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technical THERMO DYNAMICS

Problem definition fouling and mobile test rig

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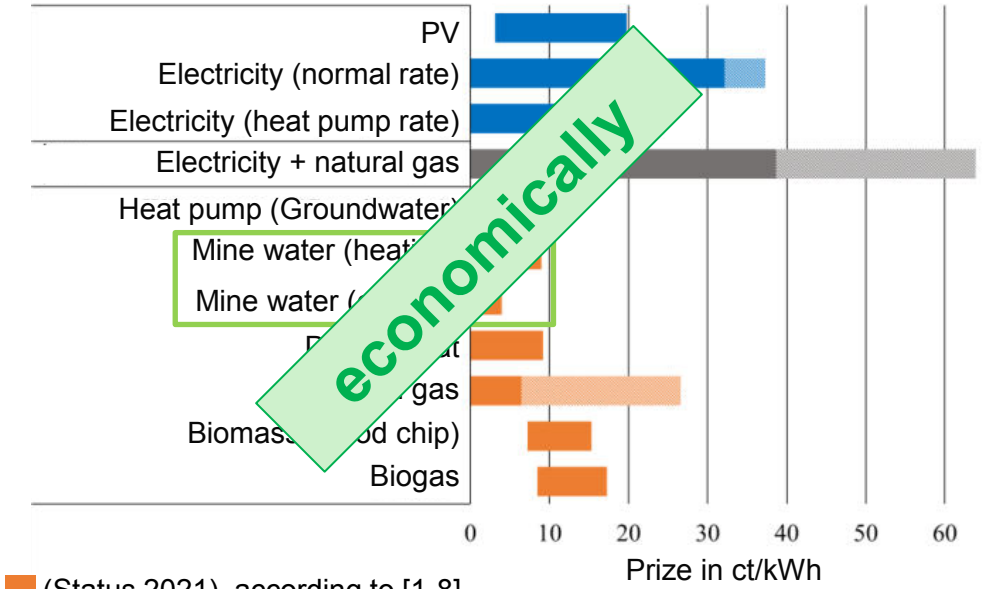
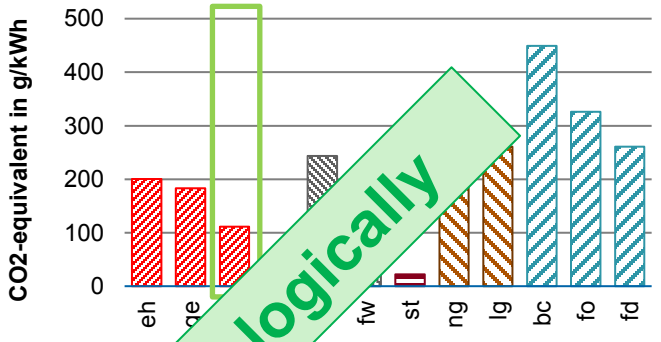
Focus: Energetic use of mine water



(Status 2021), according to [1-8]
(Status July 2022), according to [10,11]



[12]

eh	ntalheat
g	malenergy (nearsurface)
mw	water geothermalenergy
dg	ep geothermalenergy
bg	biogas
fw	firewood
st	solar thermalenergy
ng	natural gas
lg	liquid gas
bc	brown coal
fo	fuel oil
fd	fossil district heat

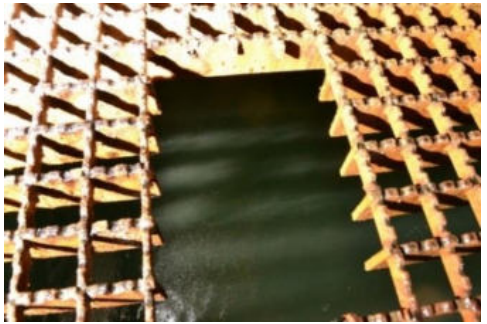
Problem fouling

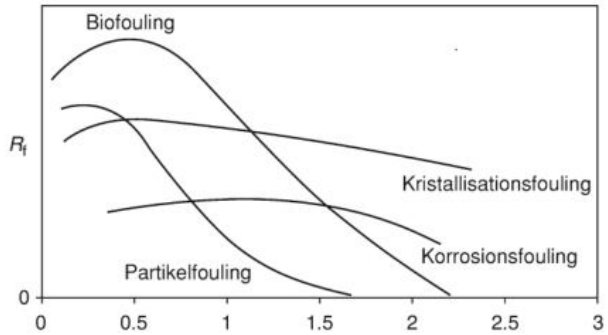
?

Co-funded by the European Union

Influence of water chemistry on plant operation

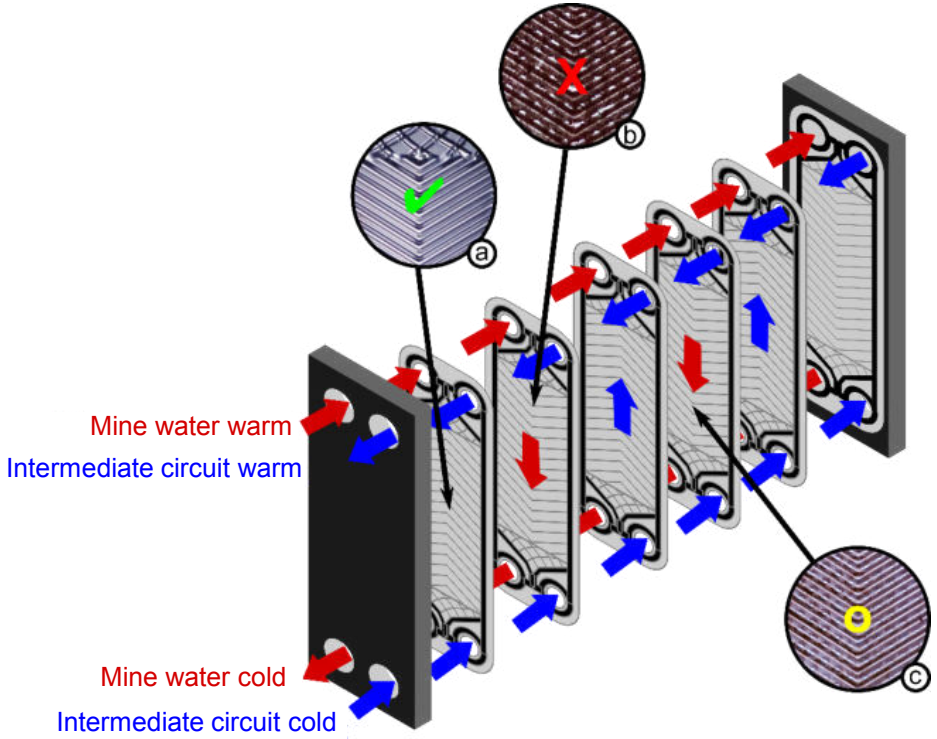
- Mine waters contain organic / inorganic partially dissolved / undissolved substances
- Chemism depends on the location
- Plant causes formation of often stable layers (fouling)
  - Crystallization Fouling
  - Particle Fouling
  - Reaction fouling
  - Corrosion fouling
  - Bio fouling



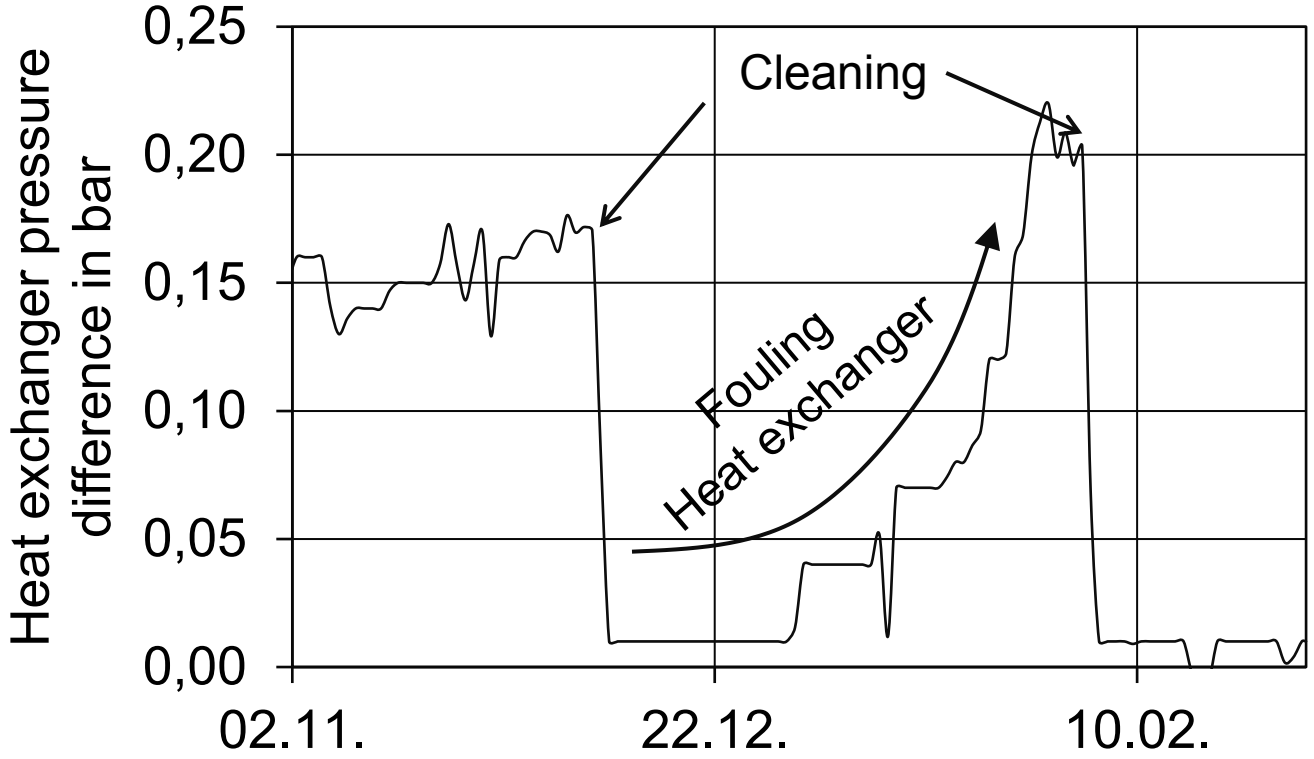


Fouling resistance as a function of flow velocity [6]

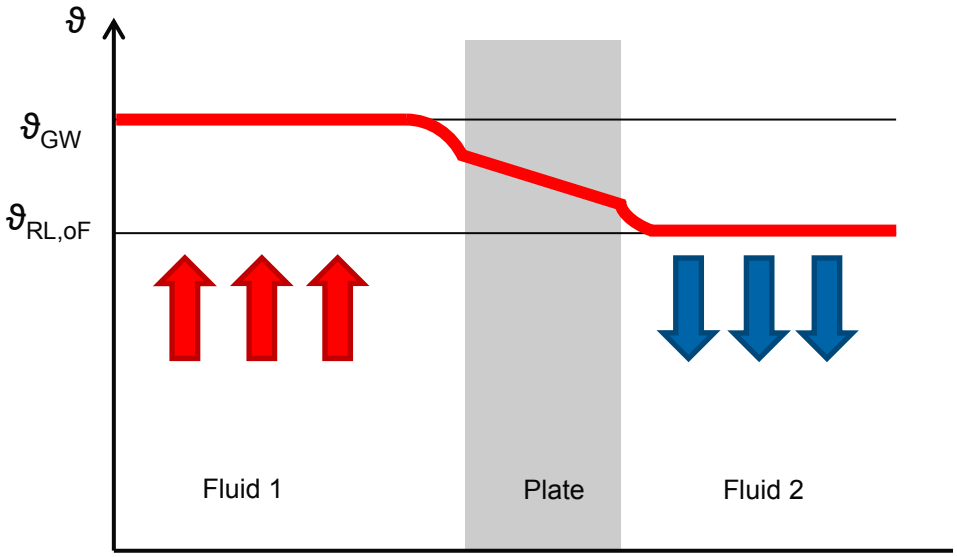
Influence of water chemistry on plant operation



Influence of water chemistry on plant operation

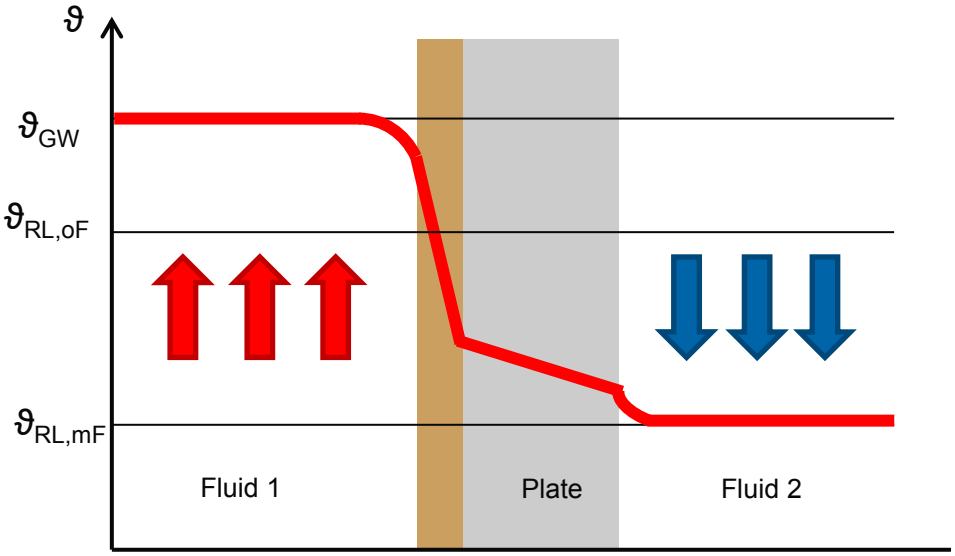


Fouling - influence on heat transfer



Material	HC in $\frac{W}{mK}$
Steel	~ 50
Stainless steel	~ 15

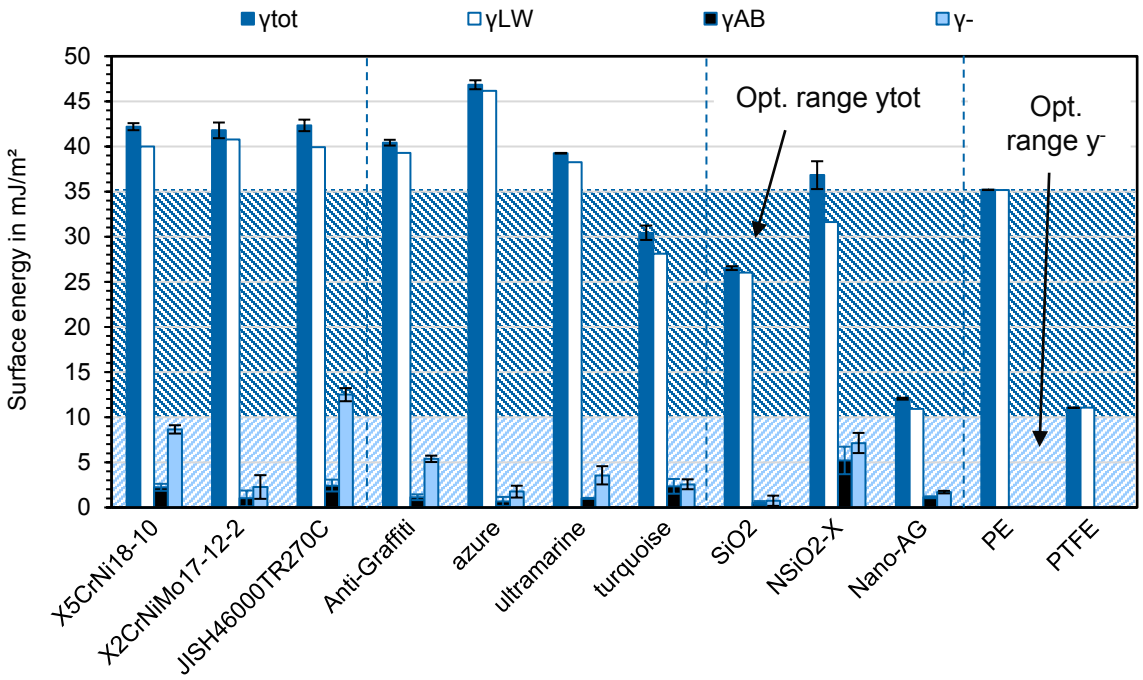
Fouling - influence on heat transfer



Material	HC in $\frac{W}{mK}$
Steel	~ 50
Stainless steel	~ 15
$CaCO_3$	~ 0,35
FeS	~ 1,2
Fe_2O_3	~ 0,6
Biofilm	~ 0,5-0,7

Fouling reduction through optimised heat exchanger design

What surface properties are to be achieved?



Metals: Stainless Steel 1.4301 + 1.4404, Titanium

Non-stick/ -fouling coatings :
Antibiofouling-Coating (ABC 1-3), Antigraffiti-Coating (AGC)

Nanocoatings:
SiO2-Coating (NSiO2), Antibacterial SiO2-Coating (NSiO2-X), Coating (NAg)

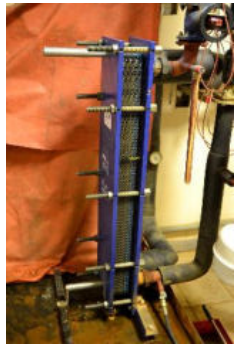
Synthetic coatings:
PE, PTFE

Problem of the Investigation on Real Plants

- Limited accessibility
- Partial load operation in the summer months as well as the transitional period
- Partly no suitable sampling possibility
- Dependence on plant operators for maintenance and inspection

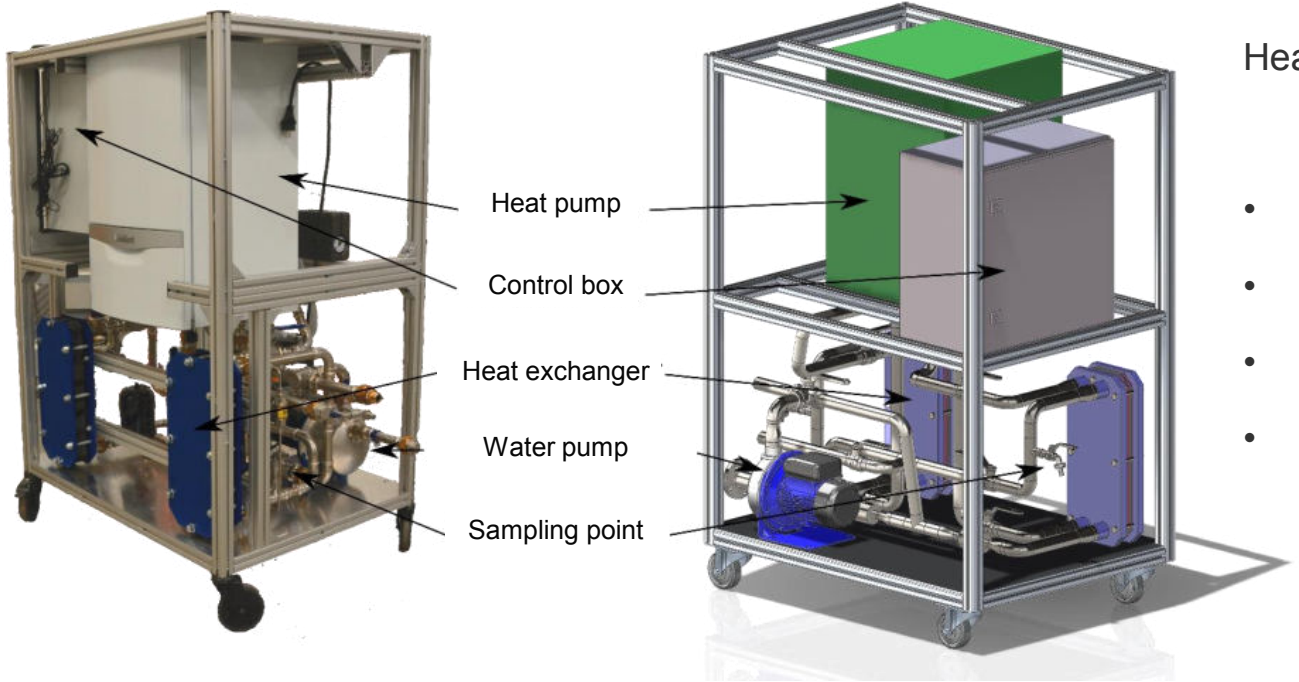
Freiberg Hospital

Exhibition mine
Ehrenfriedersdorf



Secondary School
Ehrenfriedersdorf

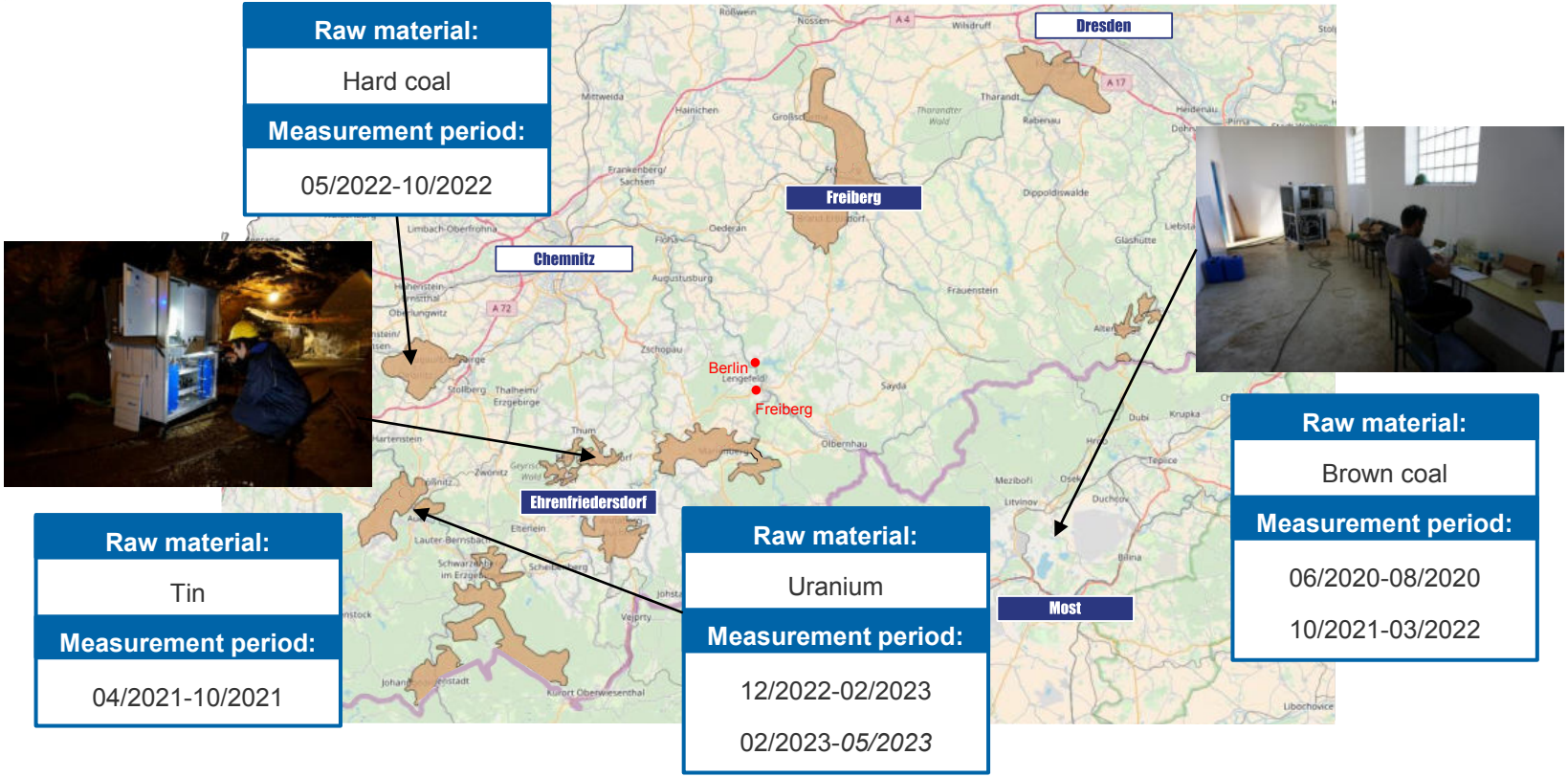
Mobile Mine Water Test Rig



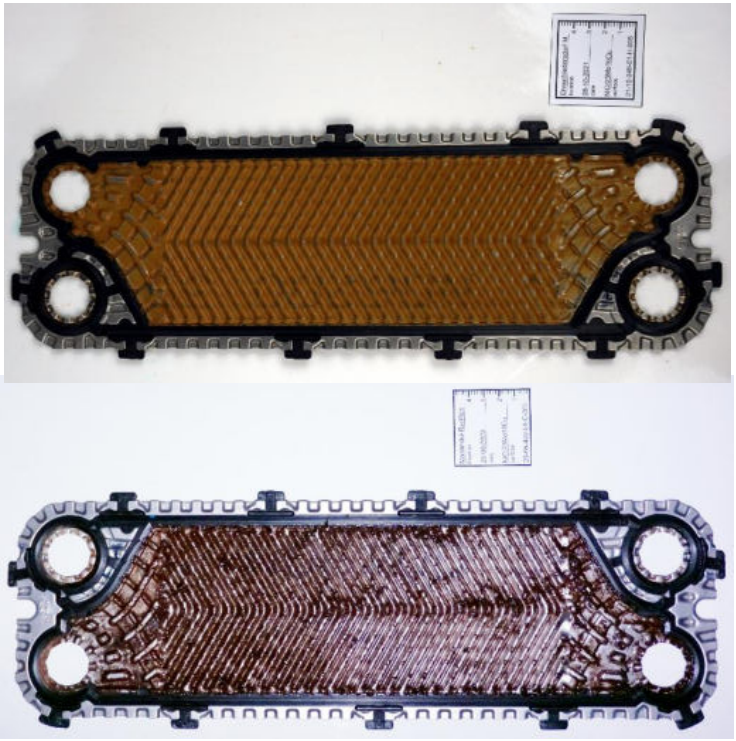
Heat pump VWS 36/4.1

- Up to 4 kW heating capacity
- -10 - 30 °C Source temperature
- 230 V supply voltage
- Compact design:
  80x100x150 cm

Heat pump test rig - Locations



Heat pump test rig - results



Measurable parameters

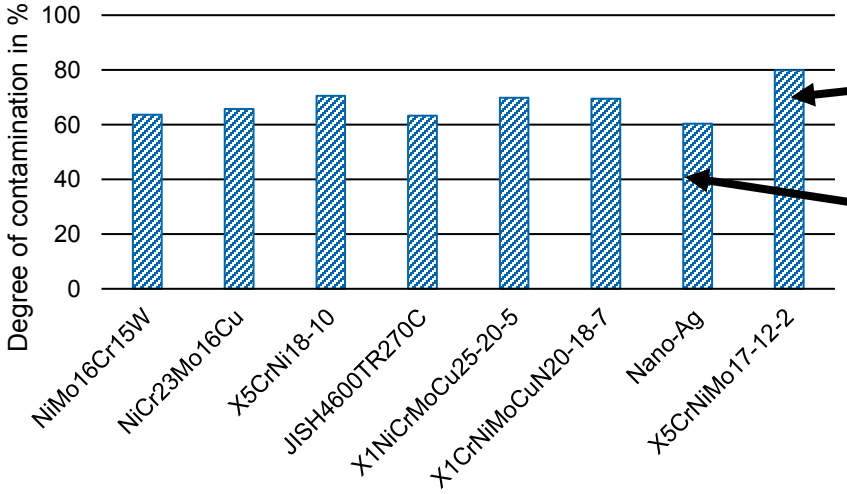
- Weight difference
- Degree of contamination
- Thickness of deposit?

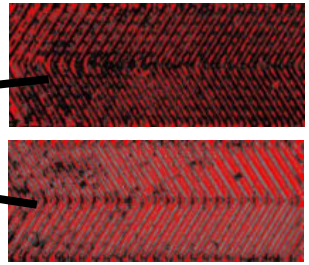
Calculated parameters

- Thick deposit?
- Transportable heat output
- Loss compared to new plate

Heat pump test rig – results (Most 1)

- 1st series of tests in summer 2020 at pumping station in Mariánské Radčice, MR1 (CZ)
- 8 different materials / coatings investigated





Contamination Level

1. Clean area = red
   Soiled area = black
2. Contermination degree=

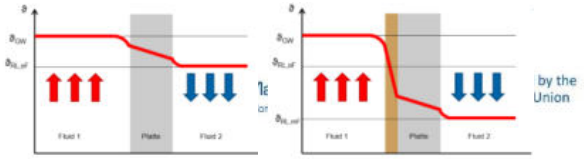
$$\frac{\text{Polluted area total}}{\text{Surface}}$$

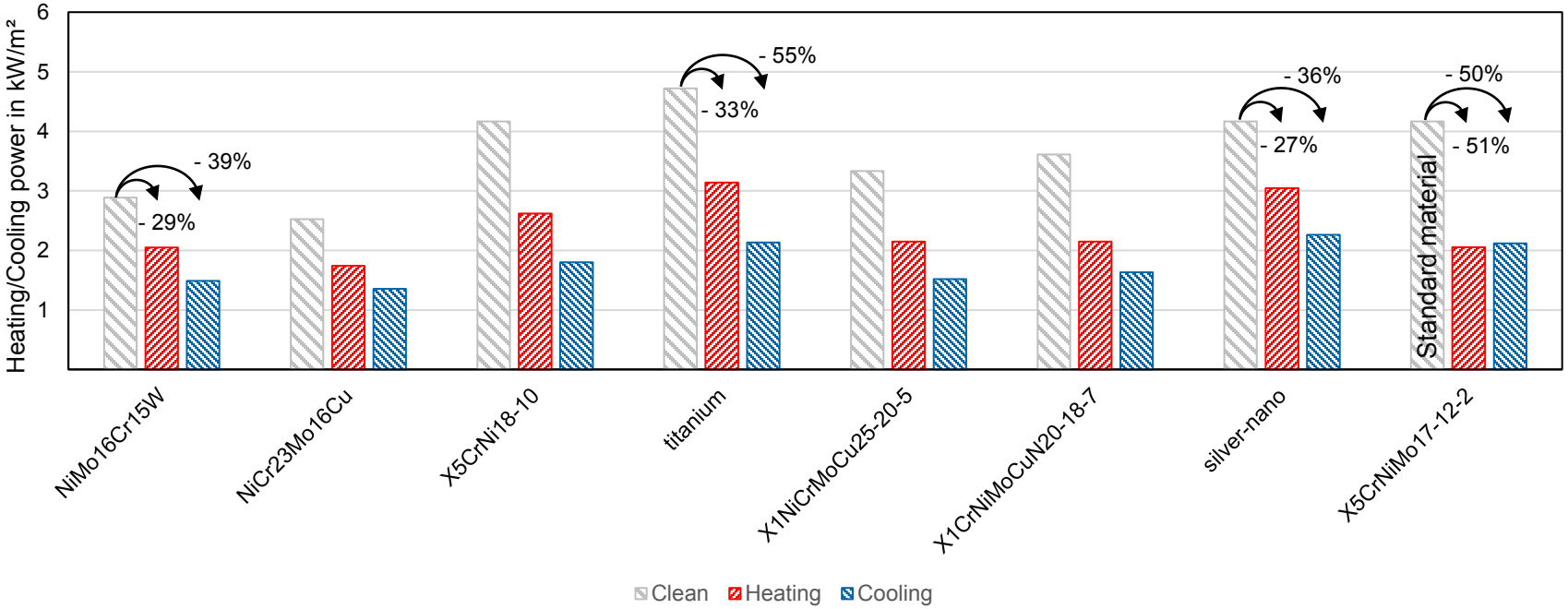
Material Number	Nomenclature
1.4401	X5CrNiMo17-12-2
2.4819	NiMo16Cr15W
2.4675	NiCr23Mo16Cu
1.4301	X5CrNi18-10
3.7025	JIS H4600 TR270C (Titan)
1.4539	X1NiCrMoCu25-20-5
1.4547	X1CrNiMoCuN20-18-7
1.4401	X5CrNiMo17-12-2 (Nano-Ag-Coating)

Heat pump test rig – results (Most 1)

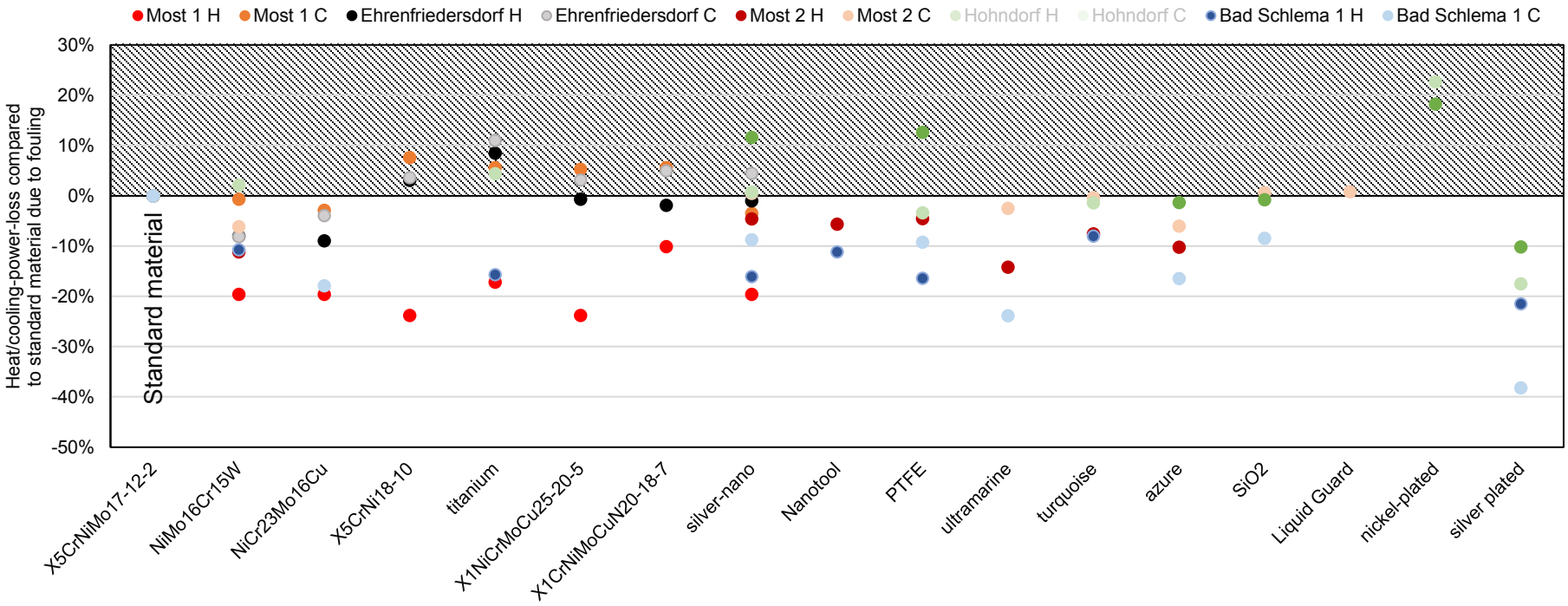
$$\dot{Q}_{HE} = k \cdot A \cdot \Delta t$$

$$\frac{1}{k} = \frac{s_{HE}}{\lambda_{HE} \cdot A_{HE}} + \frac{s_{Fo}}{\lambda_{Fo} \cdot A_{HE}}$$

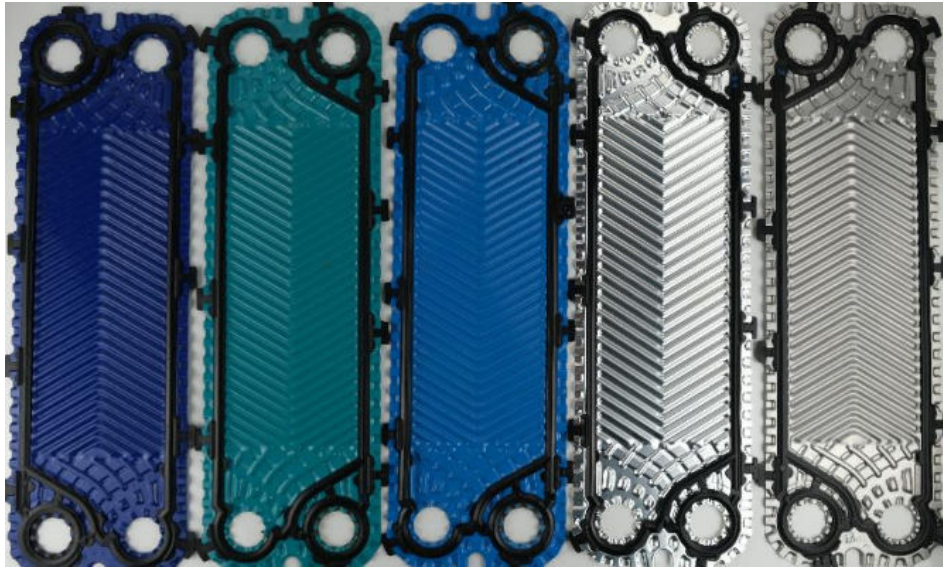




Heat pump test rig - results



Fouling reduction through optimised heat exchanger design



Linking site conditions and optimised heat exchanger

Other planned materials

- Chitosan-coating

Further planned locations

- Ostrava (Czech Republic)
- Bochum (Germany)
- Uranium mines (z.B. Königstein, Germany)
- Copper mines (z.B. Oulu, Finnland)

Quo vadis heat exchanger for mine water and more?

Characteristic mine water

⇩

Fouling will have a relevant influence?

⇩

What has influence?

⇩

How can this be counteracted?

⇩

Heat exchanger design

Project MineATES
2022-2025

TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG

DBI

Focus on materials/coatings

Project WINZER
2022-2025

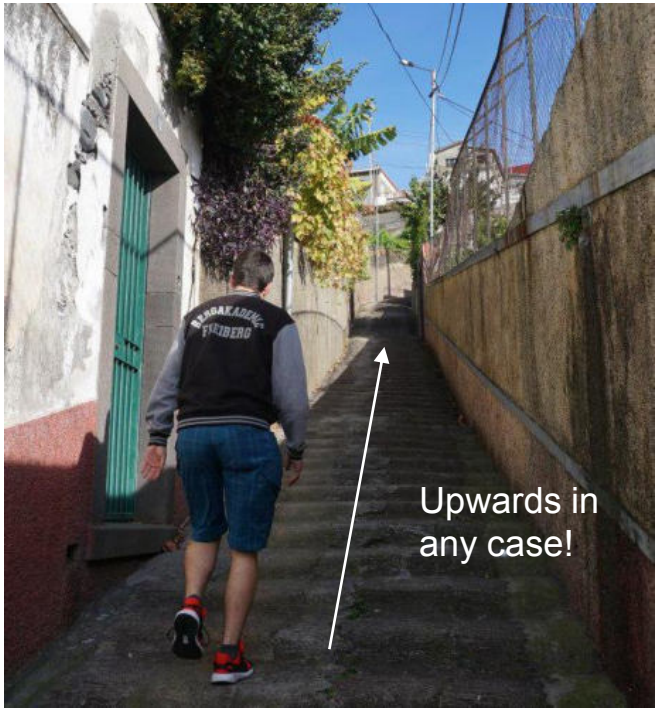
Fraunhofer IEG

TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG

RUB

delta h

Focus on operation/control



Thank you for your interest!

More informations:
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iwtt.tu-freiberg.de

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