CESI RICERCA

Third International Conference on Clean Coal Technologies for our Future

Cagliari (Italy)

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants.

F.Sigon, M.Broglia, A.Frigerio

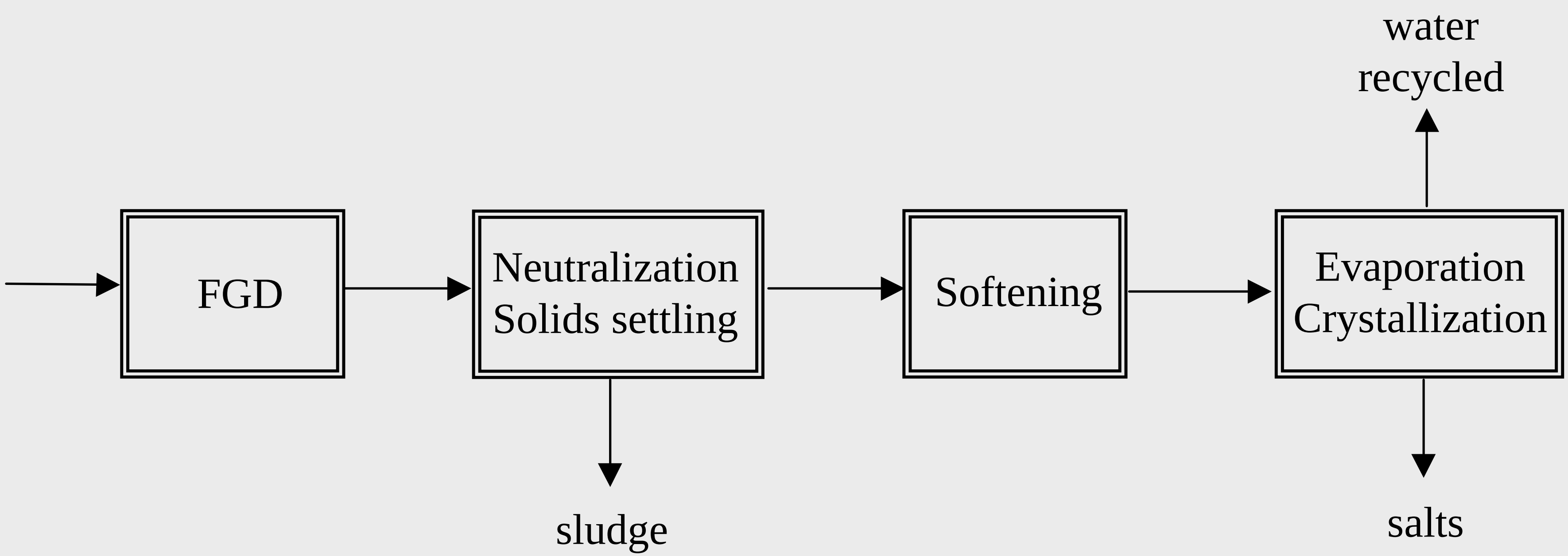
May 15th 2007

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants

Any ZLD (Zero Liquid Discharge) power plant configuration necessarily presents a new solid waste represented by the soluble (mixed) salts from the effluent evaporators. These salts must be disposeed according to the following options:

- open sea discharge
- mine disposal
- land disposal
- market allocation

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants



Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants

$DeSO_x$-TSD equipped coal fired power plants can generate significant amounts of soluble salt residuals. The total amount depends on the actual ZLD configuration adopted in each power plant. The total residual amounts actually expected will be close to 40000 ton/year (ENEL coal ZLD plants). The expected disposal costs may range from 2 to 40 and more millions Euro per year.

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants

Land disposal can be considered only if the final solid to be allocated complies with the "leaching test" limits. The "leaching test" check the residual for the potential to release undesidered chemical species from the solid in contact with water in specified standard conditions. The solution after contact with the solids for a period of time should remain as pure as described in the following table

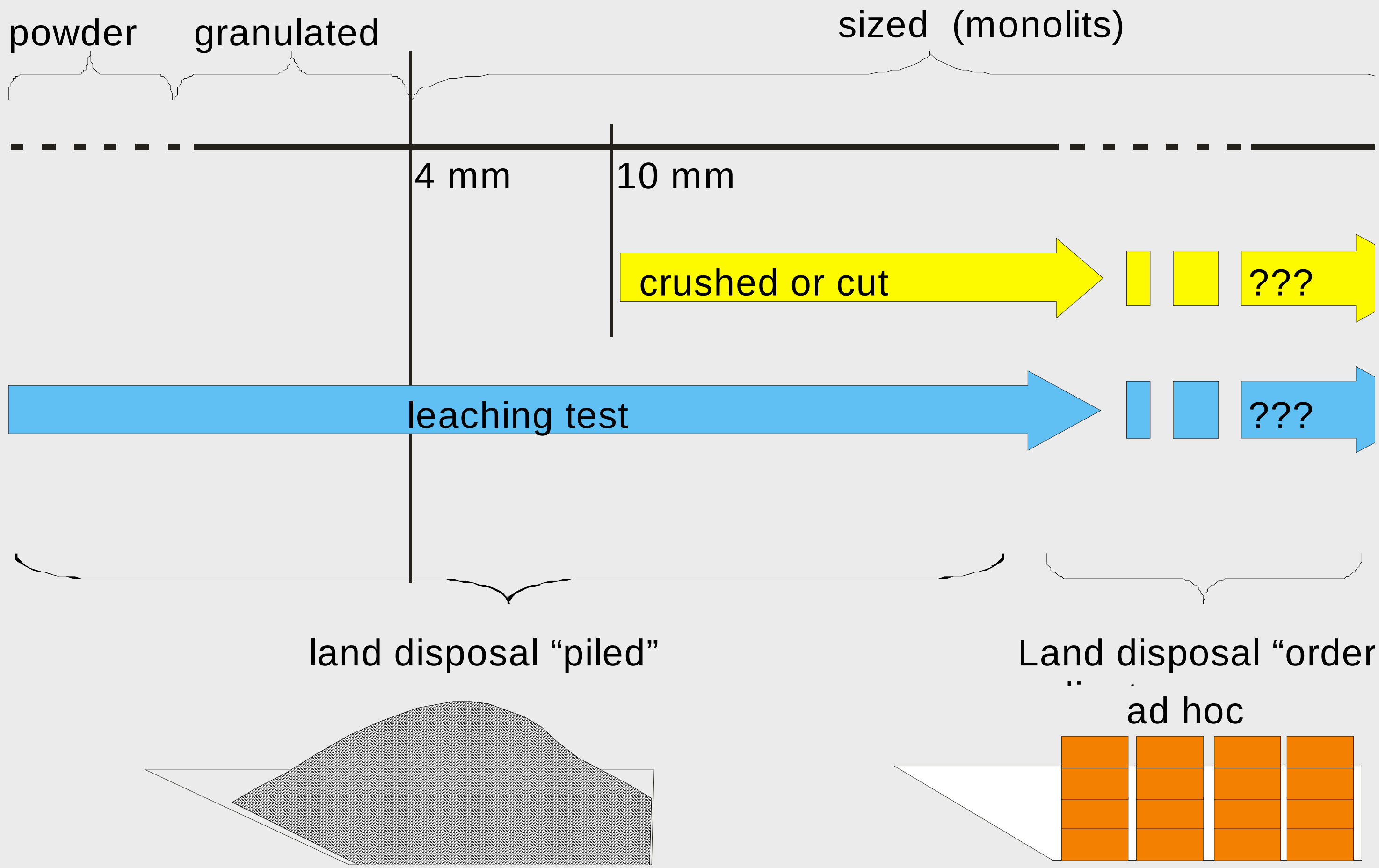
Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants

Leaching test classification limits

parameter [mg/l]	***non dangerous waste***	***dangerous waste***
As	***0.2***	***2.5***
Ba	***10***	***30***
Cd	***0.02***	***0.2***
Cr_{total}	***1***	***7***
Cu	***5***	***10***
Hg	***0.005***	***0.05***
Mo	***1***	***|3***
Ni	***1***	***4***
Pb	***1***	***5***
Sb	***0.07***	***0.5***
Se	***0.05***	***0.7***
Zn	***5***	***20***
Cl	***1500***	***2500***
F	***15***	***50***
CN	***0.5***	***5***
SO_4	***2000***	***5000***
DOC [Note 1]	***80***	***100***
TDS [Note 2]	***6000***	***10000***

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants

Waste sizing and “leaching tests” considerations



To satisfy the “leaching test” we need to treat the salts accordingly to one of these (inertization) processes:

- inorganic based ligands, as lime/clay/cements
- organic based ligands, as thermoplastics/polymers/macroincapsulating products
- vetrification or vetroceramization

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants

Until now all the inorganic stabilization processes failed because of their lack to comply with one or more of the following drawbacks:

- excessive requirements for ligand/residual ratio to obtain a final product with satisfying mechanical properties and leaching behaviour
- fail to comply with the leaching test
- excessive increase in the amount (mass/volume) to dispose
- long manufacturing process time, due to the required curing period
- high costs of the process

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants

The R&D endorsed has been specifically focused on the waste stabilization benefits of an organic polymeric barrier to solve the leaching problems and to reduce overall process drawbacks and costs. Two dimensional options, as previously discussed, have been addressed:

- small monoliths
- large monoliths

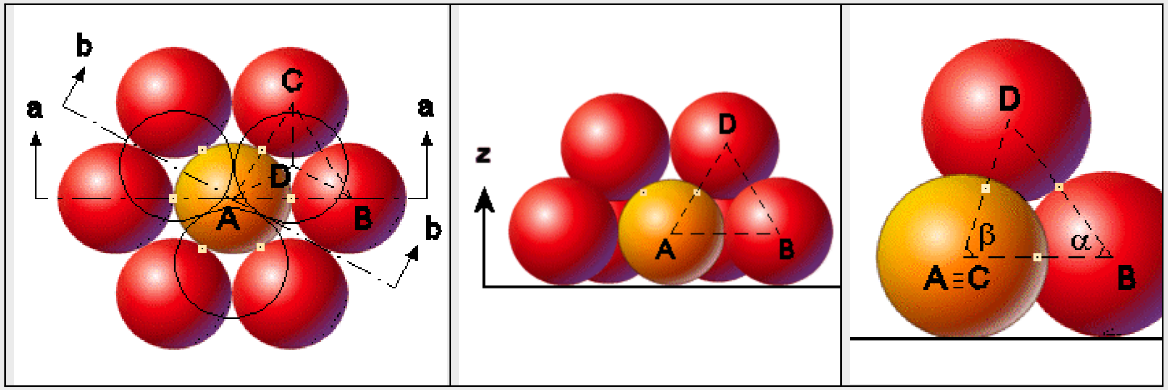
Small monoliths

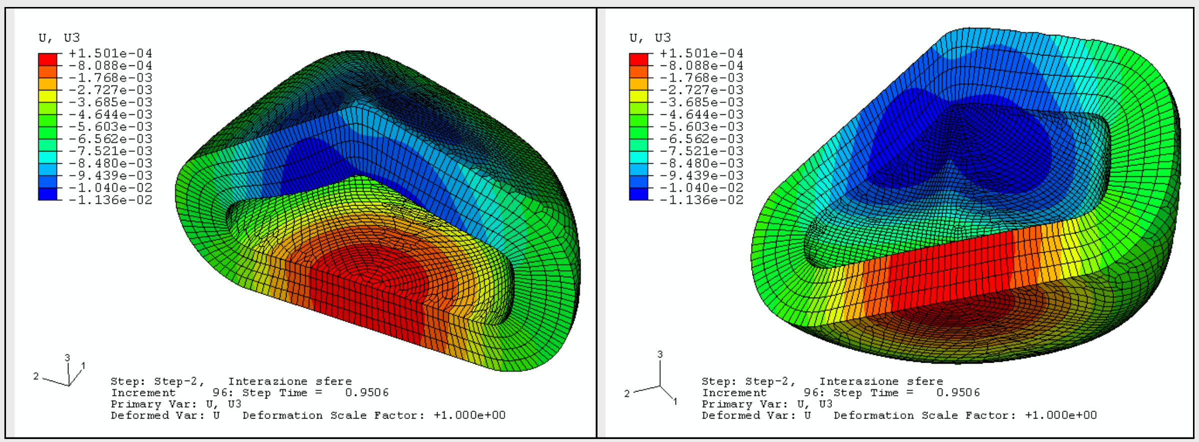
The stabilized residual is a composite product characterized by an inner core, mostly constituted by the salts alone or stabilized with inorganic or organic ligands, and an outer shell formed by a plastic coating or an organic polymer acting as a barrier to block the diffusion of the salts to the environment and providing additional mechanical strength as well.

A preliminary structural analysis has been undertaken to verify the organic coating thickness as required to comply with the leaching test and the monolith integrity in real conditions. We need to identify the optimal material to use between those easy to recover: LDPE, HDPE, PP, PVC and similar. The regenerated plastics have mechanical properties only 20% lower than the virgin ones, but costs 50% off the new ones.

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants

Organic polymeric layer: mechanical behaviour analysis





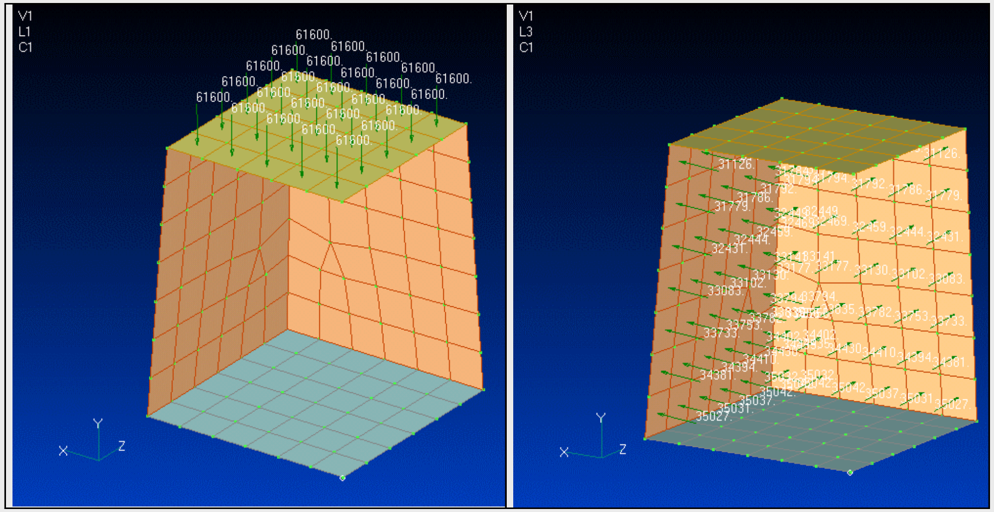
Small monoliths with a spheric form and a LDPE coating 3 mm thick, presents the greatest deformation at a pressure value of 1000 kN/m^2. Under the assumptions of a filling layer depth of 6 meters and an apparent density in the layer of 1 ton/m^3, the critical pressure is 15 times higher than actually expected (60 kN/m^2)

Large monoliths

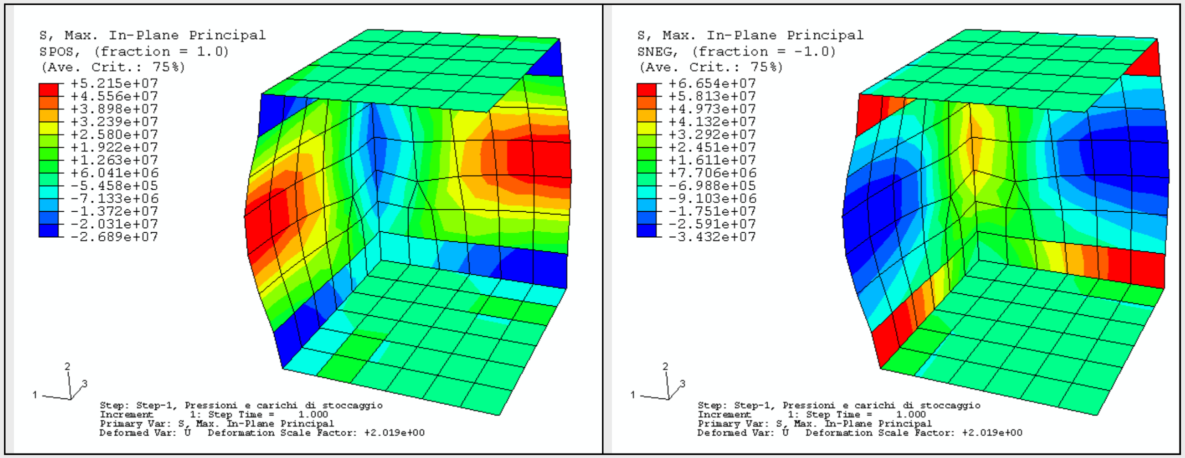
This solution corresponds to a "waste packaging" process with a robust and stable containment, good enough to avoid any contact of the residue with the external environment in the landfill.

Plastic materials are the solution of choice because of their best chemical resistance and for the lower overall costs.

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants



Plastic containers: mechanical behaviour analysis



Conclusions

Two separate options have been identified, monoliths according to the leaching test definition:

•*small monoliths*, not larger than 9 mm, covered with a regenerated LDPE plastic coating, to be allocated in the existing disposal sites

•*large monoliths*, containers formed with a virgin thermoplastic material (>0.5 to 1 m^3), to be allocated in new disposal sites.

Safe land disposal of soluble salt residuals: the ultimate frontier for the ZLD coal power plants

The CER code for both stabilized products will likely be 19 03 XX (XX=03, completely stabilized or solidified, XX=04, partially stabilized) . The used of regenerated LDPE will reduce the final cost of the small monoliths as low as 400÷600 €/ton, while the large monoliths would likely cost 350÷450 €/ton.

The R&D activities already scheduled in 2007 will develop both solutions as described.

This work has been financed by the Ministry of Economic Development with the Research Fund for the Italian Electrical System under the Contract Agreement established with the Ministry Decree of March 23, 2006.