A computer-aided methodology for the design of de-manufacturing process for waste recycling

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Introduction

- ✓ Recycling of Waste Electrical and Electronic Equipment (WEEE) is a challenging task due to their complex material structure.
- ✓ Currently, thermal and metallurgical recovery processes are used.
- ✓ Corona Electrostatic Separation is a promising technology for the mechanical pre-treatment of shredded waste.
- ✓ However, the efficiency of separation is highly affected by:
  - The presence of non-liberated particles in the mixture.
  - The influence of particle-particle interactions and impacts.
- ✓ Accurate physical modeling and tight process parameters control is needed.
- ✓ State-of-the-art models only model single particle trajectories.
- ✓ **The aim of this study is to develop a multi-body physical model of CES to capture the effect of the particle impacts on the output recovery and grade.**

Corona Electrostatic Separation

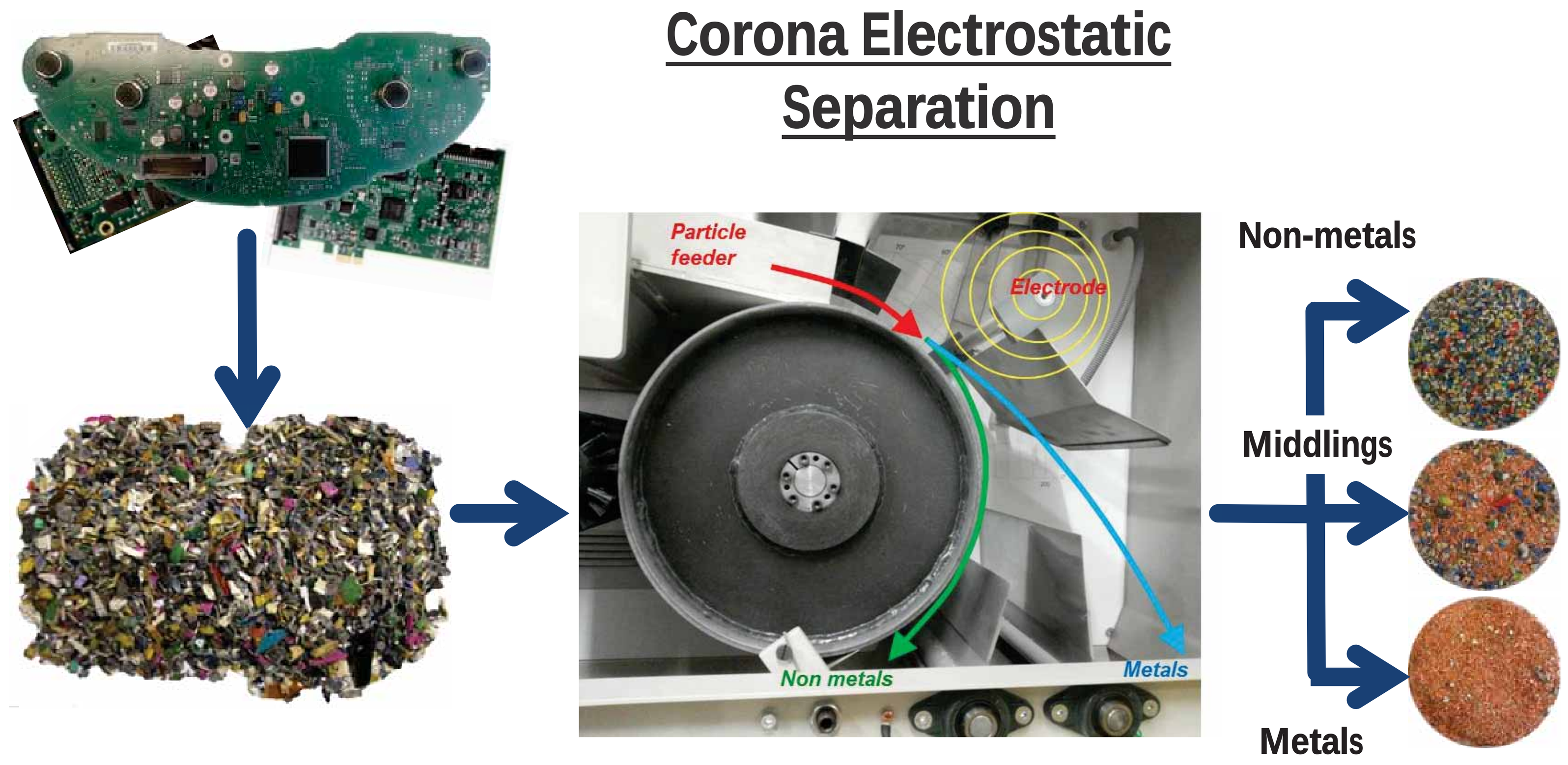
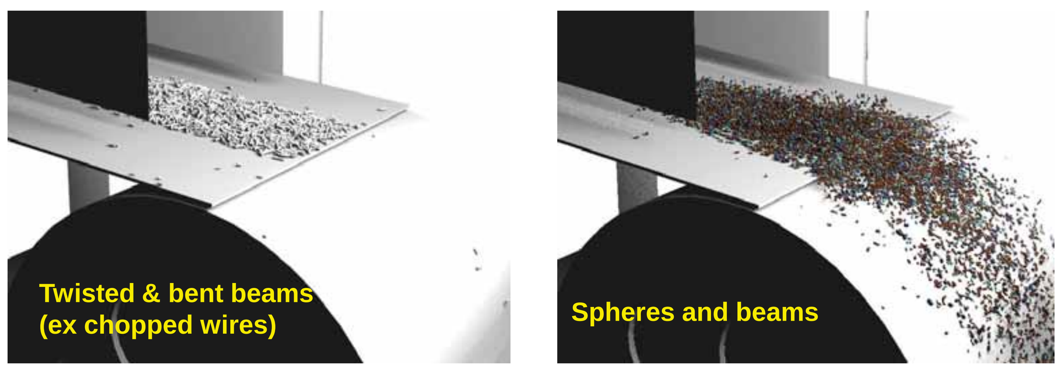


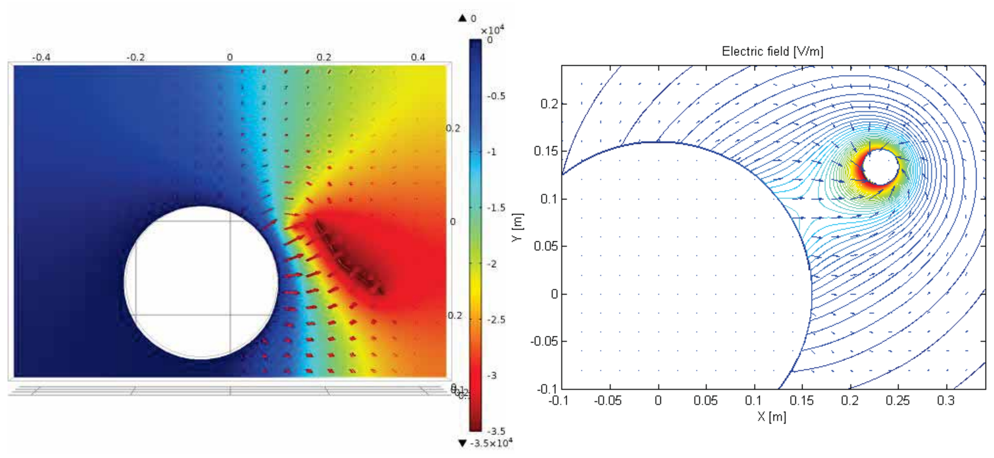
Figure 1. The Corona Electrostatic Separation process.

Method

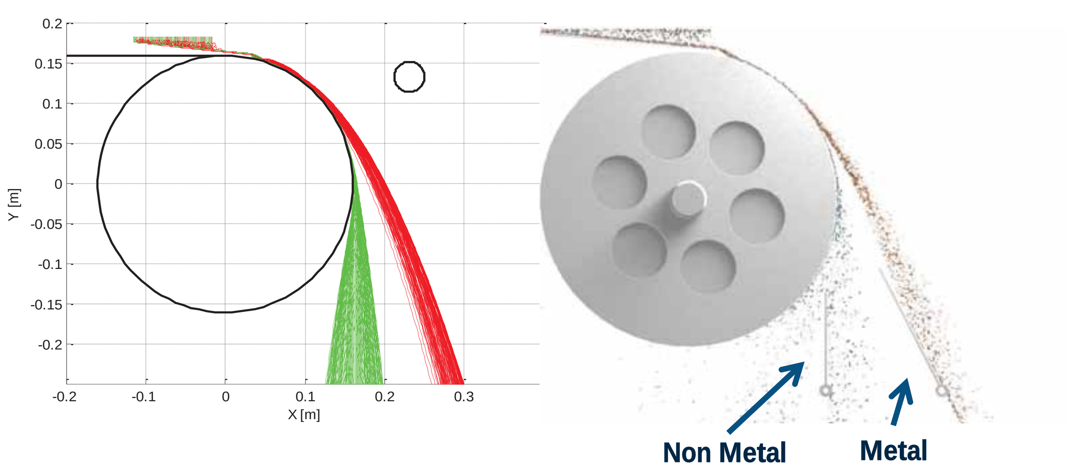
Mixture modeling



Electric field modeling



Granular flow modeling and simulation (Chrono::Engine)



- ✓ Multibody environment and colliding surfaces are automatically generated from CAD (SolidWorks).
- ✓ The particles in the mixture have been modeled with nominal particle shapes materials and size classes.
- ✓ The 3D electrostatic field has been modeled by FEM and by 2D analytical approximation.
- ✓ The Electric forces acting on metal and non metal particles are computed on the basis of the electric field.
- ✓ The Aerodynamic forces, the Centrifugal force and the Gravity force acting on the particles are modeled.
- ✓ The impacts are simulated by the DVI - based (Differential Variational Inequality) solver integrated in the Chrono::Engine environment.
- ✓ About 1 million impacts can be simulated in the granular flow.

Results and Conclusions

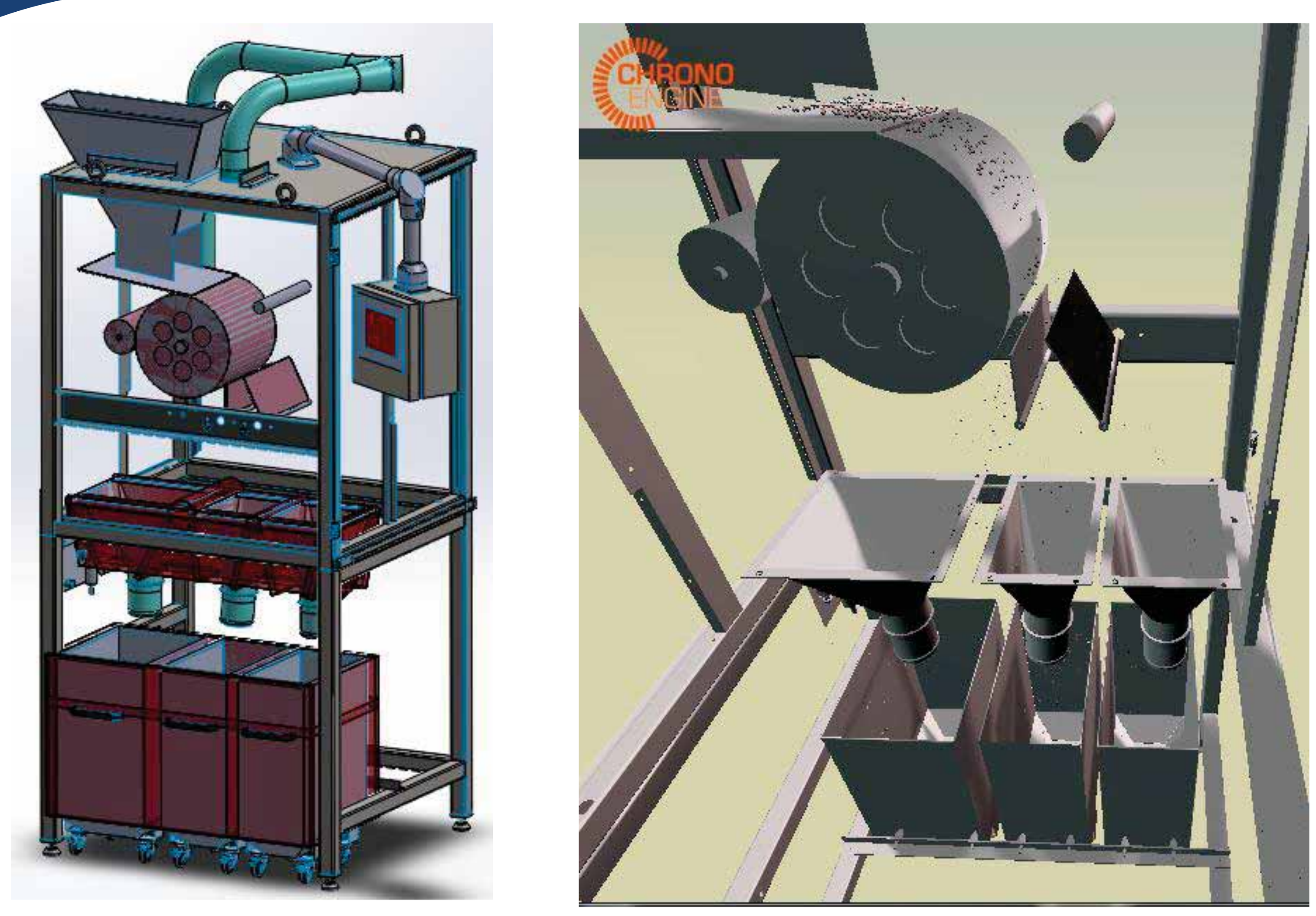


Figure 2. The CAD of the CES machine is imported in the multi-body simulation environment (Chrono::Engine). Then, the granular flow is simulated.

- ✓ **Accuracy:** it has been shown by real experiments performed at the ITIA-CNR "De-manufacturing Plant", that the developed simulation model well predicts the distribution of the throw of conductive and non-conductive particles (Figure 3). As a matter of fact, maximum squared error is about 0,013.
- ✓ **Statistical analysis:** ANOVA method demonstrates that the error is not statistically significantly dependent on factors.

- ✓ Experiments were performed at ITIA-CNR pilot plant using a controlled mixture of material.
- ✓ The validation has been done using a DOE, with three levels for the potential (factor 1) and five levels for the splitters' configuration (factor 2).
- ✓ Simulations with the same experimental conditions have been done.
- ✓ The squared error in the prediction of the metallic fraction recovery rate has been calculated.
- ✓ Statistical analysis of the experimental results has been performed using ANOVA method.

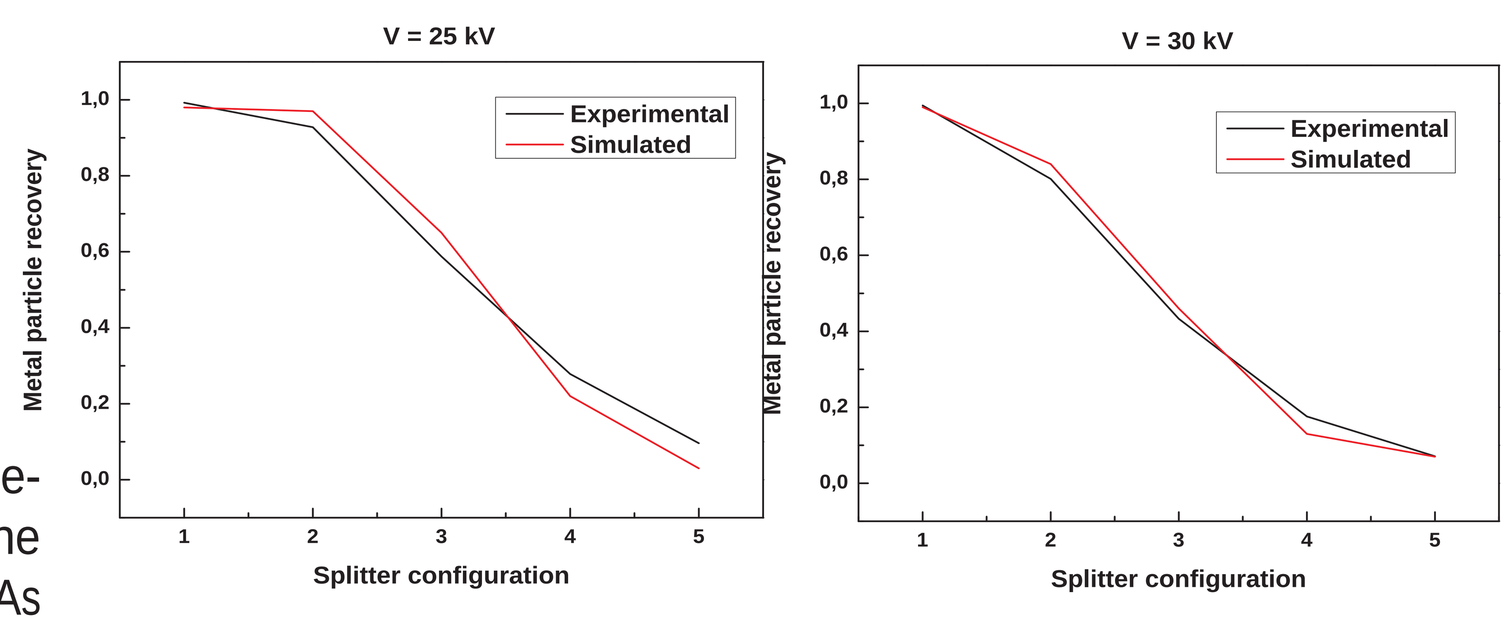


Figure 3. Output distribution of metal particles.

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