UNIVERSITY OF TRIESTE
Department of Engineering and Architecture

Master's thesis in Mechanical Engineering

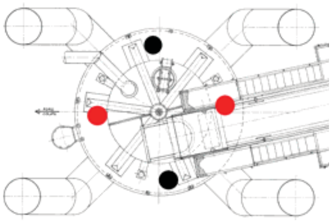
Design of a mechanical device for the optimization of the burden charge in the blast furnace's hopper with the discrete element method

Graduate:
Gabriele Degrassi

Supervisor:
Prof Lucia Parussini

0-ACTUAL SITUATION

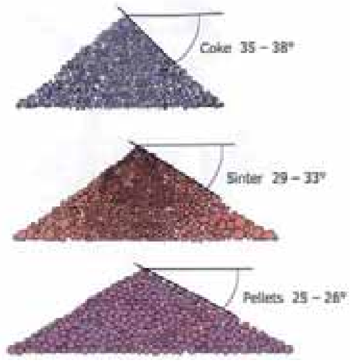
During the process of burden charge of the blast furnace of Acciaierie Arvedi Trieste, the distribution of materials in the hopper was found out to be not uniform, causing a loss of efficiency in the process of cast iron production. Materials are dropped into the hopper with a conveyor belt and then they collide a deflector which divides the flow in two, forming two different piles and two pitches on the bottom.

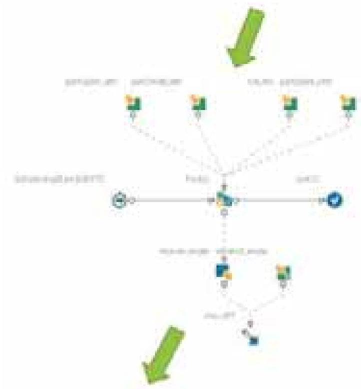


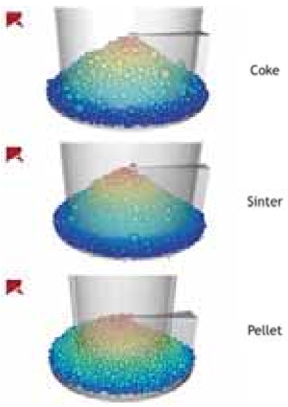
Figures: (top-left) the hopper with the deflector; (top-right and bottom-left) the piles and pitches of material photographed; (bottom-right) position of the piles (red dots) and of the pitches (black dots) with reference to the conveyor belt.

1-CALIBRATION PROCESS

Coupling modeFrontier and Rocky DEM, particles used by Discrete Element Method were calibrated to behave as real particles with reference to repose angles of materials involved in the process of burden charge. This operation is usually performed for DEM software without the support of an optimization platform, which resulted really helpful and time-saving.



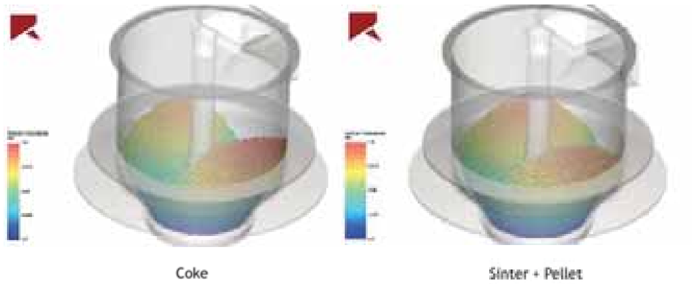




Figures: (top) repose angle values for real material; (center) workflow produced with modeFrontier; (bottom) cone obtained with the three calibrated materials.

2-SIMULATION OF ACTUAL SITUATION

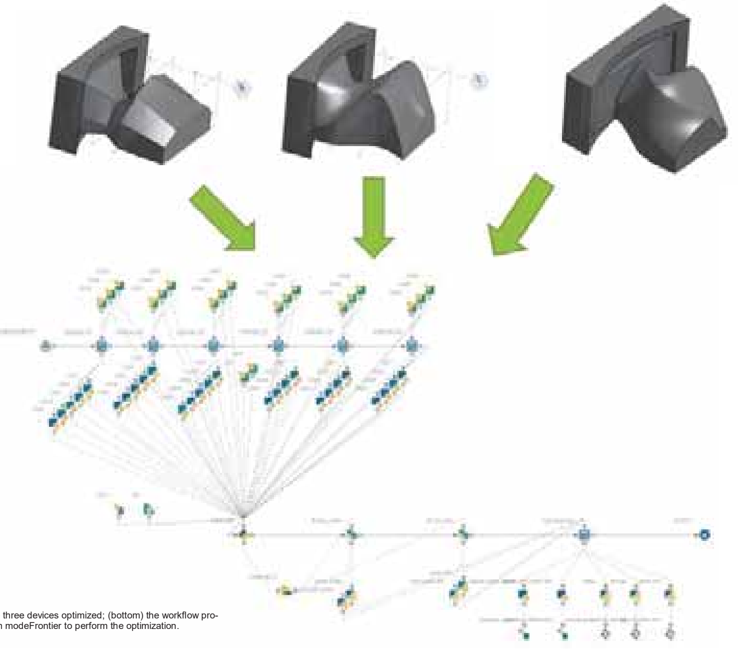
The simulation of the burden charge was performed both for coke coal and sinter+pellet mix, for which more than 1400000 particles were simulated. With these simulations, it the model was validated and the optimization phase began.



Figures: result of the simulations for coke coal (left) and sinter+pellet (right) burden charge of the hopper.

3-OPTIMIZATION

Three different devices were optimized using the model of burden charge calibrated with Rocky and a workflow produced with modeFrontier.
Up to 40 parameters were optimized, taking 1h per each design (only 15s of the complete charge were simulated).

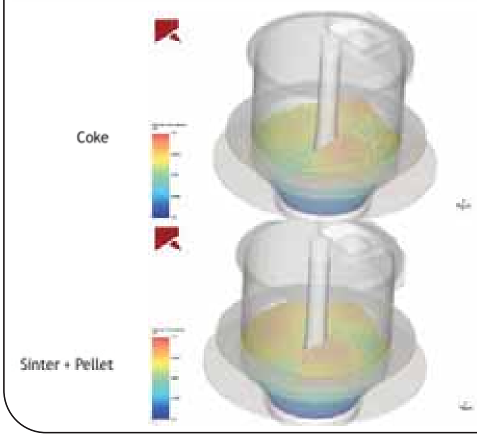


Figures: (top) the three devices optimized; (bottom) the workflow produced in modeFrontier to perform the optimization.

4-RESULTS

The best results of the three optimizations were compared and the best of them was chosen to be built and put in service.
The comparison shows a great improvement in the distribution parameters, expecially for design 365.

Parameter	Actual value [%]	Value for design 319 [%]	Value for design 196 [%]	Value for design 365 [%]
[illegible]	10.33	8.36	5.17	1.76
[illegible]	6.71	6.01	7.27	1.19
[illegible]	0.53	0.07	0.05	0.16
[illegible]	3.74	1.46	4.78	5.73
[illegible]	14.02	11.33	11.68	10.16
[illegible]	47.38	28.51	32.60	27.29
[illegible]	24.40	9.66	13.93	10.56



Figures: (top) table with values used to compare the performance of the optimized devices; (bottom) final result of hopper charging for design 365, which resulted to be the most efficient.

Thanks to:

Acciaieria Arvedi Trieste   ESSS   ESTECO