EXPERIMENTAL MODELING AND OPTIMIZATION OF THE TRIBOCHARGING PROCESS IN A SLIDING CONTACT BETWEEN POLYMERIC MATERIALS

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CONTENT

- Tanjungpura University and Universite de Poitiers
- Context
- Experimental Setup
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Polymer in industries need to be well functioning
Not to break due high load, friction and temperature
Background

STATIC ELECTRICITY

Advantages
1. Painting
2. Percipitators
3. Separator

Disadvantages
1. Static shock
2. Attract dust
3. Ignite flammable gases, fuel
4. Dust Explosion
Background

Factor: 50 Cycles, 27-95 mm/s; 0.4-2 N
Surface potential increased as the contact force increased

(Seyam, 2013)
Background

Factored: 10 Cycles, 100 mm/s; 1-2 N
Surface potential increased as the contact force increased

(Zeghloul, 2015)
Aim of the Study

Determine the optimal values of: Compressive Load (Normal Load), Number of Rubbing Cycles, Frequency

Approach: Characterizing the uniformity of the electric charge at the surface of polymers

Experimental technique:
- Tribocharging using custom-designed experimental bench
- Non-contact surface potential measurement
Materials and Method

Samples:

- Poly-vinyl-chloride (PVC), Acrylonitrile Butadiene Styrene (ABS)
- Tribocharging (A): 5 mm x 15 mm x 100 mm and (B): 5 mm x 50 mm x 180 mm
Residual charge of the samples => neutralized using a commercial ionizing system

(1) experimental sample; (2) capacitive electrode; (3) support table. Electrode ECA 88 BS and high-voltage supply SC 04 B, 5 kV, 7 mA. Manufacturer: ELCOWA, Mulhouse, France
Materials and Method

The factors under study in this experiment are the following:
1. Number of tribocharging cycles: 10, 55, and 100
2. Normal force applied on type B sample: 2 N, 6 N, and 10 N
3. Frequency of back- and-forth sliding motion: 0.5 Hz, 1.5 Hz, and 2.5 Hz.

The responses are:
1. Average surface potential ($V_{avg}$),
2. Standard deviation of surface potential ($\sigma_V$)
3. Pre- and post tribocharging temperature difference ($\Delta_{temp}$).
Materials and Method

Tribocharging Bench

• generate electric charge by friction between samples A (top) and B (bottom)

• enable the control of:
  ✓ Polymer rubbing speed
  ✓ Contact force
  ✓ Number of back and forth movements

1. Electric motor
2. Vertical force control system
3. Thermometer and Hygrometer
4. Top sample holder
5. Bottom sample holder
6. Horizontal rail guide system
7. Top sample
8. Bottom sample
Materials and Method

Tribocharging Bench

1. Observations using a thermal camera to ensure that contact between the samples occurs properly
2. Measure sample temperature increase after friction

Material friction

Thermal camera (FLIR E60)
Materials and Method

Measurement techniques

Surface Electric Potential

\[ V = f(Q) \]

Electrostatic voltmeter 10 kV
TREK model 341B
Materials and Method

Measurement techniques

Cartography of the electric potential

- Capacitive probe (model 3450, TREK Inc.) + electrostatic voltmeter (model 341B, TREK Inc.)
- Computer-controlled x-y positioning system
- Measurements are carried out in 95 points, distance between two points is 10 mm
Results and Discussion

Surface Potential Measurement after Rubbing
## Results and Discussion

### Experimental Worksheet

<table>
<thead>
<tr>
<th>Exp No</th>
<th>Exp Name</th>
<th>Run Order</th>
<th>Incl/Excl</th>
<th>Cycle</th>
<th>NForce</th>
<th>Frequency</th>
<th>AVG V</th>
<th>STDEV V</th>
<th>DeltaTemp</th>
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Results and Discussion

Summary of Fit Plot

Investigation: CCF_GreyPVC (PLS, comp.=4)
Summary of Fit

R2 & Q2

AVG V
STDEV V
DeltaTemp

N=17
Cond. no.=4.1411
DF=7
Y-miss=0
Results and Discussion

Coefficient plot of the average potential

Average Surface Potential = \(-616 + 46\times\text{Cyc} – 468\times\text{NFO} – 99\times\text{Cyc} – 119\times\text{NFO}\times\text{NFO} + 92\times\text{Cyc}\times\text{Fre}\)
Results and Discussion

Investigation: CGF_GreyPVC (PLS, comp = 4)
Prediction Plot
Results and Discussion

Coefficient plot of the $\sigma_V$

$$\sigma_V = 1740 + 282 \times \text{Cyc} + 332 \times \text{NFo} - 72 \times \text{Fre} - 92 \times \text{Cyc} \times \text{Cyc} - 288 \times \text{NFo} \times \text{NFo} - 191 \times \text{Fre} \times \text{Fre} + 113 \times \text{Cyc} \times \text{Fre} - 30 \times \text{NFo} \times \text{Fre}$$
Results and Discussion
Results and Discussion

Coefficient plot of the $\Delta_{\text{temp}}$

\[
\Delta_{\text{temp}} = 1.9 + 1 \times \text{Cyc} + 0.4 \times N\text{Fo} + 0.5 \times \text{Fre} - 0.2 \times N\text{Fo} \times N\text{Fo} + 0.2 \times \text{Cyc} \times N\text{Fo} + 0.3 \times \text{Cyc} \times \text{Fre} + 0.1 \times N\text{Fo} \times \text{Fre}
\]
Results and Discussion
Results and Discussion
Conclusions

For \( Cyc = 10, \ NFo = 10 \) \( \text{N} \) and \( Fre =1.5 \) Hz and 2.5Hz, the MODDE 5.0-predicted values of : \( V_{AVG}, \sigma V \) and \( \Delta Temp \) are: -1395 V; 1014 V; 0.4°C. and \( V_{AVG} = -1708 \) V; \( \sigma V = 709 \) V; \( \Delta Temp = 4 \)° C.

The results of the tribocharging :
\( V_{AVG} = -1288 \) V; \( \sigma V = 1123 \) V; \( \Delta Temp = 0.3 \)° C for 1.5 Hz and,
\( V_{AVG} = -1643 \) V; \( \sigma V = 728 \) V; \( \Delta Temp = 5 \)° C for 2.5 Hz.
Conclusions

- The electric charge generated during the rubbing process increases with the normal load.
- Charge generated rise with increasing frequency on low cycle
- Uniformity of charge increase after frequency more than 1.2Hz
Thank You for your Attention