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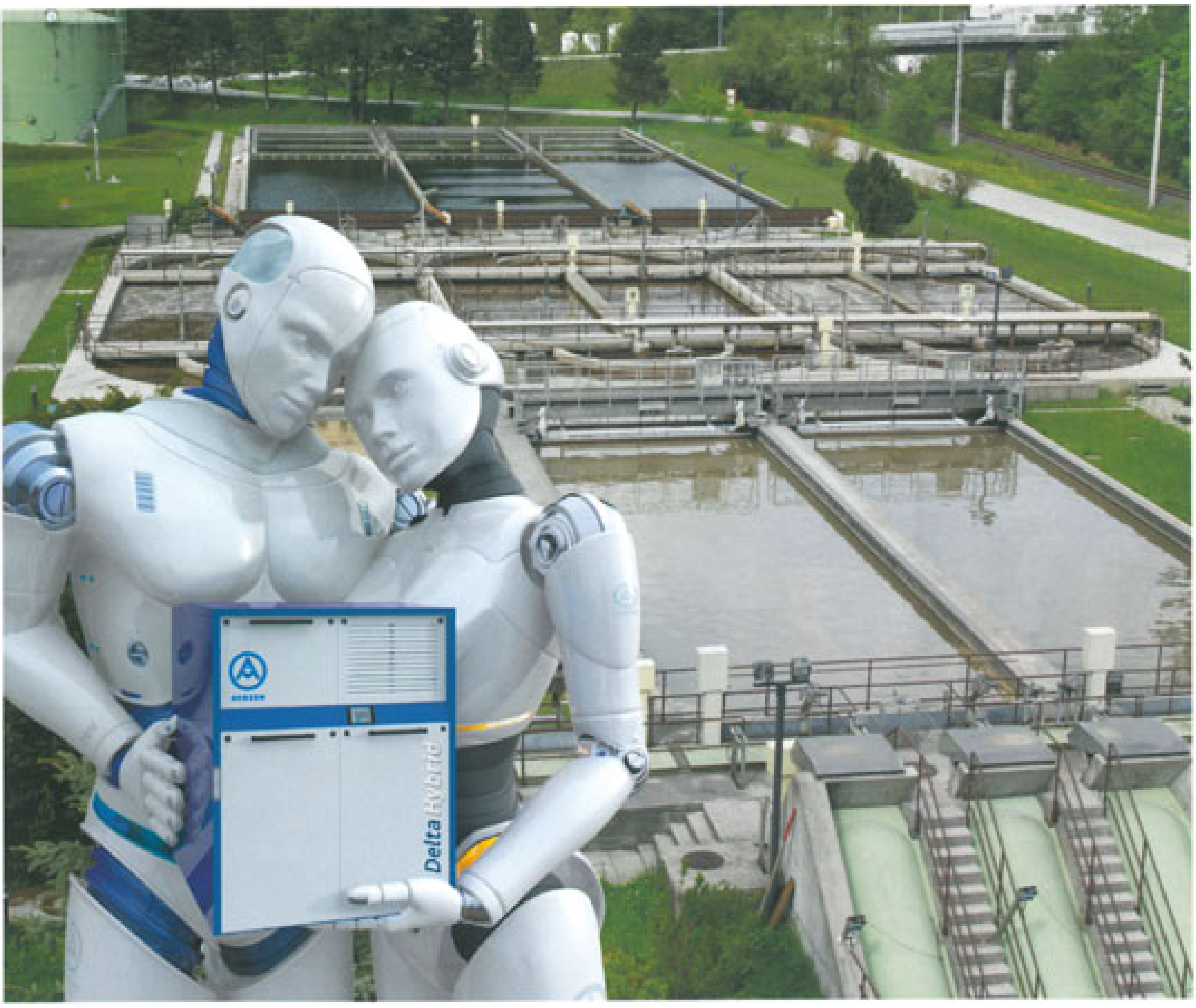

Technology for environment:

Practical concept for the wastewater treatment

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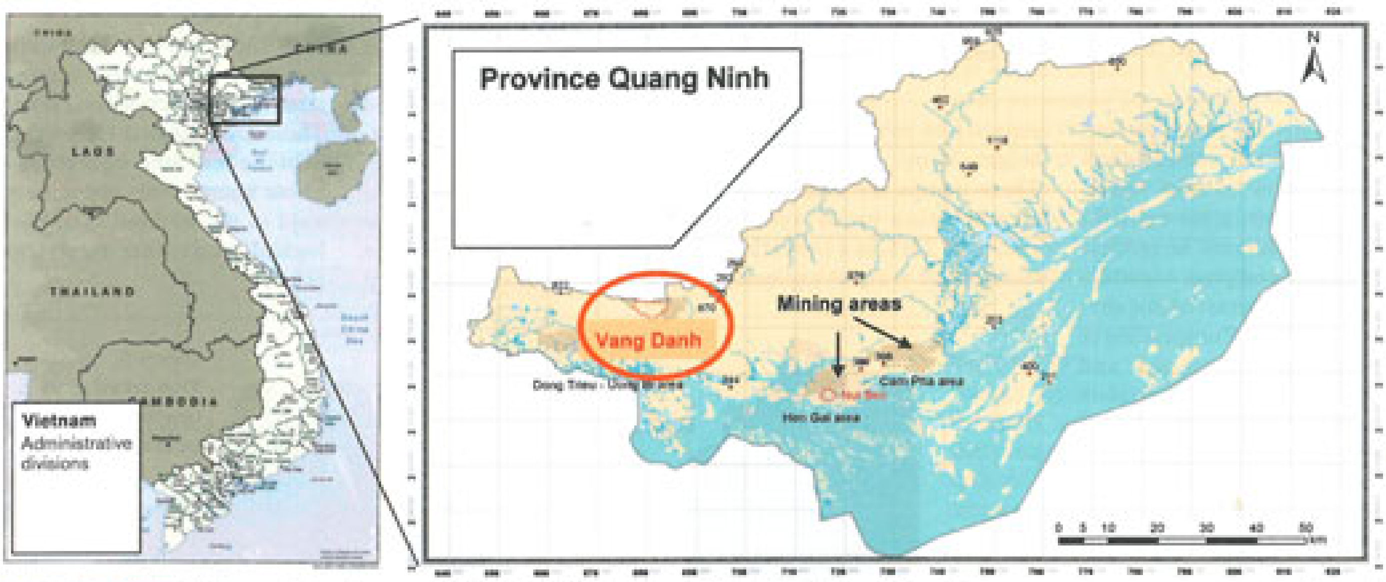
Mine drainage water treatment in Vietnam

Development and implementation of a method for removing iron and manganese and for the separation of coal dust.



PROJECT SITE: Vietnam, Province of Quang Ninh, town of Vang Danh (red circle) Image 1

The Research Association for Mining and Environment (RAME) in Vietnam – a joint project supported by Germany's Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung – BMBF) – is currently setting up a pilot plant for mine water treatment in Vietnam. As part of the project's research focus on water management and water treatment, the project partners LMBV International GmbH (coordination and monitoring), eta AG (site analysis and facility planning), and GFI GmbH, Dresden (process development and scientific monitoring), in collaboration with the Vietnamese project partners, have developed an active treatment method for mine water. The method, adapted to the project site of Vang Danh and its regional conditions, is now being implemented on site.

Site characteristics

North Vietnam's high-quality anthracite coal resources are extracted through open-pit mining or underground mining for energy generation and for export. As Vietnam's economy is rapidly growing and in need of more energy sources, and as coal mining is a major pillar of the Vietnamese economy /1/, the expansion of coal mining is promoted by the government. The concomitant increase of environmental burdens, such as the pollution of rivers due to mine water discharge, are recognised problems in Vietnam and necessitated for the installation of mine water treatment plants (MWTP).

In the coal mining district surrounding the town of Vang Danh in north-eastern Vietnam (Image 1), anthracite coal is extracted underground. Mine water, diffused in the entire mining area as a result of mine drainage operations in several galleries, currently still flows above-ground and largely untreated into the receiving rivers (Image 2), and from there into Ha Long Bay, which is a designated UNESCO World Heritage Site.

As part of the project's multi-year, onsite monitoring component, the hydro-chemical characteristics of the various branch currents of the mine water were identified and recorded. Based on these findings, the acidic mine water is iron- and manganese-rich and characterised by a high solid content, consisting predominantly of suspended coal dust (visually identifiable in Image 2). For the design of the plant, the expected composition of the mixed influent water was defined according to the monitoring results (see Table 1). The concentrations to be achieved by the treatment are prescribed by Vietnam's statutory threshold values for industrial wastewater (Table 1).

Moreover, the flow volumes of the mine water discharge are determined by means of current meters, salt tracers, and fluorescent tracers. The monitoring results showed high daily and seasonal fluctuations for the property parameters as well as for the flow volumes.

Process development in Germany

The planning process was accompanied by extensive laboratory tests and test plant experiments that were performed and evaluated at GFI in Dresden /2, 3, 4/. Within this framework, a pilot-scale MWTP was also developed (Image 3) and set up for method testing and the training of Vietnamese skilled labour. All tests were performed with site-specific water properties and in-

Design water level established from the inflows to the plant and the mandatory threshold values Table 1

parameters	Design water level parameters for the MWTP [mg/l]	Vietnamese threshold values for industrial wastewater
Fe (total)	50	5
Mn (II)	11.4	1
Solid content	1000	100
pH value	5.8	5.5 - 9

clude, tests of the pH-value-dependent sedimentation of hydrosides iron and manganese, sedimentation tests on the abstraction of the sludge generated by the treatment process, and tests of various methods for removal of the manganese.

The Vietnamese threshold values for pH, iron, and solid content are to be met with the standard active mine water treatment method using aeration, neutralisation, and

Introduction of untreated mine water in a stream Image 2

the subsequent separation of solid particles. However, manganese is generally – particularly in high concentrations such as in this scenario – much more difficult to separate from the aqueous substance, whereas iron in an aerated reaction basin can be separated in a fully oxidized state from the aqueous substance at a pH value of 7, the separation of manganese requires pH values in the order of 10 (Image 4). However, the quantity of neutralising agents required to generate such pH values would make this method economically unviable as well as counterproductive with regard to actually treating the water (Table 1). For this reason, the treatment method was designed to remove manganese in both an economically and environmentally viable manner. /4/.

The results of the tests accompanying the project showed that at a pH value of around 9 and with an economically reasonable use of neutralising agents and without a transgression of the Vietnamese pH threshold value, some 50% (w/w) of the manganese content could already be separated through sorption and pro-rata oxidation from the aqueous substance.

The remaining 50% (w/w) are subjected to a complementary manganese removal method based on the catalytically accelerated oxidation of Mn(II) in manganese oxide fixed bad filters.

Procedural adaptation to Vietnamese conditions

Based on the research results, a treatment concept was developed for the site of Vang Danh and adapted to the site-specific conditions in Vietnam for its procedural implementation:

- Climatic conditions in North Vietnam with frequent torrential rains in the summer months are taken into consideration by ensuring the separation of surface water flows from mine water flows.
- The strongly varying mine water properties and flow volumes are homogenised by mixing the different inflowing gallery waters.
- To minimise the need for space and to ensure the secure operation of the process and control of the plant, modern technology is used according to German standards.
- To minimise costs, the process should be designed to rely as much as possible on a minimum number of simple, inexpensive resources and materials that can be acquired within Vietnam.
- To adapt the plant to local conditions and requirements, the Vietnamese Project Partners were actively integrated right from the start in each decision-making phase of the planning and construction of the facility.

TEST PLANT EXPERIMENT: Image 3
Mine water treatment plant at GFI GmbH, Dresden

Technical implementation of the mine water treatment plant

The MWTP (longitudinal section in Image 5) was designed for a flow volume of 800 m³/h. Its capacity can be expanded, in two further stages, to 2400 m³/h for a three-level operation. To prepare for the considerable increase in the volume of mine water flows resulting from the expanded mining activities, the collected raw water is channelled to the plant via closed pipes. As part of the system control, the inflow is subjected to an MID-based flow volume measurement. The inflow also has a controlled sliding gate as an emergency stopper, which channels the mine water during maintenance procedures or in cases of a high inflow volume on a pro-rata basis through a bypass around the plant.

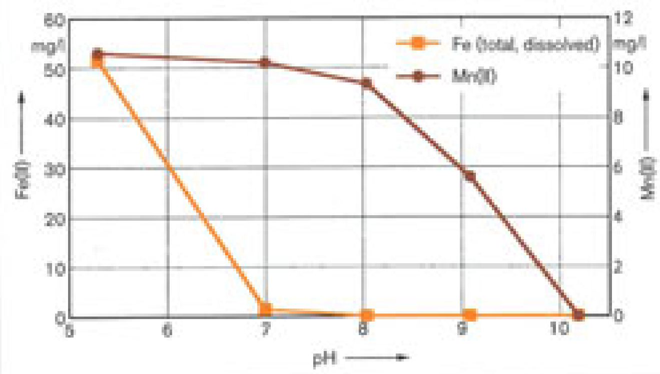
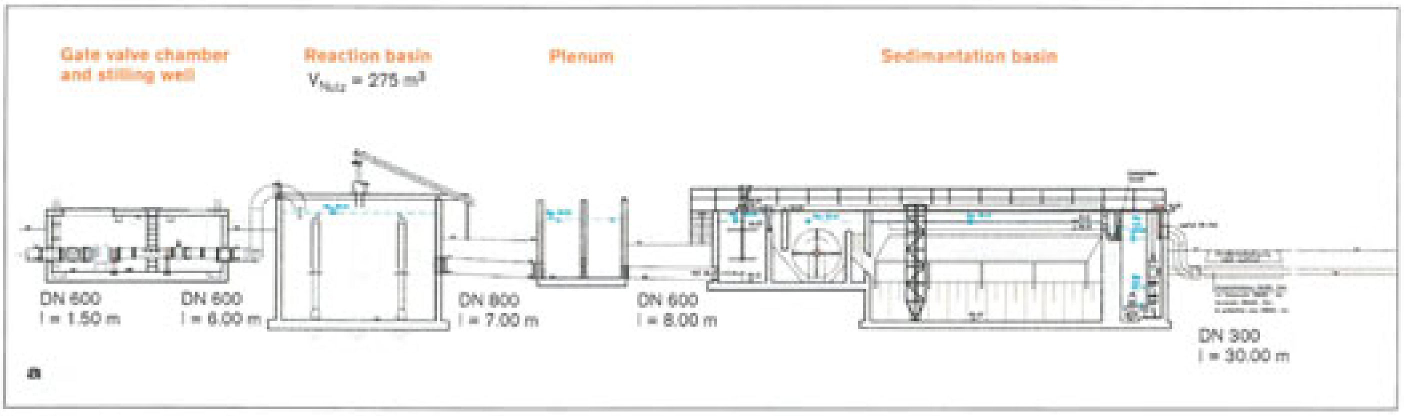
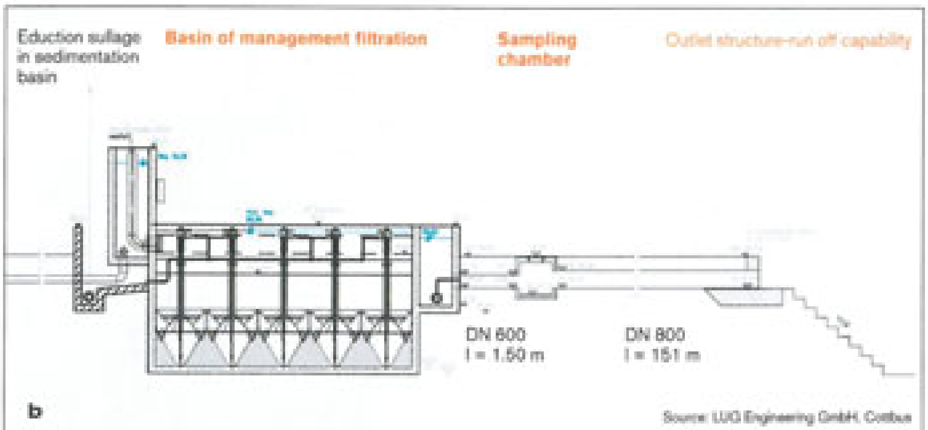


Image 4
Dependency of Fe concentrations (total, dissolved) and Mn(II) as a function of the pH-value in an aerated reaction basin at practice-relevant residency times





Source: LUG Engineering GmbH, Cottbus

Images 5 a and b

LONGITUDINAL SECTION:

Blueprint of the mine water treatment plant

The mine water flows by gravitation into the reaction basin, which, with a volume of 275 m^3 and a required residence time of at least 10 minutes, is designed for a capacity of approximately 1600 m^3/h.

At this stage, the pH value is increased to 9.0 by adding a lime milk suspension. The required hydrated lime is stored in two closed silos and added to the basin via two separate dosing stations.

In addition, a controllable addition of oxygen is provided to the basin by means of mammoth pumps, which also serve to generate turbulence and to add the neutralising agent. In the basin, iron is fully oxidised and manganese is partly oxidised before being transformed into insoluble deposits. A further portion of the manganese content is also separated from the solution by means of sorption.

For the mechanical separation of its solid content (coal dust and other sediments), the water is then channelled, via a plenum, to the sedimentation unit, which consists of the following three partial tanks for each planned phase (each 800 m^3/h):

- In basin 1, a polyacrylamide is turbulently added, and a horizontal stirring mechanism is used to support flocculation.
- In basin 2, the maturation of the floc takes place under a decreased and well controlled turbulence, generated with a vertical paddle mechanism.
- In basin 3, the suspended solid particles are separated by means of lamella separators.

The base of basin 3 has scrapers, which, equipped with sludge pumps, channel the solid particles to a sludge thickener and then to a decanter, which ensures a sludge dehydration of 30 to 40% (w/w) of the solid content.

Groundbreaking ceremony (November 2009)

Image 6

The advantage of the sedimentation plant over the traditional sedimentation basin (round basin) is that it is considerably smaller, which minimises construction costs. This means that there is enough room on the small area of land available to construct the rectangular tanks used in the three expansion stages.

Following the separation of solid particles, the turbidity-free water is channelled to the manganese removal stage, consisting of a group of 20 parallel-connected fixed bed filters with a filter surface of 100 m². The filters are filled with a manganese ore as filter material in order to catalytically accelerate the progress of manganese removal. The dissolved manganese remaining in the water is catalytically oxidised in the filters, which have a bottom-to-top through-flow, and forms solid particles that are then removed through continual backwashing of the filters. The separated manganese sludge is transferred in two alternately supplied and cleared sedimentation basins, where it can settle during a residence time of four days.

A bypass constructed as an overflow channels the water to be treated, which cannot pass through the manganese filter plant during maintenance works, around the filter plant. The drainage of the manganese removal stage has a sampling chamber for monitoring and maintenance purposes, and from which the treated water is channelled to the discharge system.

The processing equipment described includes redundat pH, turbidity and $c(O_2)$ sensing instruments installed at various locations. These allow the plant to be controlled largely automatically and ensure that monitoring data can be supplied for scientific analysis during commissioning as well as for plant monitoring purposes during normal operations. Other elements of the plant are an administration and storage building, lime silos, a flocculation aid preparation and dosing station, compressors for the manganese removal and aeration, as well as areas for the access roads and the surface water drainage.

Plant construction

Based on the facility planning described and in close consultation with the German and Vietnamese project partners, the MWTP is currently under construction (official start of construction was November 2009, Image 6). Image 7 shows the construction works completed by the Vietnamese project partners in January 2011.

Summary and prospects

So far, experience shows that the planning processes for international projects managed in cooperation by both parties, and in which the local partners are integrated into the planning and construction operations, can be expected to take considerably longer than usual. Frequent person-to-person contacts and consultations are required. For these reasons, the different geographic, cultural, economic, political, and legal conditions of the partner countries must be taken into consideration. It cannot be assumed that decision and planning processes in the partner countries will proceed in the same way as they would in Germany.

The project successes achieved so far were realized thanks to a high degree of flexibility in the approach and manner of managing operations by both parties. The MWTP is slated to be finished before 2011. Measures for training the future staff are currently in preparation. Following the completion of the plant, a commissioning process and a monitoring of the control of the developed treatment technology will be performed by the German and Vietnamese project partners.

The research and development tasks required for the process development were financed in part by the Federal Ministry for Education and Research. The German project partners thank the Federal Ministry for Education and Research for its support.

PLANT CONSTRUCTION: **Sludge thickener (front) and sedimentation basin (back) of the first expansion stage (January 2011)** Image 7

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