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Hg and SO_2 emission control potential of activated carbons based on brown coal and influence of material structure and composition

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Outline

1 Motivation

2 Screening of feedstock

3 Optimization of carbon adsorbents production

4 Conclusion

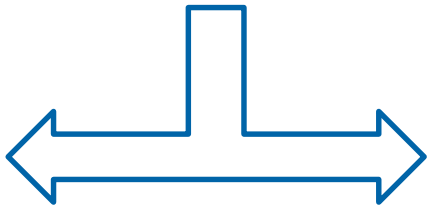
Increasing demands on activated carbons

- Power plant operators have to meet newly introduced emission limits in EU countries

  e.g. mercury emissions from 2019: max. 10 µg/m³

- Mercury emissions are mainly determined by used combustible material, influence of process parameters (lambda, boiler-temperature, etc.) is comparatively low

- Downstream applicable techniques have to be adopted

Fixed bed adsorber  Entrained flow adsorber

→ Different requirements towards properties of carbon adsorbents

e.g. grain size, impact resistance, ignition temperature, sorption rate,…

Selection of feedstock

- Ideally, power plant companies can use their own coal as feedstock for carbon adsorbents

- Different coals from central german mining area were chosen

- Influence of grain size (fine and coarse) and mechanical pretreatment (granulation, pelletization) is determined

- Additionally, the influence of upstream material utilization on the product is evaluated, by sampling different stages of the wax extraction process from Romonta GmbH

- All in all 14 different feedstock products are investigated

2 dry coals (1 extracted), 2 raw coals,
Pellets, electrostatic filter dust,
5 fine granulates < 4 mm, 3 microgranulates < 1 mm (1 extracted)

Determination of suitability for production of carbon adsorbents

Feedstock characterization + thermochemical behaviour

- Proximate + ultimate analysis
- LHV + HHV
- XRF
- Hg-porosimetry + He-pyknometrie (apparent and skeletal density, pore size distribution)
- Mass loss curves via TG-DSC
- Fixed bed pyrolysis (mass balance and product yields)

Production of carbon adsorbents using constant process conditions

- Retorte furnace
- Process conditions in analogy to HOK®
  - High heating rate (app. 40 K/min)
  - Bed temperature ~ 950 °C
  - Dwell time 60 min
  - Fast cooling under water vapor
  - Injection of air below 120 °C

→ low activation rate and oxidation

Characterization of adsorption relevant properties + Benchmark

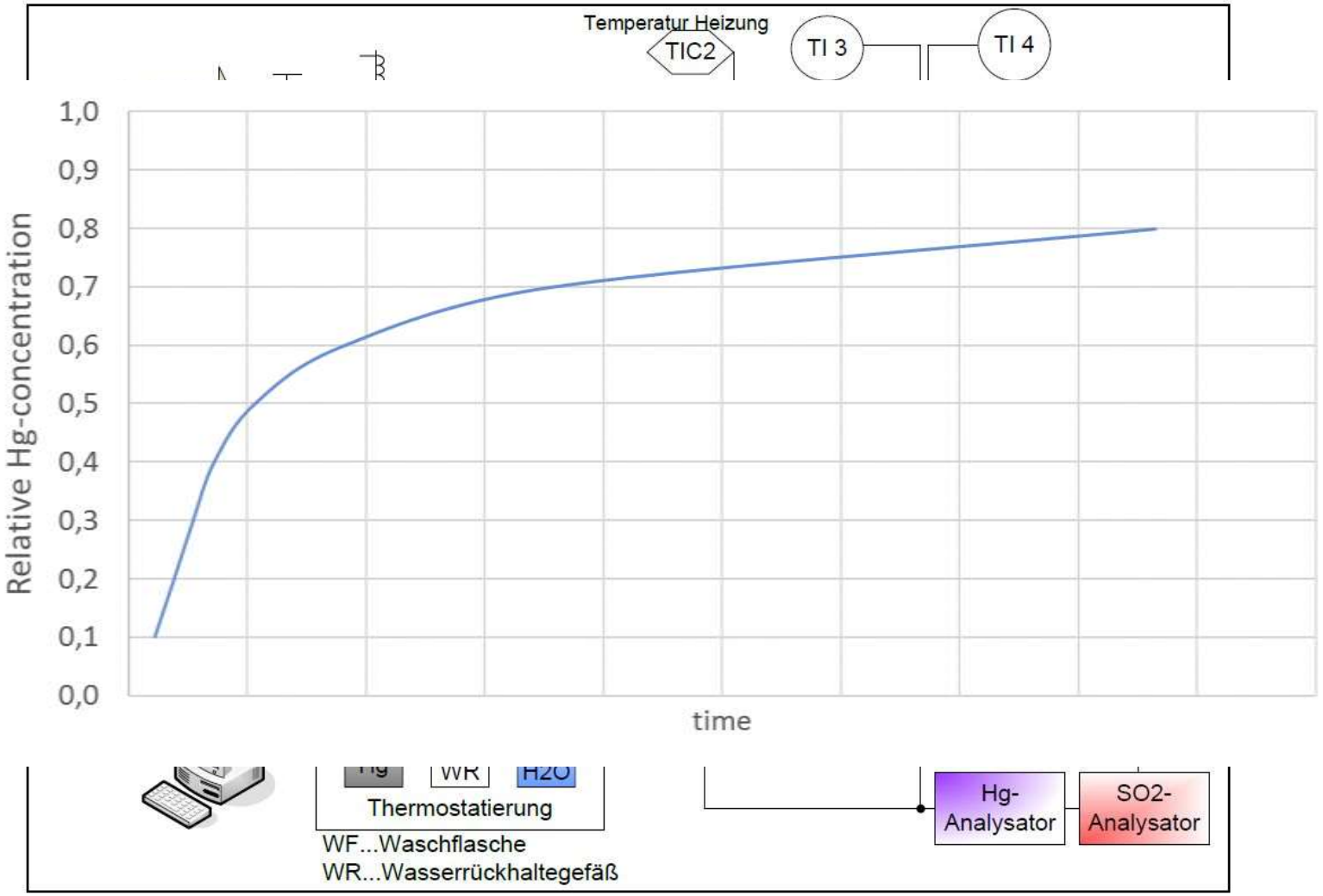
- Proximate + ultimate analysis
- Hg-porosimetry + He-pyknometrie
- Reactivity towards CO_2
- Impact resistance
- Ignition temperature
- Burning number
- Inner specific surface area (BET)
- Iodine number
- Methylene-blue number
- Adsorption characteristics (Hg/SO_2)

→ Benchmark: HOK® products from RWE
granulate, medium, dust and super

Determination of adsorption performance

- Heated fixed bed reactor
- Appr. 10 g sample mass
- T ~ 140 - 160 °C
- Simulated flue gas
- 600 µg/m³ Hg / 400 ppm SO_2
- Constant measuring of Hg/SO_2-concentration

→ Results: dynamic adsorption capacity, breakthrough time, inhibitive influences of flue gas



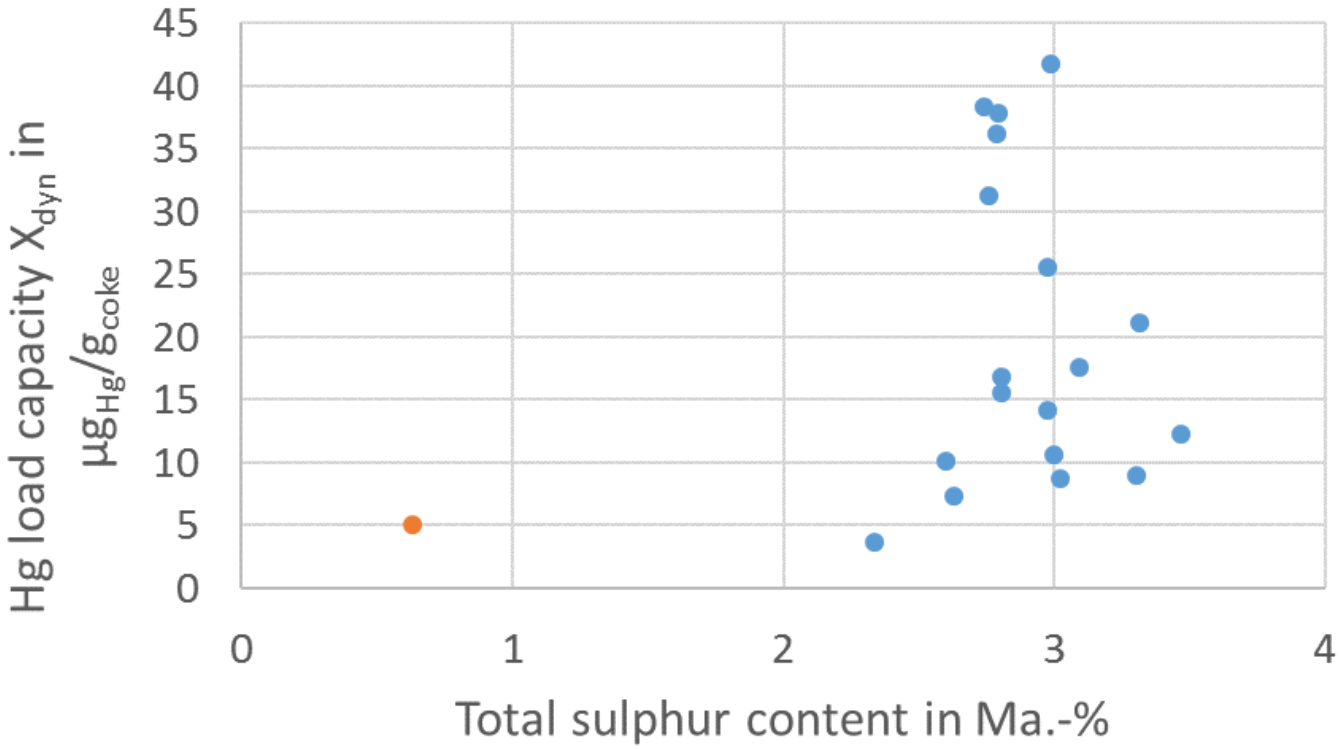
Results

- Retorte furnace adsorbents show superior adsorption behaviour compared to ● HOK®
- Similar burning behaviour
- Lower values for ignition point, impact resistance and reactivity
- Increased adsorption behaviour is observed
- Lower inner specific areas are created

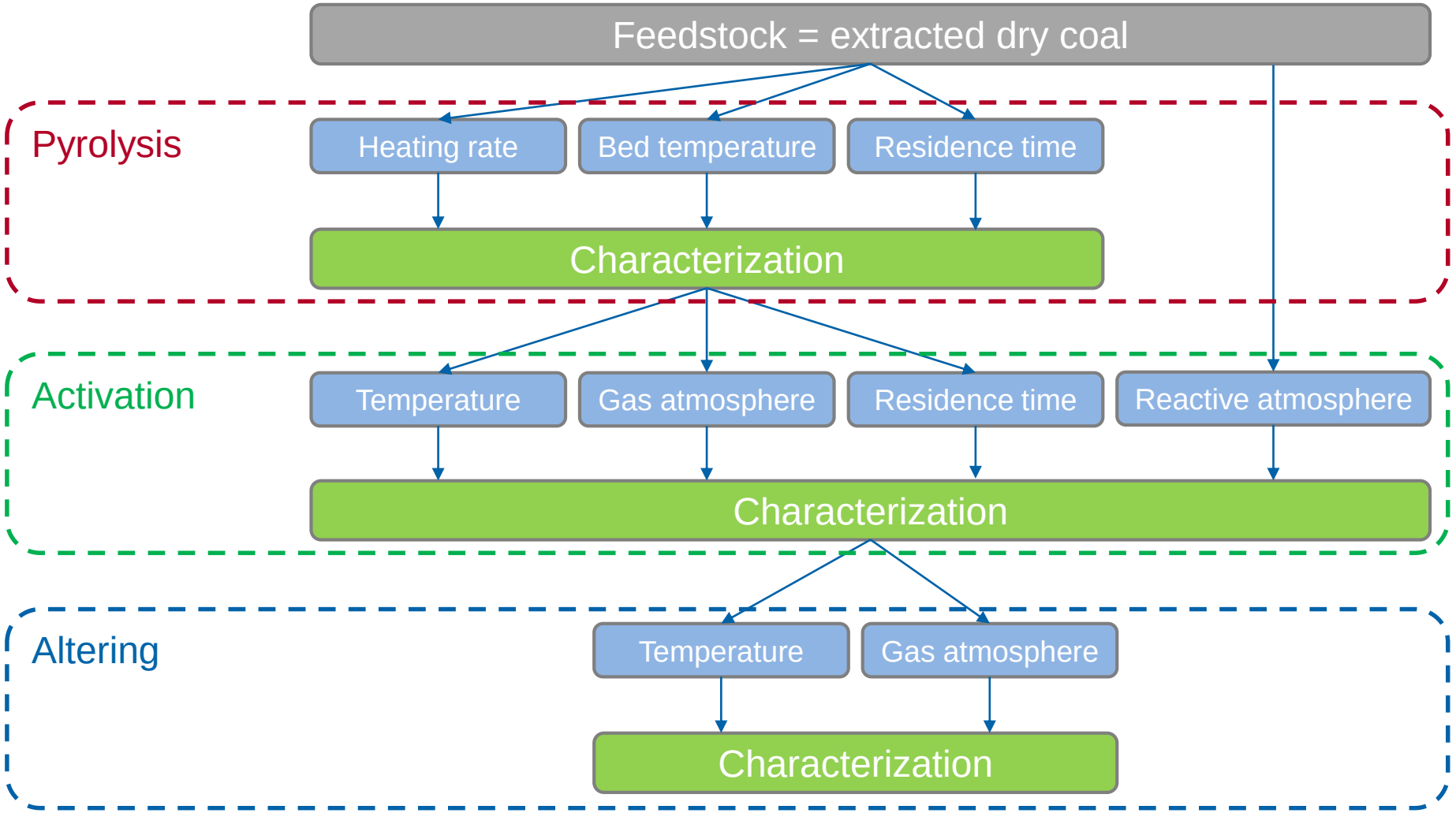
→ Sulphur content of coke is essential for mercury adsorption

→ gas activation is indicated for higher porosity and inner specific surface area

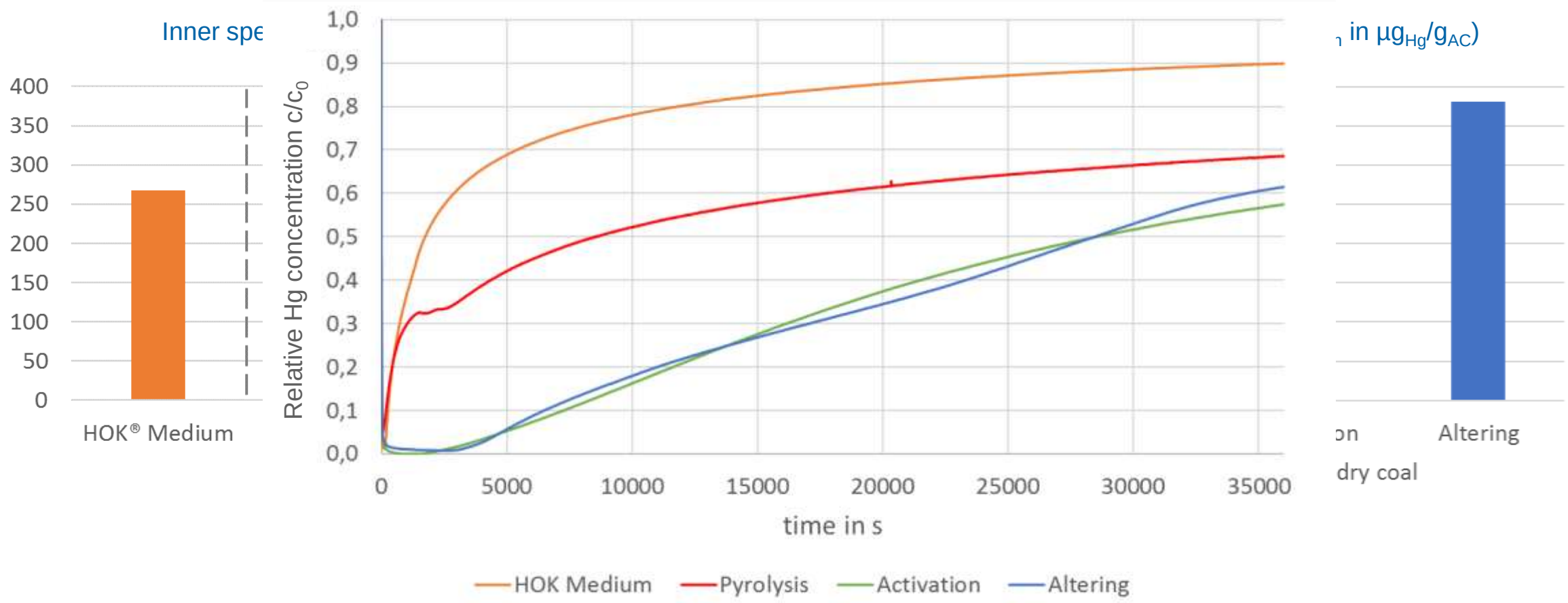
Hg adsorption capacity vs. total sulphur content



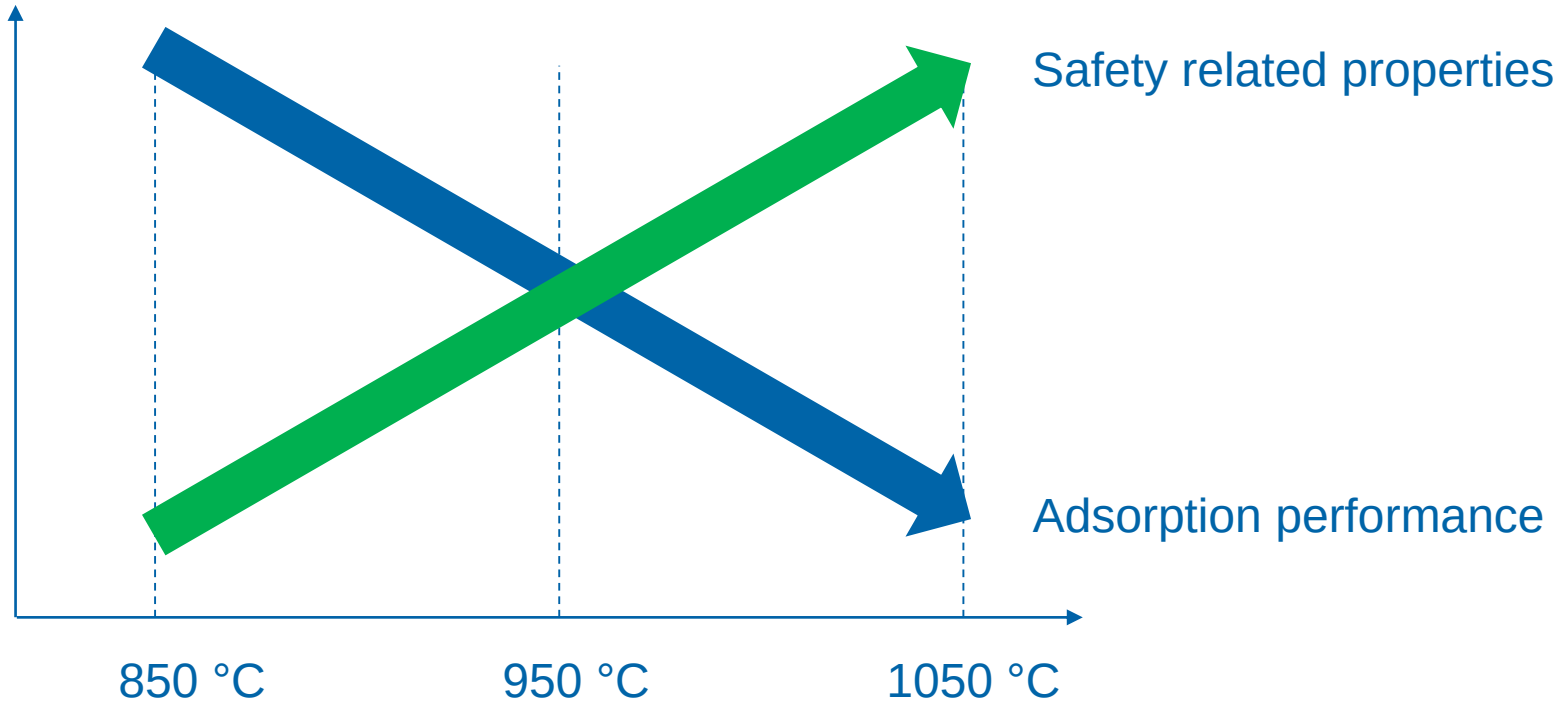
Variation of process parameters - pyrolysis, activation and altering



Results of parameter variation



Results of parameter variation



→ optimal parameters for carbon adsorbents production assessable

Properties of possible products

- High-quality and competitive carbon adsorbents from Romonta feedstock materials are fabricable
- Relevant properties regarding adsorption performance and safety-related characteristics exceed the values of HOK®
- Upstream granulation process is essential for impact resistance, a former extraction process is non-constraining applicable

→ single-use carbon adsorbents for gas treatment in granulated and powdered form are feasible

Parameter	AC from extracted dry coal	HOK® Medium	AC from fine granulate
Porosity	52 %	55 %	46 %
Inner specific surface area (BET)	351 m²/g	267 m²/g	395 m²/g
Iodine number	285 mg I_2/g	325 mg I_2/g	310 mg I_2/g
Impact resistance	46 %	52 %	65 %
Ignition temperature	325 °C	345 °C	310 °C
Burning number	4	3	4
Reactivity	1 cm³/(g s)	1,8 cm³/(g s)	1,3 cm³/(g s)
Methylene-blue number	2,5 ml	3 ml	2 ml
Hg-adsorption capacity*	38,4 µg/g	5,1 µg/g	36 µg/g
SO_2-adsorption capacity*	33,5 mg/g	3,5 mg/g	36,1 mg/g

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