Water drainage in the German coal mining after the close-down in 2018

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Abstract

As from 2018, coal mining in the Federal Republic of Germany will be terminated. The last mine will stop coal extraction. Nevertheless, for the operators an important task remains:

Rain water still continues to accumulate in the depths of the mines. This may enrich with minerals and reach a high salinity. In order to avoid contaminating the groundwater, this mine water needs to be pumped above ground.

In conventional water drainage, this task is done by underground dry-installed pumps. Which means ventilation, transport, and personnel must be maintained and the annual operating costs are quite substantial.

A new concept involves replacing the underground dry-installed pumps with floodable submersible pumps. The mine water can be allowed to rise to a level that would still be below the groundwater horizons so that mixing would definitely not be possible.

This concept's benefits are obvious. Ventilation and transport are no longer required when using submersible pumps. Along with the now lowered power consumption of the pumping system, this leads to a significant reduction of the total operating costs.

For its technical implementation, cladding tubes, into which the submersible pumps can be lowered, will be introduced into existing mine shafts. In the former Walsum mine, for instance, two double-suction, and thus axial thrust free, submersible motor pumps are installed to pump the highly saline mine water at a depth of 800m.

Because changing the pump could be extremely complex and expensive because of the installation depth, highest operational safety, a long service life and ease of use – even under the harshest conditions – must be imperative.

Key words: Water management in disused mines, mine water drainage, water management, ground water level in mining

Introduction

Germany belongs to the classical European Mining Countries. Mining in Germany started already in the 12th and 13th century. With the beginning of the industrialization in the mid of the 19th century the stone coal became a very important resource for the production of the necessary energy. For this reason more and more mines were installed to meet the requirements.

Based on this the mines had to go deeper and deeper to reach the seams with the rich deposit of coal. This also was the time when pumping in the mining sector got more and more important.

Today in Germany there is a huge amount of abandoned mines mainly in the Ruhr and Saar area. These mines are partly used to handle the water balance for the still active mines. This is enabled because of the connections by the drifts in-between the different mines.

Actually around 13 mine drainage stations in the Ruhr area are active. After 2018 when the last active coal mine will be closed some of these stations still need to be in operation due to the fact that the mine water should not reach the ground water level because the ground water is used for the production of drinking water.

The mining area around the River Saar shows more or less similar picture of the situation. There actually 5 pumping stations are active. One of the differences there is that an electricity supplier is using submersible pumps to keep the water level in a specific depth for using the natural gas in place for power and heat production.

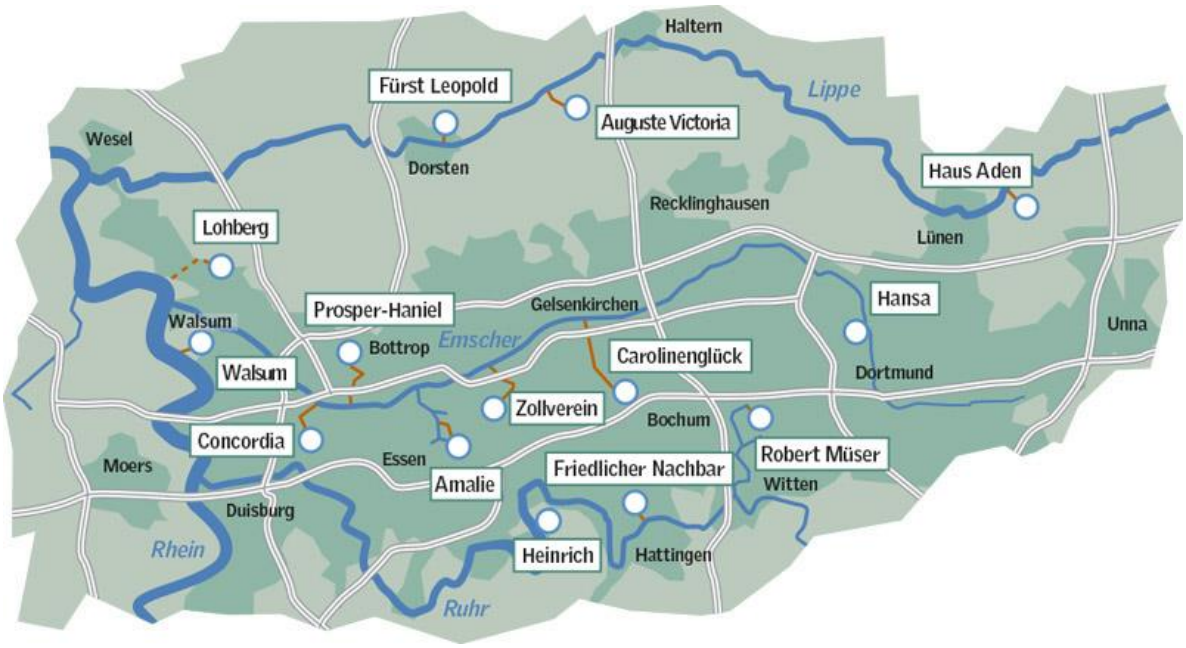

Figure 1. *Map of the actually active mine drainage stations in the Ruhr Area.*

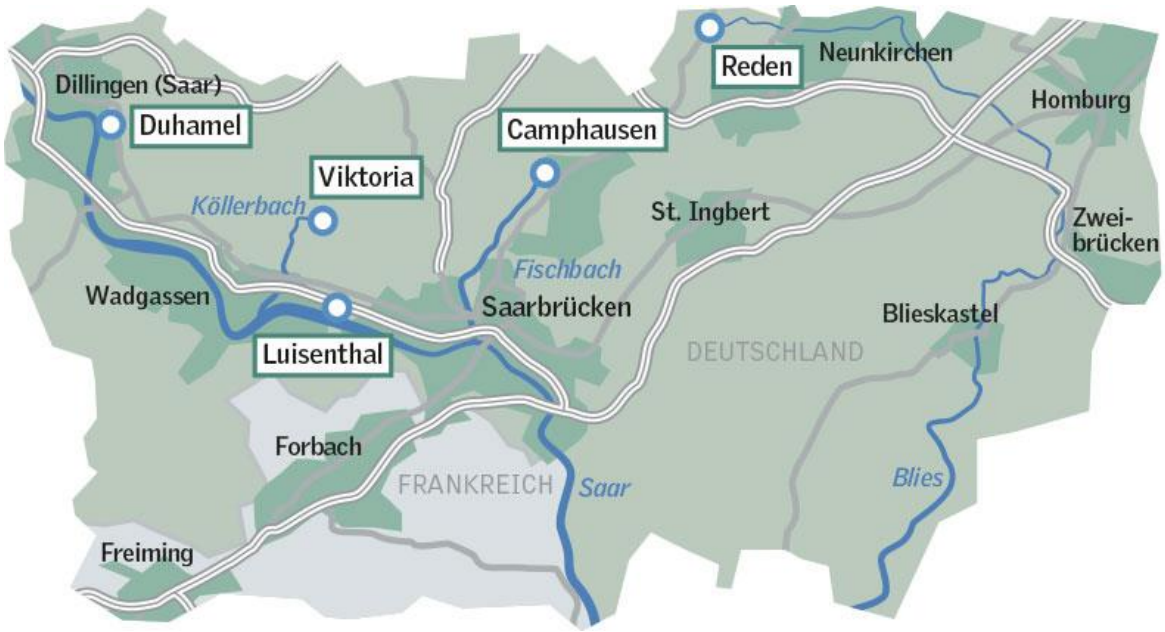

Figure 2. *Map of the actually active mine drainage stations in the Saar Area*

Recommended Measurements

Pumping out underground mine water to prevent reaching the environmentally critical level, controlling the ingress of water into mine shafts and to find a long term solution that allows keeping the costs in the ballpark.

Challenge – pump solution

A pumping solution does not only belong to the pump and motor unit itself. In fact it is also very important to develop and design pumping stations that can be operated from the surface level. The installation of the necessary equipment should be possible from the surface. This allows the company which is responsible for the water handling to decommission the conveying systems and also the ventilation systems are not necessary anymore.

From this point of view the Experts in the RAG company decided to close the vertical mine shafts with concrete and to implement so called cladding tubes through which the pumps and the necessary sensor (for example to measure the water levels) can be installed. Also it is important that the gas can be dealt which is coming out of the mines.

Solution

The responsible technical experts looked for a long term draining solution to face the problem. Related to the pumps and motors two main challenges had to be matched in this issue.

The materials which are in contact with the mine water – metals and elastomers – have to resist the medium for a long time. Therefore, the best material to face the medium and the mechanical properties had to be chosen. Multiple material options were taken into account and qualifying tests were necessary. Therefore, the renowned institute FEM (Forschungsinstitut für Edelmetalle) rebuilt artificial mine water based on the chemical analysis out of the mine and put test materials for a term of three months into this medium. Additionally by using higher temperatures, the reaction time gets faster and a longer period of time could be simulated to get findings of the long-term behavior of the materials.

As a result of these tests, the material selection was refined. Out of the remaining materials the materials with the best mechanical properties for the parts of the pump unit were chosen to enable a compact design of the pump unit.

The used duplex steels combine the features of stainless chromium steels (ferritic or martensitic) and stainless chromium-nickel steels (austenitic). They have those rust and acid resistant properties which are necessary to resist the medium influences. Further they have the required mechanical properties.

Nevertheless, the water analysis may always only be counted as a snapshot of the current situation. As caused by environmental influences the water composition may change. But due to the selected high value materials absolute safety and resistance in operation can be expected.

As a further step and in order to protect the motor of the pump unit against the entrance of the contaminated medium it has been designed encapsulated. That means that the motor is packed into an additional casing to protect the motor materials against the acid medium. The motor itself is filled with drinking water.

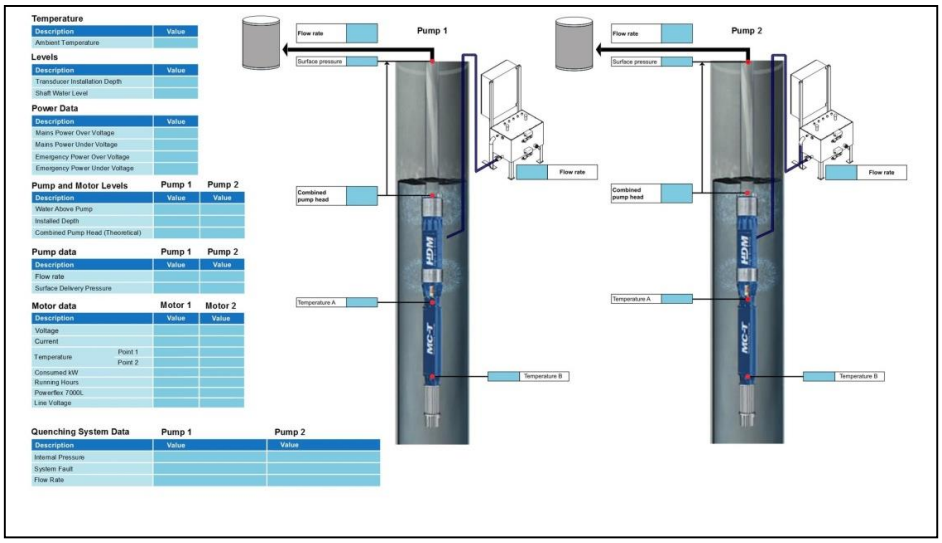

Figure 3. *Example for a monitoring scheme*

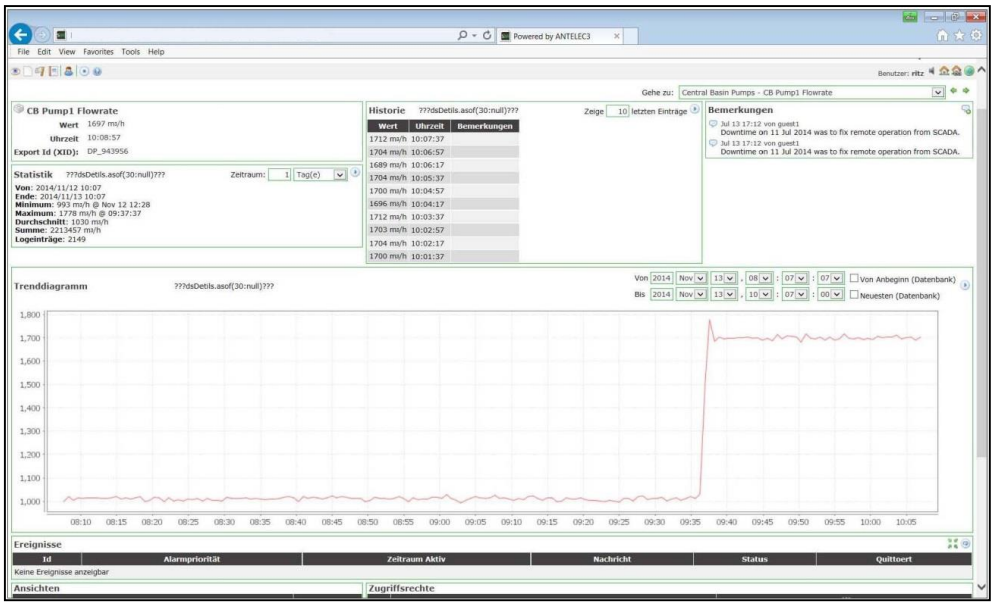

Figure 4. *Example for a remote monitoring display*

The mechanical seal is tailored to the requirements of that special application. The sliding surfaces of the mechanical seal are specialized and all components are also matched up to the medium. A special construction of the mechanical seal guarantees absolute reliability and best operational characteristics. It is also charged with the inner pressure from a quench.

Weather conditions like rain influence the medium level as experienced with ground water all over the world. The changing water level requires a specific pump hydraulic to drain the water. Additionally, the level gets more or less steadily lower because of the dewatering. The more medium is pumped the lower is the level of the contaminated mine water. So the pump has to have a widely spread operation range until the calculated level is reached and to be kept stable.

The pump is submerged up to 70 m below the level of the mine water. When the level has reached the next lower marking, the pipe is enlarged with another pipe part. For the planning team it was important that the column pipe can be enlarged easily and without loss of time. Therefore, quick snaps are used. Additionally to the quick assembly they score with their compact design, low weight and less effort in comparison to conventional screw connections.

With every step down, the pump has to manage a higher pumping head. This has also been considered in pump selection. Furthermore, the pump is equipped with a cooling shroud to guarantee the necessary cooling flow. In future planning it is thought about operating the pumps within the cladding tubes. This way the cooling shroud is not needed anymore.

The used double-suction design of the pumps reduces any axial thrust nearly to zero. As a result, the pumps are extremely persistent and nearly maintenance free. Some pumps of that type had run in best performance up to 25 years without the need of maintenance. But considering the critical medium the terms of maintenance are shorter in this case. In case of maintenance the use of the quick snaps show their advantages. The pumps can be pulled out, maintained and re-installed in a comparably short time.

All pump units are especially designed for each location. This ensures an ideal use of electrical power and prevents the environment as much as anyhow possible.

Also belonging to the power absorbed by the motors the voltage of those is adapted to the electrical equipment, so that this can be sourced for esay handling and as cost effective as anyhow possible.

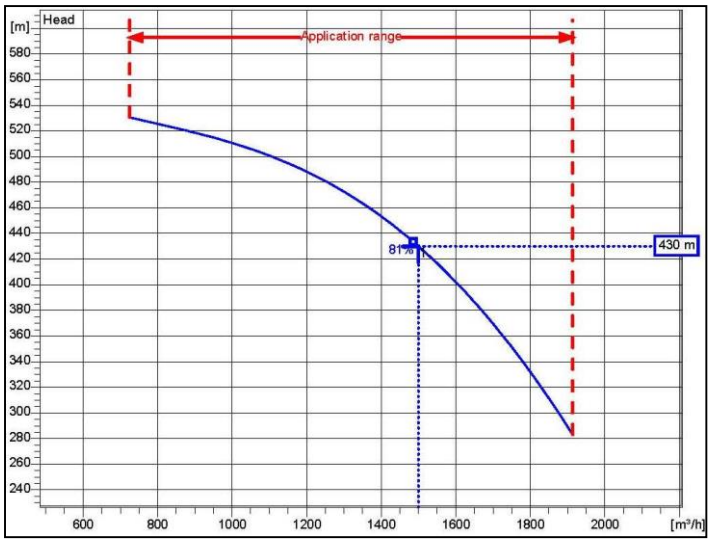

Figure 5. *Example of a performance curve of a pump*

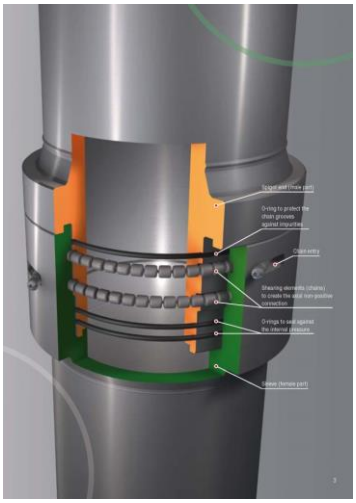

Figure 6. *Quick snap connection (from Carl Hamm Pipesystems; ZSM-Connection Brochure English; issue 07/13)*

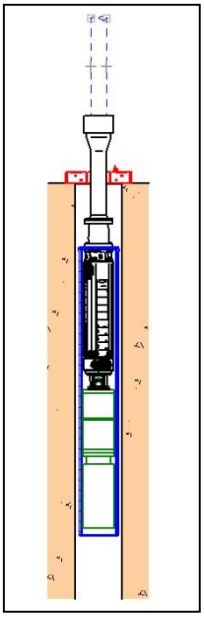

Figure 7*. Assembly scheme*

Figure 8. *Assembly*

Conclusion – Ecological Aspect

The mine water is being transported to the surface and onwards into an adjacent treatment plant. There, through the addition of lime, the pH value is raised, the acid is neutralised and the dissolved metals in the water are (co-)precipitated as hydroxides.

The South African authorities are planning a total of three pumping stations, which will each be developed at the mines' disused extraction shafts. In addition to the Central Basin in Johannesburg's city centre, pumping plants for the Eastern Basin and the Western Basin are currently in progress. The long term measurement is to force the water level in the flooded mines back from its current level of approx. 200 metres to a depth of 1000 metres and to keep it there, to then be able to begin mining gold and gold ore in the drained upper layers of the mines once again.

References

Carl Hamm Pipesystems; ZSM-Connection Brochure English; issue 07/13http://superiormining.com;Wikipedia.