FAMDT - A new Approach for flexible AMD Treatment

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Abstract

The treatment of acid mining drainage (AMD) affected surface water is a worldwide challenge. Corresponding to this, the aquatic ecosystems in Lusatia has suffered from high loads of iron hydroxide sludge, which can be traced back to the inflow of ferrous groundwater into the surface waters. Due to the centralized location of the existing state of the art water treatment plants, these cannot contribute adequately to solve the widely spread problem of the region. Therefore, decentralized solutions at strategically important strain hot spots are required. Against this background flexible acid mining drainage treatment (FAMDT) was developed, which offers a new approach in technical AMD treatment. FAMDT forms a kind of modular construction kit for the building of treatment plants. Its modular character gives a number of benefits. Differently equipped transport containers encase the various process technologies. This allows easy adjustment to the specific site conditions or in case of temporarily changing boundary conditions. Thus, FAMDT is suitable for a markedly wide range of construction sites. The high flexibility allows a manifold reuse of the modular components. For the treatment of ferrous waters with FAMDT three construction sites have been projected in Lusatia already. The first realized FAMDT plant will be „Burgneudorf". Its commissioning is scheduled for the year 2017.

Key words: FAMD, iron hydroxide, sludge, modular, water treatment

Introduction

The treatment of AMD affected waters is a worldwide challenge. Especially mining regions require appropriate solutions to solve the environmental problems caused by AMD (Kurtz et al 2009). Lusatia, located in the east of Germany, is one of the world's greatest lignite mining region. Decades of open cast mining have substantially affected the hydrogeology of the catchment area. Here, especially the inflow of ferrous groundwater into the water courses has become an obvious issue.

Starting just a few years ago, the aquatic ecosystems have suffered from high loads of iron hydroxide sludge. Although iron hydroxide shows no acute toxicity, it harms the environment by clogging the sediment interspace and sticking the gills of fishes. To ensure the hydraulic discharge, the river beds have to be excavated periodically and the sludge needs to be deposited. This procedure is incurring high river maintenance costs.

According to the state of the art, these loaded waters need to be collected and transferred through pipes to central water treatment plants. The treatment capacity of the central water treatment plants is determined by the quantity and quality of the incoming water. It is strictly fixed due to the physical structure of the plants (Bilek et al 2013). In case of later adjustments high expenditures incur.

The construction of central plants for the treatment of AMD loaded waters is determined by serious cuts to land demand, ownership structure and infrastructure. Thus, this treatment option induces high expenditures of costs and time.

The waters, that have to be treated, are characterized by high spatial and temporal variability in regard to their quantity and quality. To achieve a significant reduction of the iron burden, new technologies are required. For this purpose the LUG Engineering GmbH has developed FAMDT. FAMDT is following a new approach in the design of AMD treatment plants.

FAMDT features the following benefits:

- High application flexibility

- Wide range of treatment capacity
- Easy to adapt to changing boundary conditions
- Compact building space
- Short time demand for building, mounting and dismounting
- Reusability of the modular components


Figure 1&2 *Ochre color of AMD affected streams in Lusatia, pictures by LUG.*

State of the Art

State of the art water treatment plants in the region are large and stationary technical objects. Those plants require high efforts for planning, permit procedure and building. Furthermore the construction design defines a treatment capacity corresponding with only a relatively small margin of the influent flows. In case of changing influent flows high expenditures are needed for the adaption of the plants.


Figure 3&4 *Central water treatment plants in Lusatia „Rainitza“ and „Am Wolkenberg“, pictures by Peter Radke LMBV and Vattenfall EM.*

Likewise, water treatment systems based on standardized containers are state of the art. They are characterized by the installation of all essential process steps within a single container. Due to the fixed dimensions of the casing this induces unfavorable limitations of the treatment capacity.

To improve the capacity of those systems a number of containers have to be operated parallel. Therefore the number of containers is necessarily determined by the limiting process step. This means, that most of the installed process steps are overdimensioned, so that the whole plant threatens to run inefficient.

FAMDT

FAMDT is a further development of the widely used stationary treatment plants as well as of container based plants. It uses the proven and tested process technologies of aeration, flocculation and sedimentation. These process technologies are commonly used in plants for the treatment of AMD affected waters - but FAMDT puts them together in a new approach.

Every particular process technology performs in different equipped transport containers. This forms a kind of modular construction kit characterized by a maximum of flexibility. Depending on the specific requirements of a construction site or in case of changing influent flows it offers the opportunity to add, to remove or to combine modular components. This ensures an easy adaption on changing boundary conditions. So FAMDT is suitable for a markedly wide range of construction sites. The high flexibility allows the manifold reuse of the modular components on different sites.

The high grade of prefabrication ensures short time demands for mounting, dismounting and modification. This helps to save efforts in time and costs. FAMDT is applied for patent under the registration number DE 10 2015 106 823.0.

A Construction Kit of Modular Components

1 Reaction container

The reaction container encases a number of aerators following the principle of airlift pumps or ejectors. The arrangement of the aerators allows carrying out several process technologies simultaneously:

- Input of fine air bubbles for the complete oxidation of the solute iron
- Mixing of flocking agent (e.g. lime hydrate) to adjust an optimal pH value for the flocculation
- Creating turbulences in order to avoid undesirable depositions

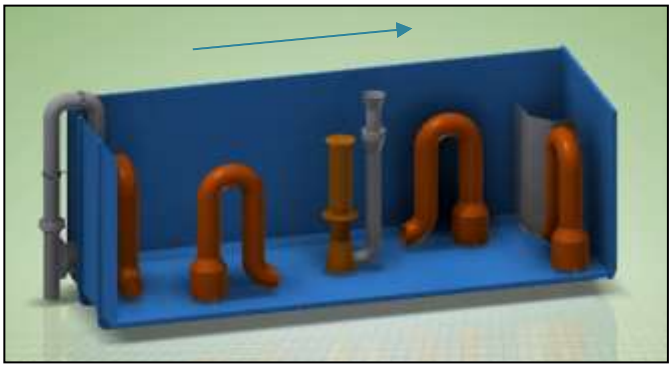

Figure 5 *Reaction container with airlift-aerators.*

The aerators are specially designed for operating within the reaction basin. Besides their function as aerators they allow to delete a disperser that is commonly used as an addition unit for the flocking agent. Furthermore they substitute stirring units. This multifunction offers some benefits:

- Highly efficient oxygen input
- Absence of mechanical construction elements
- Minimized wearing elements
- High operational safety

2 Flocculation container

In the first sector of the flocculation container the addition and mixing in of flocculation aid (e.g. polymer) is carried out. A highspeed vertical stirring device ensures over-all mixing.

The second sector is constructed for the ripening of the iron hydroxide flocks. For this a slow spinning horizontal paddle supports the agglomeration of the flocks. Furthermore this paddle lifts the flocks nondestructively into the transfer line to the subsequent sedimentation container.

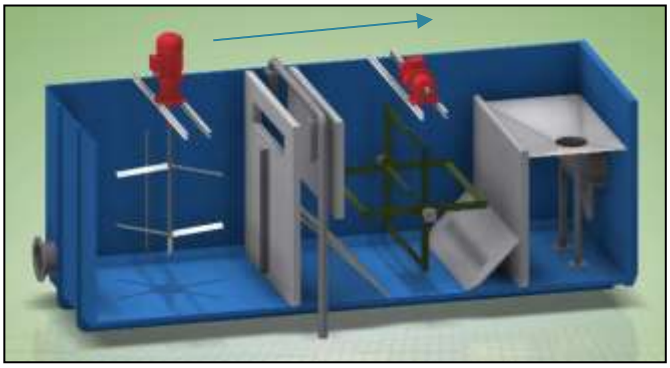

Figure 6 *Flocculation container with basins for mixing and for flock ripening.*

3 Sedimentation container

The sedimentation container is arranged with baffle plates for high efficient separation of the beforehand generated iron hydroxide flocks.

In the upper container the clear water discharges through a dented sill. In the lower part the sludge is taken off by pumps through a pipe system.

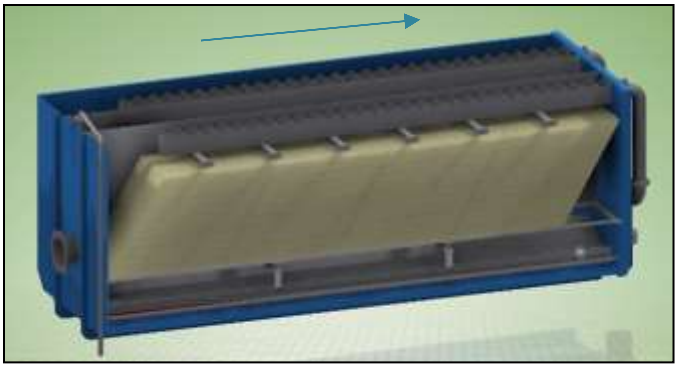

Figure 7 *Sedimentation container with baffle plates.*

Sludge Recirculation

A part of the extracted sludge from the sedimentation container recirculates back to the flocculation container. There it works as an initial nucleus and supports the formation of preferably large flocks. This helps to save flocculent aid, enhances the degree of efficiency and increases the dry substance content of the finally separated sludge.

Sludge Treatment

The treatment of the sludge takes place by thickening and if necessary by additional pressing. This improves the sludge quality with view to transportation and to dumping. Therewith the options for feedstock utilization of the high purity iron sludge improve significantly.

Flexibility

The intended use of FAMDT is the treatment of AMD affected waters. For this its strong point is high flexibility. The approach allows treating influent streams with a wide range of iron concentrations between 50 and 1,500 mg L^{-1}. The adaption to a volume flow of 5 to 500 L sec^{-1} is easy to be done and it can deal with oxygen free groundwater as well as with fully oxidized surface waters with oxygen demands from 0 to 230 mg L^{-1}.

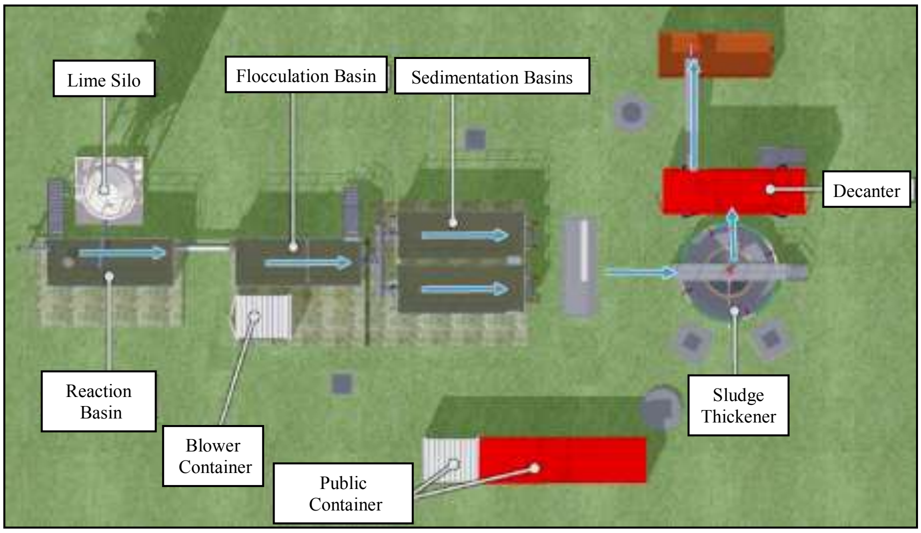

Figure 7 *Floor plan for a plant with a treatment capacity of 25 L sec^{-1} respectively 90 m^3 h^{-1}.*

Examples

For the treatment of ferrous waters with FAMDT three construction sites have been projected already. The waters to be treated vary especially with view to the iron concentrations.

First realized FAMDT plant will be „Burgneudorf". It is going to be put to operation in the year 2017. According to the existing permission, this plant has to show a cleaning capacity of not less than 90 % of the average incoming iron (Kochan & Bilek 2016).

Table 1 *Main parameters of the influent flows of three already projected FAMDT plants in Lusatia.*

Site		Burgneudorf	Neustadt	Ruhlmühle
Influent Flow		Well Bar	Trench	Creek
pH Value		5.3	3.5	4.8
El. Conductivity	µS cm^{-1}	600 - 800	1800	1300
Fe total	mg L^{-1}	60 - 120	365	208
Flow Rate	L sec^{-1}	100	25 - 50	100

Acknowledgements

Thanks to the Lusatian and Middle German Mining Management (LMBV mbH) for giving us the opportunity to design a new approach in the treatment of AMD.

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