) and in gsc mode (figure 7), the SV(t) average (and normalised) curve shows an immediate drop: such a decay is more “important” in the case of gth mode than in the case of gsc mode.

This observation appears consistent with the fact that the grounding path, in the case of the gsc mode, does not involve the segments running from the center square to the borders of the square, as the contact is taking place between the small plate and one point along the “conducting” border of the square. Actually the grounding path on the composite textile surface has an important influence on the behaviour of the textile sample.

Further experiments are under way, in order to investigate the nature, reversible or irreversible, of the mechanisms which appear to drive the initial drop in the SV(t) curves.

The so far obtained data output shows a very small scatter, compared to the commonly obtained data sets, e.g. to the dispersion of data reported in [3]. Therefore the ongoing experiments should offer a good basis for the next investigation step.

CONCLUSIONS

The data obtained from of the here presented experiments were very repeatable (owing to controlled conditions and to suitable data acquisition processes). Such data-output appears consistent with common experience on garments in operating conditions. Besides, it seems to offer a useful starting point for modelling the charge dynamics on several composite textiles for ESD garments, explicitly taking into account a charging process obtained through a well controlled triboelectric processes.

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