IMPACT ON THE QUALITY OF THE INDUSTRIAL SIDERURGICAL WATERS BY REPLACING THE CLASSICAL BLAST FURNACES' BF/LDAC BASIC OXYGEN FURNACES' BOF FILE (WET GAS CLEANING) THROUGH THE ELECTRIC ARC FURNACES' EAF FILE (DRY GAS CLEANING)

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1. Introduction

The plants of ProfilARBED and ARES in Luxembourg represent two business units of the ARBED group that, with production capacities of 11 millions tons of steel per year, is the 4th iron and steel industry in Europe. They employ in Luxembourg about 5500 persons and have a production capacity evaluated at 3 millions tons of steel per year. ProfilARBED is focused on long heavy products. Long light products are concentrated at ARES, Esch-Schifflange and Rodange.

During the period 92/94 ARBED has decided to pass, in the Luxembourg plants, from the classical file (sinter plant, blast furnaces BF, LDAC basic oxygen furnaces BOF) to the all electrical file (electric arc furnaces EAF, ladle heating furnaces LHF, continuous casting machines CCM, walking beam furnaces WBF). Thus, the classical file will be replaced by three electric arc furnaces in the plants of Esch-Belval, Differdange and Esch-Schifflange. This structural change will be finished in the second half of 1997.

2. Target of the report

The present report has as target to show the impact on the quality of industrial siderurgical water by changing the classical file, with wet gas cleaning, through the all electrical file, with dry gas cleaning, at the plant of ProfilARBED, Esch-Belval.

3. Water circuits for the classical file with dry gas cleaning

3. 1. Situation concerning water supplies

All the Luxembourg plants of ARBED are situated far away from the great rivers of the region and are thus largely limited concerning the water supplies and the industrial water discharge. Therefore, they are oriented from their beginning, as far as possible, on closed circuits. Low water consumptions' are the consequence.

3. 2. Potential pollutants of the siderurgical water

A great variety of pollutants, in variable concentrations, may be found in the siderurgical waters of the different kinds of production installations. These waters are either washing waters of off-gases, process waters or cooling waters.

The waters of the overflow of the internal circuits flow in the rolling mills' pond or in the reserve pond. They may hold suspended solids, hydrocarbons (oil/grease), heavy metals (Zn, Pb, Cd, Fe, Cu .....) or other pollutants (BOD-5, COD, NO_2, NH_4.....).

The siderurgical waters are checked by a systematic follow-up of the water treatments of the different internal circuits and by a day per day monitoring of the water quality of the effluent.

3. 3. Monitoring of the waters of the internal circuits and of the effluent

In order to follow continuously the quality of the siderurgical waters a systematic check is realized on the waters of the internal circuits to adapt respectively to improve the physical/chemical treatment modes of these waters and to supervise the effluent of the plant.

To check the effluent's water a continuous sampling equipment, corresponding to the legislation, is installed. Furthermore, on-line measurements of pH, temperature and conductivity of the effluent are also installed.

The sampling frequencies and the chemical analysis are realized according to the working permit of the plant. In order to calculate the pollution charge leaving the plant a continuous measurement of the water flow is also put in the effluent.

The waters of the internal circuits are sampled manually and analysed according to a procedure defined individually for every circuit.

The management of the results with regard to the waters of the effluent and of the internal circuits is carried out by the sector " Contrôle et Gestion Environnement " of ProfilARBED. The results determined on the water of the effluent are forwarded every month to the national Administration of Environmental Affairs.

3. 4. Water supplies and water discharges

The only water supplies of the plant of ProfilARBED, Esch-Belval are a small brook " Wenschel ", the flow of which varies between 20 and 200 m^3/h, and the water effluent of an external communal mechanical water treatment installation of the commune of " Belvaux " STEP, the flow of which varies between 50 and 200 m^3/h. Besides these supplies, the plant collects a great deal of rain water, surface water and sanitary water and is also obliged to take intercommunal water.

The water's discharge is composed exclusively by the overflow of the reserve pond that flows directly into the brook " Dipbach ", the flow of which varies in large proportions, 0-50 m^3/h during dry periods, and up to 500 m^3/h during important rain falls. Normally, the overflow of the rolling mills' pond passes only into the reserve pond by three sewer pipes. Floating dams hold back hydrocarbons of the rolling mills that have passed accidentally in the rolling mills' pond. If necessary, they are recuperated by pumping and eliminated by an aggregated firm.

Both ponds, that make up the water reserve of the plant, have as other function to allow the suspended solids to deposit. Cleaning of these ponds by an aggregated firm is done periodically

The cooling water supplied to the blast furnaces comes from the two blast furnaces' pools and goes back to them after utilization.

The water for the rolling mills is supplied by the rolling mills' pond and goes back to this same pond after clarification and disoiling in a modern thickener where mill scale sludge and used oils and greases are recovered.

The water balance for 1996 is given in the table below.

Specific water consumption
(Input water-Output water)/steel production: (4.775.000-1.850.000)/1.168.068 = 2,5 m^3/t steel

Input	m^3/year
" Wenschel "	2.700.000
STEP	795.000
Intercommunal water	900.000
Rain water/sanitary water	380.000
Total	4.775.000

Outtput	m^3/year
Effluent plant, " Dipbach "	1.850.000

This specific water consumption can be considered as one of the lowest in the world's iron and steel industry. It could be realized by the systematic development of closed or semi-closed circuits and air-tight circuits with high recycling rates.

3. 5. Internal circuits

3. 5. 1. Closed and semi-closed circuits

3. 5. 1. 1. Washing circuit of blast furnaces' gas

After primary purification in the pots and cyclones, the blast furnaces' gas contains about 450 mg/m^3 dust. The final purification is done in Venturi washers of a wet Bischoff dedusting system.
The water recuperated at this washing is treated in a thickener. Acid out of the blast furnace (pH 4-6), the water is neutralized to pH 8,2-8,7 by regulation through addition of soda. This allows a quasi quantitative precipitation of the metals Zn, Pb, Cd soluble at pH < 8. A floculation agent is added in the thickener to increase the decanting speed of the sludge. The sludge, with high zinc content, and not recyclable in the blast furnace, is pumped to a decantation basin until the disponibility of an economic justifiable valorization technology.
The water supply comes from the reserve pond and the purge is evacuated through the blast furnaces' pools into the same pond.

3. 5. 1. 2. Granulation circuit of blast furnaces' slag

The installations have a granulation capacity of about 1.000.000 t slag/an. The water supply necessary to compensate the loss of water contained in the slag and the evaporated water, evacuated through a chimney, comes from the blast furnaces' pools. The purge is evacuated into the reserve pond.

3. 5. 1. 3. Washing circuit of the LDAC basic oxygen furnace's gas

After combustion of the converter gases, charged with CO, in a smoke gas boiler, that recovers energy, the off-gas is washed by Venturi washers of a Bischoff dedusting system.
The sludge issued from this operation is collected in a pre-thickener (coarse) and in a thickener (fine). The coarse sludge is recycled through the sinter plant and the fine sludge, not recyclable at the blast furnace, is dumped until the disponibility of an economic justifiable valorization technology.
To avoid lime deposits in the circuit, additions of dispersants and Na_2CO_3 are carried out to soften the water of the circuit. The precipitation of $CaCO_3$ is generated in the thickener and the $CaCO_3$ is evacuated with sludge.
The water supply of this circuit comes from the rolling mills' pond. The purge is evacuated through the circuit of the rolling mills into this same pond.

3. 5. 1. 4. Cooling circuit of the rolling mills

Out of the rolling mills, the raw waters contain 150-450 mg/l suspended solids (mill scale and mill sludge) and 10-30 mg/l hydrocarbons. They are introduced by gravity in a mechanical pre-thickener, equipped with 8 arms capable of bringing the mill scale < 0,2 mm (coarse) to a classification installation related with the pre-thickening compartment.
The classification installation gets the mill sludge < 0,2 mm (fines), recuperated at the underflow of the thickener-disoiler. These fines, charged with oil and grease, are pumped to a decantation basin where they are extracted periodically in order to be stocked until the disponibility of an economic valorization technology. The mill scale > 0,2 mm is evacuated by a skip. Due to the low oil/grease content it can be recycled in the sinter plant.
The pre-decanted water is evacuated to the thickener-disoiler equipped with a double blade-scraper allowing the sweeping of the entire surface of the thickener and the evacuation of the oil/grease residues in a post-separation tank. These residues are eliminated by an aggregated firm. The cleaned water returns to the classification installation.
The effluent of the thickener-disoiler has among 20 and 50 mg/l suspended solids and less than 5 mg/l hydrocarbons. The cleaned water flows afterwards into the rolling mills' pond and then in the reserve pond. The overflow of this pond represents the effluent of the plant, the " Dipbach ".
The water effluent standards of the National Environmental Administration are shown in Table 1. They are respected with some rare minor exceptions (Zn, NO_2, BOD-5).
For all these circuits the recycling rate is higher than 90%.

3. 5. 2. Hermetically closed water circuits

Besides the closed and half-closed water circuits, different installations of the BF and the BOF are equipped with hermetically closed water circuits. They are run with demineralised water that is treated with additional products to protect the walls of the water mains from corrosion and deposits.

3. 6. Impact of the different water circuits on the chemical quality of the effluent of the plant

3. 6. 1. Contamination by heavy metals

An uncontrolled purge respectively overflow of the circuits and faulty BF and BOF water treatment installations (thickeners) may breed higher values of Zn and/or Pb of the water of the reserve pond and thus of the effluent of the plant. An overtaking of the standards may be the consequence

3. 6. 2. Contamination by hydrocarbons

Only a faulty rolling mills' water treatment installation (thickener) may breed higher values of hydrocarbons of the water of the rolling mills' pond. In such a situation, an oil pumping operation is executed. Besides floating dams are installed to avoid the discharge of hydrocarbons over the reserve pond into the effluent. Pollution risks are thus limited.

3. 6. 3. Contamination by BOD-05, NH_4, NO_2

The water supplied by the mechanical communal water treatment installation of the commune of " Belvaux " may cause sporadic increases of BOD-5, NH_4 and NO_2 of the effluent of the plant.
This situation is however of minor importance. Indeed, an increase of these parameters is on one hand of no influence on the internal water circuits and and on the orher hand it should be emphasized that the effluent " Dipbach " is treated some km further away in a biological communal water treatment installation.

3. 7. Chemical quality of the effluent of the plant

During 1996, due to a systematic monitoring of the water quality of all the circuits, the mean values of the parameters of the effluent did never show significant overtaking of the standards.

However, it should be pointed out that the waters of the two ponds are characterized by a higher salinity (conductivity) and a hardness higher compared to the hardness of intercommunal water. These values are originated by the salty overflow of the wet cleaning installations of the BF and the BOF. Due to dilution by rain water the values are lower in winter than in summer.

Considering the mean values, the standards for heavy metal and hydrocarbons are largely respected. This result is explained by the continuous and systematic monitoring.of the water quality of all the circuits.

Only punctual small increases of the parameters Zn, BOD-5, NH_4 and NO_2 are observed especially in the summer time. They are caused by an uncrontolled overflow of the blat furnaces' circuit and by the continuous and necessary supply of the water from the mechanical urban water treatment installation of the border commune " Belvaux " of the plant.

4. Water circuits of the all electrical file with dry gas cleaning (Fig. 2)

4. 1. Closed circuits

The waters of the new siderurgical installations (EAF, LHF, CCM, WBF) are run in closed and semi-closed circuits. The water supplies come from the reserve pond, from the rolling mills' pond and from the intercommunal water network.

These circuits are treated with chemical agents to avoid corrosion and encrustation.

Furthermore, for the CCM, due to an acidification caused by the use of fluorspar as lubrification agent, the water of this circuit has to be neutralized by NaOH.

The rolling mills' circuit is not at all changed. The water continues to be treated in a clarification-disoiling installation that is of best available technology.

4. 2. Hermetically closed cooling circuits

Besides the closed and the semi-closed circuits, the new installations are equipped with hermetically closed circuits. The water of them is systematically treated by chemical agents to avoid corrosion and calcareous deposits. The water losses are compensated by water supplied from the intercommunal network.

4. 3. Chemical quality of the effluent of the plant

The waters of the overflow of the different circuits of the new file will no more be charged with heavy metals and the salinity of them will be largely reduced. Therfore, it is evident that the chemical quality of the reserve and the rolling mills' ponds will be improved by the replacement of the BF/BOF file through the EAF file.

The only possible remaining pollution will be an uncontrolled leakage of hydrocarbons. However, as the rolling mills' water treatment can be considered as best available technology, the risks of higher hydrocarbons in the effluent are limited. The supplementary dams installed in the rolling mills' pond are to be considered as a further security.

4. 4. Water needs for the EAF file

The theoretical needs of water to compensate the evaporation and the necessary purge are estimated at 1.700.000 m³/year. This corresponds, for an aimed production of 1.000.000 t steel/year, to a specific water consumption of 1,7 m³/ t steel, value diminished by about 30% compared to the value measured for the BF/BOF file.

5. Conclusions

The replacement of the BF/BOF file (wet gas cleaning) at the ProfilARBED, Esch-Belval steel plant by the EAF file (dry gas cleaning) will have the following positive consequences :

- a decrease from up to 30% of the specific water consumption due to the installation of closed, semi-closed and hermetically closed water circuits,
- an roughly zero risk of heavy metal pollution in the effluent of the plant,
- a progressive decrease of the salinity (conductivity) and the hardness of the water of the reserve and the rolling mills' ponds and thus a drastic improvement of the chemical quality of the effluent's water,
- a limited risk of hydrocarbon pollution due to a rolling mills' water treatment installation thas is of best available technology,
- the systematic and continuous monitoring of the quality of the waters of the internal circuits, the ponds and the effluent is a further assurance to avoid pollution in the effluent, location of assessment of the water quality by the National Environmental Administration.

Table 1 : Water effluent standards for ProfilARBED, Esch-Belval and Differdange and for ARES, Esch, Schifflance

pH		6.5-9
Temperature	° C	< 30
Suspended solids	mg/l	< 30
Conductivity	µS/cm	p.i.
Fe	mg/l	< 2
Zn	mg/l	< 2
Pb	mg/l	< 0,5
Cd	mg/l	< 0,1
Cu	mg/l	< 0,5
As	mg/l	< 0,1
Hg	mg/l	< 0,01
Cr tot.	mg/l	< 0,5
Cr VI	mg/l	< 0,1
NO3 (drinking water)	mg/l	< 50
NO2	mg/l	< 1
CN free	mg/l	< 0,1
Phenol	mg/l	< 0,1
Cl organic	mg/l	< 0,1
BOD-5	mg/l	< 20
COD	mg/l	< 100
NH4	mg/l	< 10
Hydrocarbons	mg/l	< 5

Water sampling by continous automatic equipments
Continuou registration of water flow, pH, temperature and conductivity

Figure 1 : Industrial water circuits of the ProfilARBED plants, Esch-Belval (PA-EB) Classical file, blast furnaces BF/LDAC steel plant BOF (wet cleaning of off-gasses)

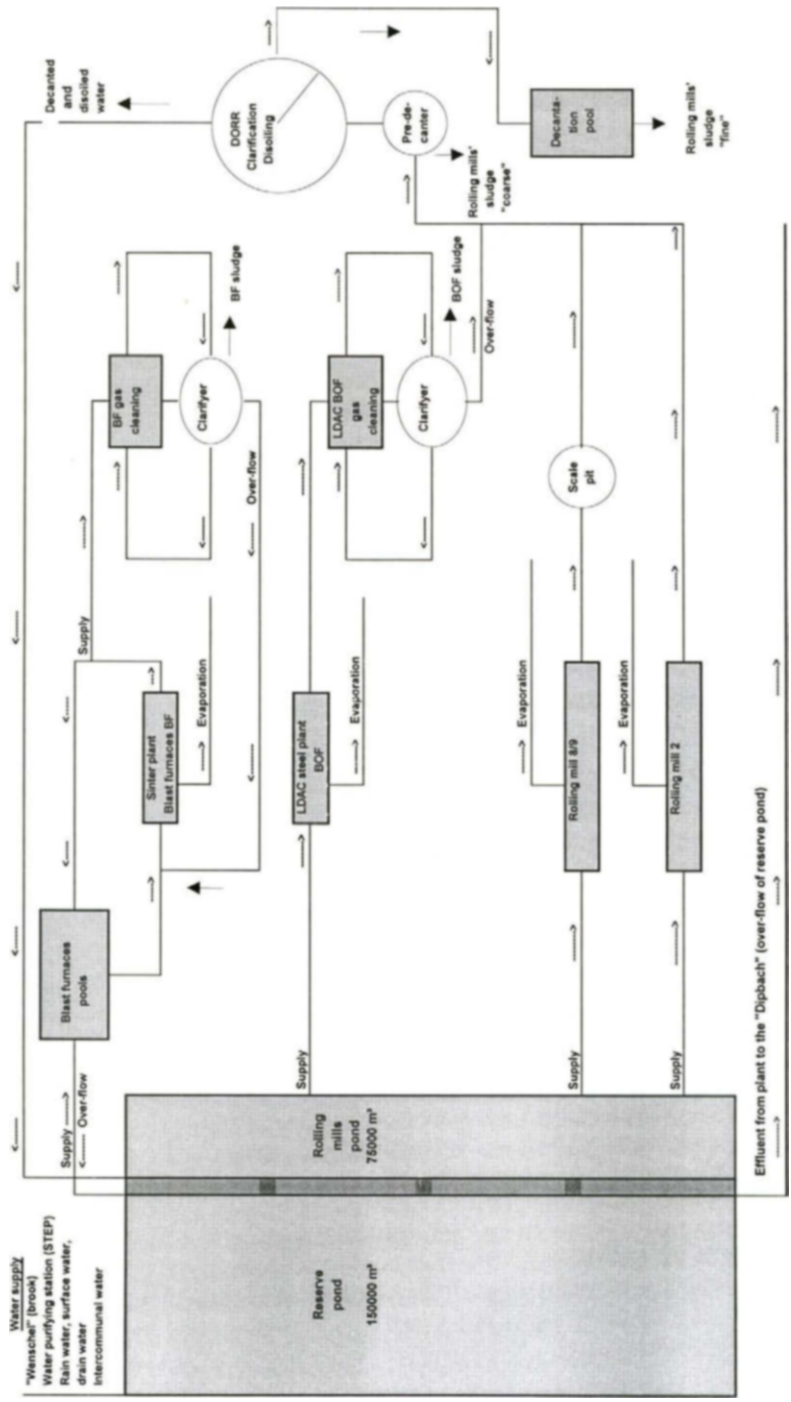

Figure 2 : Industrial water circuits of the ProfilARBED plants, Esch-Belval (PA-EB)
All electrical file, electrical arc furnance EAF (dry cleaning of off-gases)