Summary:

Start of cooperation with OSE Germany: 24.09.2018

Date of interim report / status: 06.12.2018

Active tasks:

Documentation: holistic documentation with all the basics and the detailed description of all components and backgrounds	**In progress**	Johannes
Sludge removal: concept for sludge removal and implementations in reaction chamber	**In progress**	Vaishnavi Victoria
Recycler: concept for recycler system and implementations in the process	**Starting**	Hans

Presentation of results in this interim report

Simulation (Master thesis): optimization of fluid-dynamic boundary layer for functionality and optimization of efficiency	**In progress**	Isabel

Separate presentation of results

1 Topic: Documentation

1.1 Description and aim

Holistic documentation with following topics:

- Why the Zinc Air Cell is important? Which potential?
- State of the art? General information to fuel cells?
- Which other research and development activities worldwide?
- Differentiation to other systems of ZAC?
- Description of the system and all components with the background ideas (focus on every part)?
- Which development states and which results?
- View to the future?

➔ Done in German – then translation

1.2 Actual results

- Documentation started in German
- Introduction chapter and descriptions done (still subject to corrections and additions)
- Papers found on other fuel cells
- Most parts of the groundwork information is already done in the Master Thesis – needs to be reviewed and added to the documentation

1.3 Next steps

- Step by step adding more information to the report
- Review the report
- Translation into English
- Question: Should the documentation contain a review of the progress or rather be a brochure for the final state of the project?

Next meeting: presentation of results “other development and research activities regarding Zinc Air Cells”

2 Topic: Sludge removal ZAC+

2.1 Done tasks

- ✓ Description and aim
- ✓ Requirements
- ✓ Creation of concepts for sludge removal with choose of 3 final conepts

2.2 Free space for deposition

As second topic, here are ideas for the deposition listed. An extensive rating is not planned. The choose for a concept is only to justify below. Next figure shows the space for deposition and the removal system.

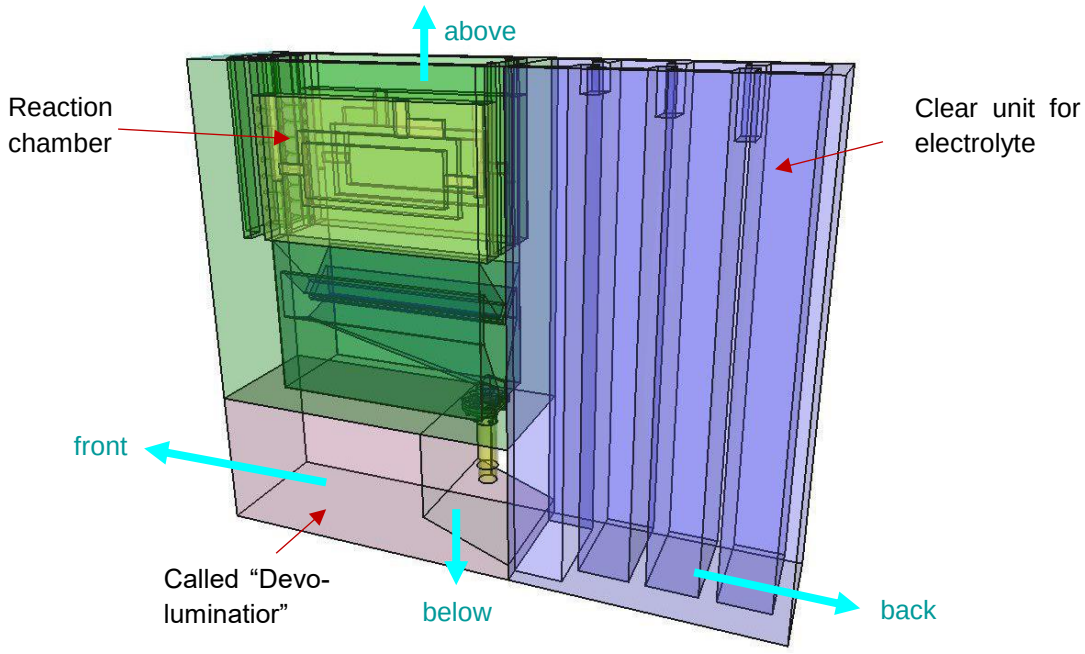


Figure 1: Free space for deposition and space for the removal system
Based on the sketch of the prototype of ZAC, one separate cell

Later multicell stacks are planned. The cells will be positioned next to each other on the long sides of the cells. Free space for adaptions are: front, back, below and above.
The devoluminator has the potential of free space. The collection of the sludge will be on de diagonally surface in the devoluminator. Ideas are f. e. a collection tank below or a kind of tube from the diagonally surface of the free space in the devoluminator to the front.

Remark: If an adaption of the deposition area is necessary the kind of deposition area must be designed after choosing a concept based on the final evaluation and can be a combination of the following ideas.

2.3 Concepts for sludge removal

3 final concepts

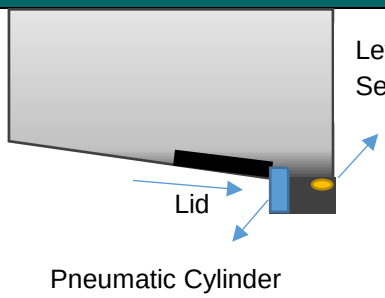
Shovel or lift	Collector box separated by fluid gate	Tube for suction
○ Simple way in the beginning ○ To do: ○ Concept for lid or cover ○ Concept for way out of the system ○ Search for materials and parts	○ Smart solution, but challenge of fluid gate ○ To do: ○ Concept for fluid gate ○ Concept for box (f. e. under ZAC) ○ Search for materials and parts	○ Other option ○ To do: ○ Concept for geometry at the inlet ○ Concept for way out of the system ○ Search for materials and parts

2.3.1 Showel or lift

Idea of the concept:

1) Collection the ZnO sludge in a box or collection system (in the following only called box) at the bottom
2) Cover up the box when full
3) Lift the box by shovel or lift system
4) Empty the box

Table 1: Creation of concepts for lid or cover
New concepts and search for established concepts with description, sketch or picture and remarks from team

ITEM	Idea / characteristic	Sketches / pictures / links	Remarks from team / discussion
1	A sliding box at the bottom of the chamber, where the ZnO sludge can be collected at the corner. Using a level sensor, a pneumatic cylinder can be actuated down and then the lid will cover the box. The sliding box can then be manually slided and the sludge can be emptied		○
			○

More ideas will follow

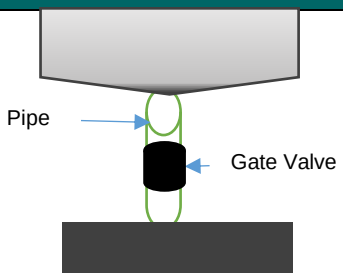
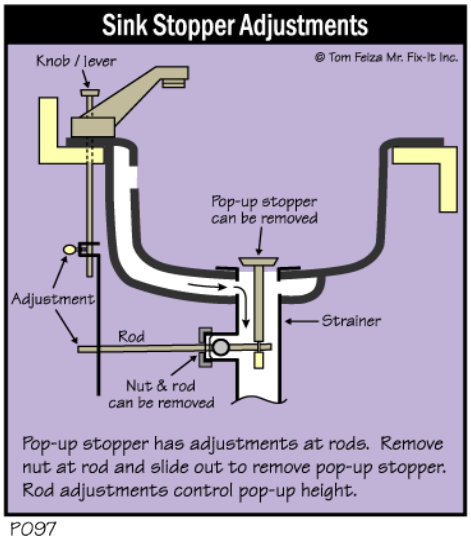
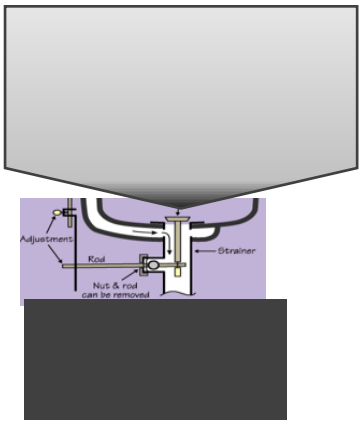
2.3.2 Collector pox separated by fluid gate

Idea of the concept:

1) Collection the ZnO sludge in a box or collection system (in the following only called box) out of the direct ZAC system (f. e. under the ZAC)
2) Close the fluid gate and seal up when full
3) Remove without system leakage of ZAC

4) Empty the box

Table 2: Creation of concepts for collector pox separated by fluid gate
New concepts and search for established concepts with description, sketch or picture and remarks from team

ITEM	Idea / characteristic	Sketches / pictures / links	Remarks from team / discussion
1	Gate Valve: The red knob can be manually rotated in one direction to stop the flow of the sludge and in opposite direction to allow the flow of sludge 		○
2	Like stopper in wash basins: A lever can be pressed which will not allow the sludge to pass through to the collection chamber. Once the lever is released, all of the sludge connected, drains into the collection chamber. 	 	○

More ideas will follow

2.3.3 Tube for suction

Idea of the concept:

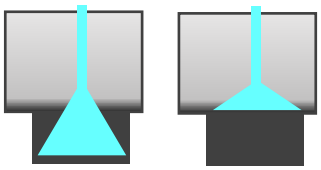
1) Collection the ZnO sludge in a collection area
2) Place the tube above the collection area
3) Start suction
4) Empty the collection system of the suction system

The need of a concept for geometry at the inlet:

By suction of the ZnO sludge there is the risk of turbulences in the suction area which will distribute the small particles in the area around instead of removal the most of collected sludge. The side effect is that too much electrolyte is sucked out.

Way out f. e. by manual or electrical pump → searching for concept ideas

Table 3: Creation of concepts for geometry at the inlet instead using only the end of a tube
New concepts and search for established concepts with description, sketch or picture and remarks from team

ITEM	Idea / characteristic	Sketches / pictures / links	Remarks from team / discussion
Size of the end of a tube for suction			
a	Geometry in the whole smaller than collection area → move through the collection area)		
b	Geometry covers up the whole collection area: ▪ Position into the collection area or ▪ Position above the collection area		
Geometry of the end of a tube for suction			
1	1) Longer and wider area of tube at the end, f. e. cylinder or cone or other geometry customized for collection area (when collection area rectangular: wider area of tube rectangular too) 2) Two possibilities see size concepts (a) and (b) above 3) No use of free space at the end of geometry	 	○
2	1) Characteristics 1 and 2 see ITEM 1 2) Use of free space at the end of geometry, f. e. rectangular notches, see pictures	 	

3	1) Characteristics 1 and 2 see ITEM 1 2) Use of a kind of brushes in edge area		

2.4 Next steps

- Finish concept creation
- Based on the applicable concepts: technical-economic evaluation according to VDI 2225 (sheet 3) with strengths-weaknesses-diagram is in progress.
- Construction of the chosen concept

3 Topic: Recycler

3.1 Description and aim

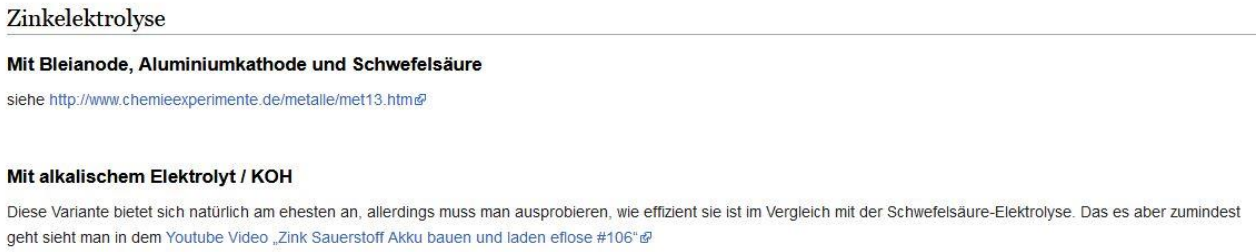
The sludge from the chemical reaction in the Zink Air Cell should be recycled. The Recycler works independently and is separately located from the ZAC+. For sustainability, ZnO should be transfered back to Zn in order to press new plates of Zn for the ZAC+ to generate electricity. Then the circle is closed.

First the functions of the recycler will be divided into part-functions. The morph-box is a suitable tool to find possible concepts by combining alternatives for each part-function. The morph-box can be found in the file: Morph_Box_Recycler_REVONEER.xlsx
At the moment there is still just one alternative. So far no combinations.

Then, if there are enough alternatives, some concepts can be extracted. These concepts can be assessed and compared in technical and economical aspects with the file: Validationmatrix_Recycler_REVONEER.xlsx

The best concept can be detailed with CAD.

3.2 Current state of the art



Zinkelektrolyse

Mit Bleianode, Aluminiumkathode und Schwefelsäure

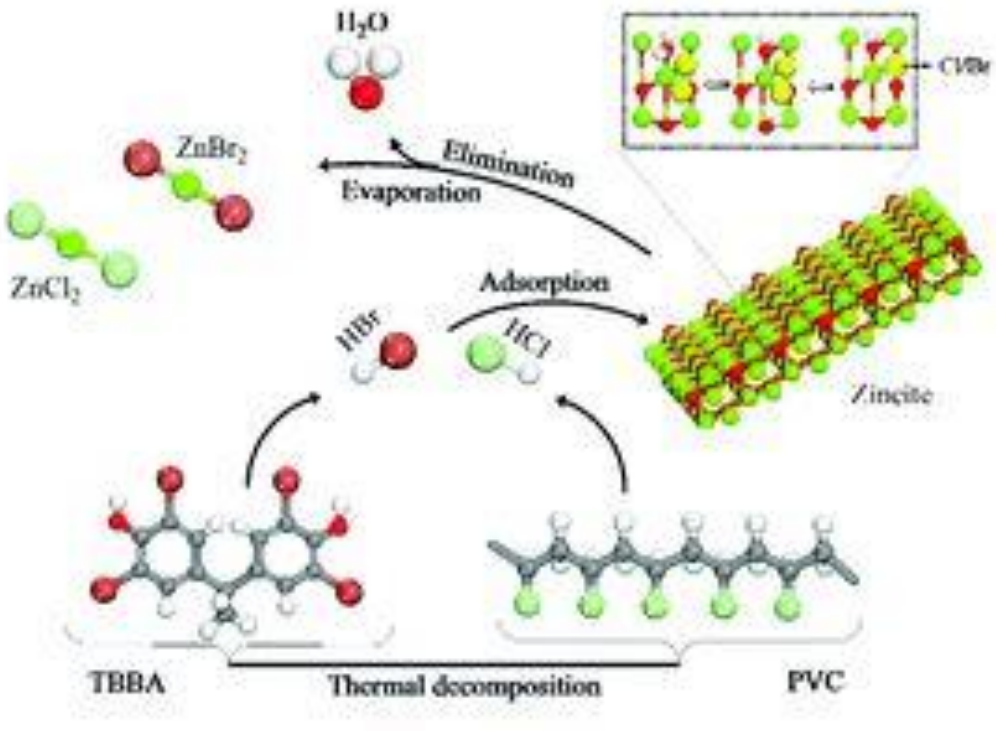
siehe http://www.chemieexperimente.de/metalle/met13.htm

Mit alkalischem Elektrolyt / KOH

Diese Variante bietet sich natürlich am ehesten an, allerdings muss man ausprobieren, wie effizient sie ist im Vergleich mit der Schwefelsäure-Elektrolyse. Das es aber zumindest geht sieht man in dem Youtube Video „Zink Sauerstoff Akku bauen und laden eflose #106"

https://wiki.opensourceecology.de/ZnO-Recycler

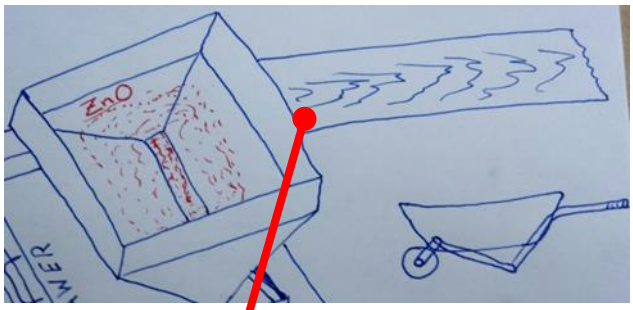
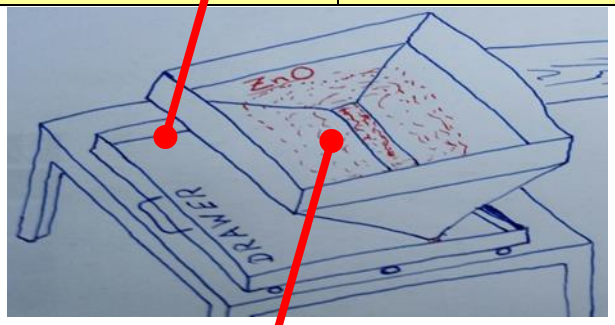
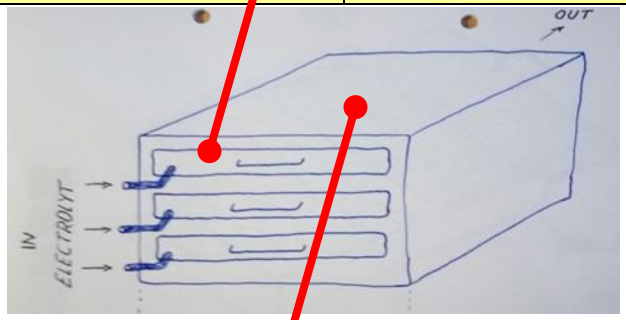
Hydrogen halides (HCl/HBr) represent major halogen fragments from the thermal decomposition of halogen laden materials, most notably PVC and brominated flame retardants (BFRs). Co-pyrolysis of halogen-containing solid waste with metal oxides is currently deployed as a mainstream strategy to treat halogen content as well as to recycle the valuable metallic fraction embedded in electric arc furnace dust (EAFD) and e-waste. However, designing an industrial-scale recycling facility necessitates accurate knowledge on mechanistic and thermo-kinetic parameters dictating the interaction between metal oxides and hydrogen halides. In this contribution, we investigate chemical interplay between HCl/HBr and zincite surfaces as a representative model for structures of zinc oxides in EAFD by using different sets of functionals, unit cell size and energy cut-off. In the first elementary step, dissociative adsorption of the HCl/HBr molecules affords oxyhalide structures (Cl/Br–Zn, H–O) *via* modest activation barriers. Conversion of the oxyhalide structure into zinc halides occurs through two subsequent steps, further dissociative adsorption of HCl/Br over the same surface Zn atom as well as the release of a H_2O molecule. Evaporation (or desorption of zinc halide molecules) signifies a bottleneck for the overall halogenation of ZnO. Our simplified kinetic model on the HCl + ZnO system concurs very well with experimentally reported TGA weight loss profiles on two grounds: accumulation of oxyhalides until ~700 K and desorption of $ZnCl_2$ at higher temperatures. The thermo-kinetic and mechanistic aspects reported herein could be useful in the pursuit of a design of a large-scale catalytic upgrading unit that operates to extract valuable zinc loads from EAFD.

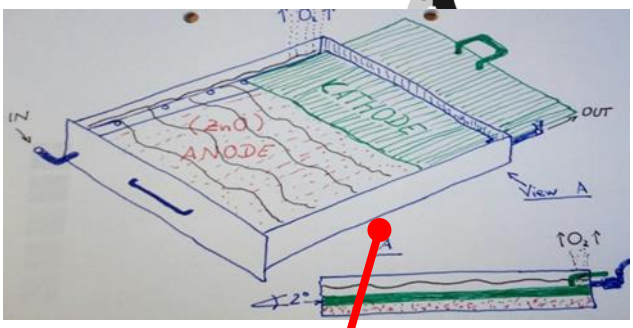
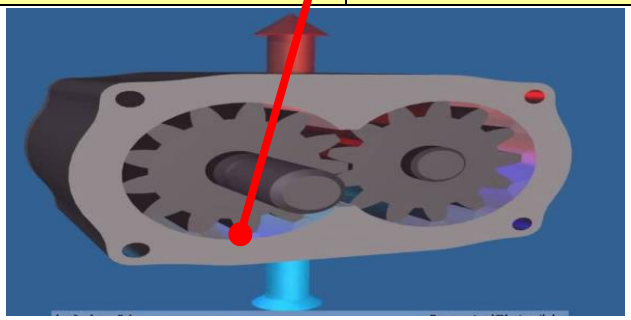


https://pubs.rsc.org/en/content/articlelanding/2018/cp/c7cp06159e#!divAbstract

3.3 Actual results

1) Research: concepts for recycling ZnO
   Morph box

alternatives / part-funktions	alternative 1	
memo		
	Nr.: 1.1	Na.:
Raw material storage		
memo		
	TW:	EW:
	Nr.: 2.1	Na.:
Apply raw material in reaction chamber		
memo		
	TW:	EW:
	Nr.: 3.1	Na.:
reaction		
memo		
	TW:	EW:
	Nr.: 4.1	Na.:

Transfer ZnO back to Zn		
memo		
	TW:	EW:
	Nr.: 5.1	Na.:
pumping-system		
for the flow of electrolyt and to get rid of O_2		
	TW:	EW:
	Nr.: 6.1	Na.:
Electricity genera-ting		
to keep the process running		
	TW:	EW:
	Nr.: 7.1	Na.:

➔ More alternatives will follow