Treating Make-up Water and Condensate by Reverse Osmosis in an LP Vinyl Records Pressing Plant

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ABSTRACT

At the Czech company GZ Media a.s., which produces vinyl records, the vinyl presses are heated by steam and after pressing, the steam is rinsed from the press by cooling water. The condensate therefore contains a high proportion of cooling water.

In the original system, the losses of steam and cooling water were replaced by filtrated and softened raw water. The polluted condensate was also treated by filtration and softening. The water used as make-up, which was originally considered drinking water, has been replaced for economic reasons by surface water with high salinity and alkalinity. Due to high operational costs and other considerations the original design was replaced with a new one in 2019.

The new system treats the mixture of raw water and cooled condensate by on-line coagulation followed by reverse osmosis. The hot condensate is cooled by heat exchange, which transfers the heat to the permeate as feedwater.

The new system exhibits very low boiler blow-down, minimal consumption of chemicals and low operator attendance.

INTRODUCTION

In recent years, there has been a big comeback of long play (LP) vinyl records. As almost all music record producers had changed their production to compact disc (CD) records, very few producers were able to come back to the production of LP vinyl records. The Czech company GZ Media a.s. is one of the record producers that has become one of the biggest producers of LP vinyl records.

LP vinyl records are produced in pressing plants. The main principle of pressing records from vinyl matter has remained unchanged for several decades. There have, however, been some slight improvements in the technology though, such as electronically controlled presses or automatic production. In a hydraulic press fitted with 2 pre-heated moulds and fitted with stampers, the pre-heated vinyl matter is inserted into the machine sandwiched between two completely dry labels. Once the pressing process is started, the labels and vinyl matter are pressed under a pressure of 100 or more tons at a temperature of 160 °C for a precise amount of time. The surfaces of the grooved stampers are copied exactly into the vinyl matter. After the pressing mould is sufficiently cooled, the press opens and the vinyl record is removed [1].

The presses are heated by saturated steam (1.3 MPa, 190 °C) and subsequently cooled by cooling water at very short intervals. The steam is rinsed from the press by cooling water and therefore the resulting condensate also contains cooling water. The condensate is reused as feedwater for the boiler. Due to the direct contact of steam and cooling water on the surface of the record press, part of the steam condenses into the cooling water. The cooling water is cooled in air-cooling towers.

THE ORIGINAL SYSTEM

In the original system, the losses of steam and cooling water were replaced by filtrated and softened raw water. The polluted condensate was also treated by filtration and softening. The water used as make-up, which was originally considered drinking water, has been replaced for economic reasons by surface water with high salinity and alkalinity.

The water treatment plant was originally delivered with filtration and softening of make-up water and condensate for the boiler as well as for the make-up water for the cooling system. The filters for the boiler were regenerated manually; the filters for the cooling system were regenerated according to the volume treated automatically.

For the regeneration of the softening filters for the boiler make-up water, technical NaCl was used, and for the regeneration of the softening filters in the cooling system more expensive tableted NaCl.

For the removal of alkalinity, alkaline coagulation in a clarifier was provided, but it was not used anymore after a certain period.

The average analysis of individual streams in the original system is shown in Table 1 and a schematic of the original water treatment plant is shown in Figure 1.

High salinity of the feedwater also means a high boiler blow-down (6.41 %), causing higher consumption of make-up water and mainly heat loss.

Due to the high alkalinity of the feedwater there is a high decomposition of alkalinity, causing a high boiler water pH and a corresponding presence of CO_2 in the steam. High pH of the boiler water can cause the dissolution of the magnetite protective layer in the boiler and CO_2 may cause corrosion in the steam zone.

Softening of the make-up water for the cooling system causes a rise in the Ryznar Index above 7.0, which means that the softened water is highly corrosive. The dosing of anticorrosive chemicals is therefore recommended.

The original system could have been further used under the following conditions:

- Alkalinity removal in the make-up water for the boiler must be performed, either by alkaline coagulation or by dosing acid
- Corrosion activity in the cooling system must be controlled by anticorrosion inhibitor
- The supervising and operational resources must correspond to the state-of-the-art

However, the running cost would be high, namely from the high consumption of tableted salt for regeneration of the softening filters for the cooling system and of corrosion inhibitor for the cooling system. The high boiler blow-down also means high costs due to heat loss.

NEW CONCEPT FOR WATER TREATMENT PLANT

Make-up Water Treatment

The original make-up water treatment based on softening was supplied with the presumption of using drinking water with moderate salinity as the influent water. For water with high salinity, softening is uneconomic from the point of view of the high running cost of NaCl for regeneration and high heat loss in blow-down. The best suited technology is reverse osmosis, which is nowadays used even for waters of moderate salinity where ecological limitations exist and where operation with continuous production with low supervision is attractive.

Parameter	Unit	Raw Water	Make-up Water	Conden-sate	Treated Conden-sate	Feed-water	Boiler Water	Cooling Water
pH	–	7.9	8.0	8.0	8.1	8.9	12.0	8.4
Conductivity	$\mu S \cdot cm^{-1}$	755	729	406	414	470	7786	1011
Hardness	$meq \cdot L^{-1}$	6.3	0.04	0.17	0.03	0.04	0.08	0.37
m-alkalinity	$meq \cdot L^{-1}$	3.7	3.5	1.9	2.2	2.1	24.8	4.1
p-alkalinity	$meq \cdot L^{-1}$					0.4	22	0.1
Iron	$meq \cdot L^{-1}$					0.5	0.7	
Chloride	$mg \cdot L^{-1}$	62	58	28	29	35	417	80
Sulphates	$mg \cdot L^{-1}$	128			414			186
P_2O_5	$mg \cdot L^{-1}$						17.2	
Na_2SO_3	$mg \cdot L^{-1}$						9	
Ryznar index	–	6.0						7.8

Table 1:
The average composition of individual streams (3.11.2017–1.12.2017).

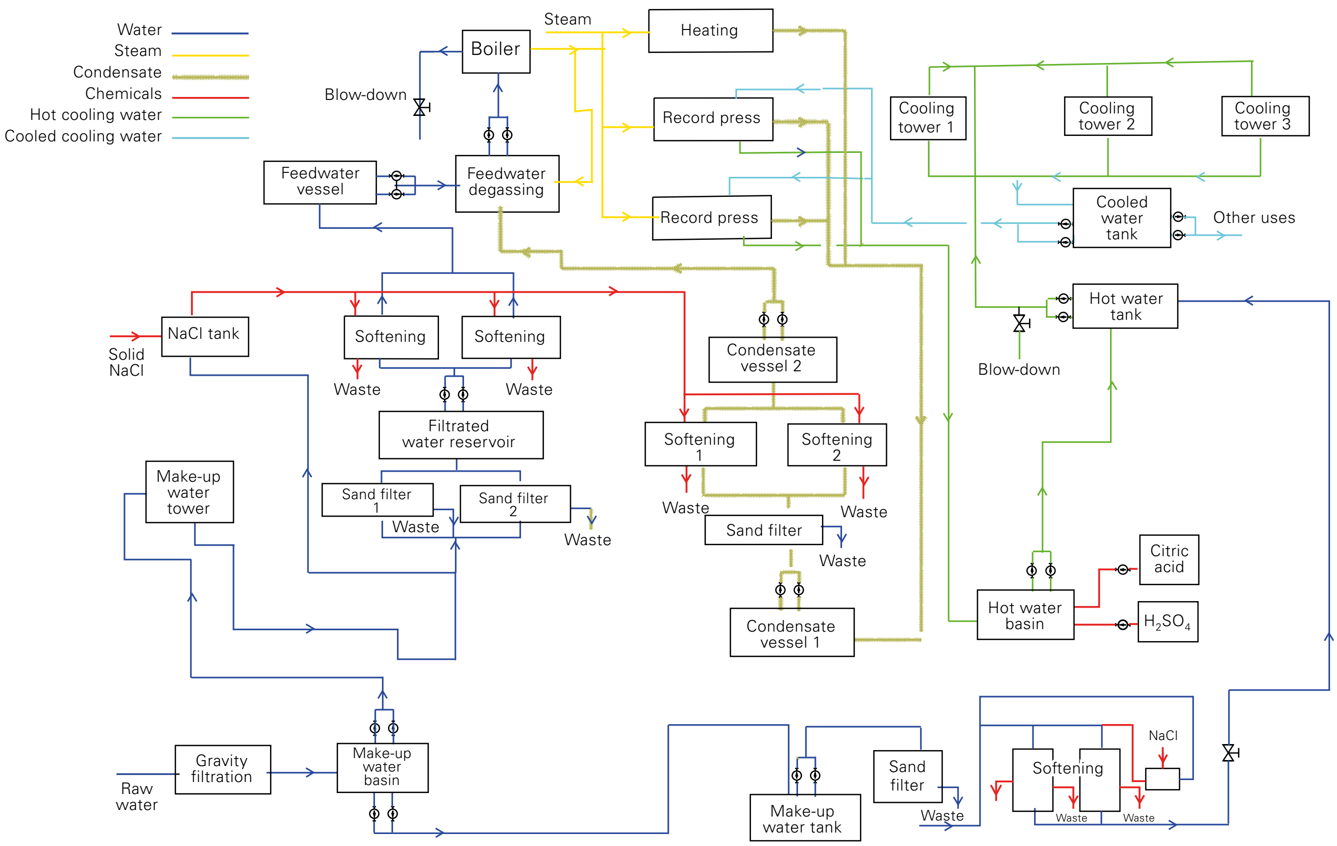

Figure1:
The original scheme of the water treatment plant.

Parameter	Unit	Raw Water	Conden-sate	RO Influent	Permeate	Feedwater	Boiler Water	Cooling Water
pH	–	7.8	9.3	7.5	6.7	7.9	11.6	8.7
Conductivity	$\mu S \cdot cm^{-1}$	848	284	603	12	14	2010	1008
Hardness	$meq \cdot L^{-1}$	6.8	2.2	5.2	0.05	0.05	0.24	8.2
Calcium	$meq \cdot L^{-1}$	4.6		2.8		0.4		6.0
m-alkalinity	$meq \cdot L^{-1}$	3.5	1.4	2.2	0.4	0.0	6.8	4.4
p-alkalinity	$meq \cdot L^{-1}$		0.4			0.1	5.8	0.3
Iron	$mg \cdot L^{-1}$	0.1	0.2	0.2	0.1	0.4	0.4	0.3
Chloride	$mg \cdot L^{-1}$	91	26	74		8	155	111
Sulphates	$mg \cdot L^{-1}$	658		105				173
P_2O_5	$mg \cdot L^{-1}$						30	
Na_2SO_3	$mg \cdot L^{-1}$						19	
Ryznar index	–	6.1		7.3				4.9
Temperature	°C		27.1	19.2		82.3		

Table 2:
The average composition of individual streams (14.11.2019).

Two reverse osmosis lines with on-line coagulation with $FeCl_3$ dosing replaced the existing softening set-up. To decrease the consumption of inorganic coagulant, a polymer coagulant aid was added in front of the filter.

Condensate Treatment

For condensate treatment, two options were considered:

1) Use the same softening technology that is generally used where the condensate contains a very low concentration of impurities.
2) In this case, where the condensate is polluted with cooling water, the loss of heat is high. The direct use of reverse osmosis is generally impossible due to the high condensate temperature in this plant (ca. 95 °C). Reverse osmosis is limited to temperatures below 30 °C. However, if the condensate temperature could be decreased under 30 °C, then the use of reverse osmosis is possible. The cooling of the polluted condensate is performed by counter current heat exchange, where the heat from hot condensate is transferred to cold feedwater consisting of a mixture of make-up water and cooled condensate, both treated by reverse osmosis (Figure 2).

After implementing the changes in the water treatment presented in the second option, the boiler blow-down markedly decreased (0.69 %).

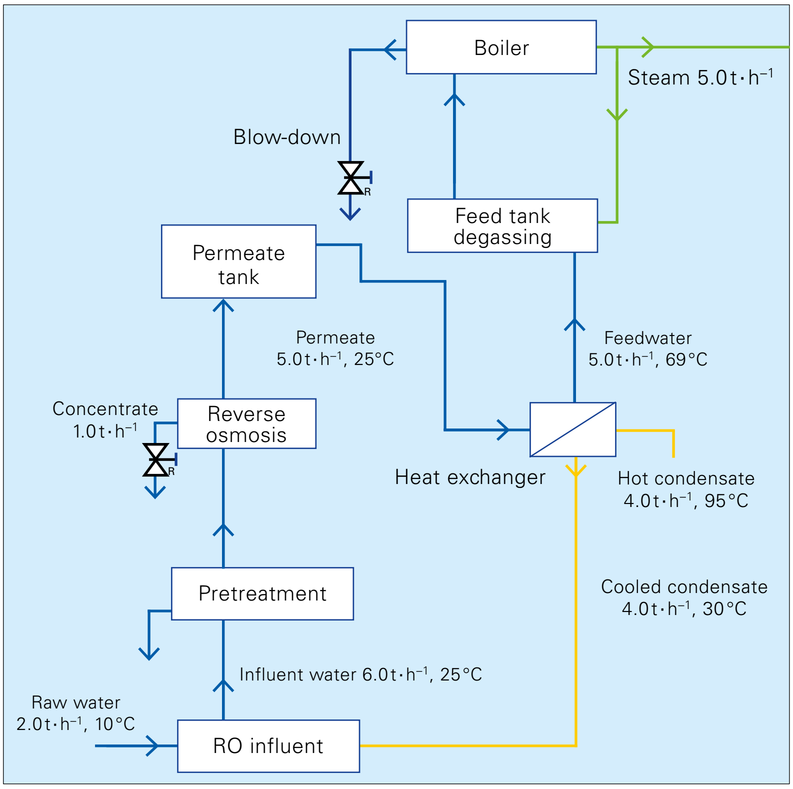

Figure 2:
New scheme of the condensate cooling.

Cooling Water

The main problem of all cooling systems is precipitation of $CaCO_3$ in the cooling system pipes. The precipitation of $CaCO_3$ is governed by pH, temperature, water salinity and the concentration of calcium.

Corrosiveness or the tendency for $CaCO_3$ precipitation can be calculated by using the Ryznar index. An optimum value of the Ryznar index is between 6.0 and 7.0: above 7.0 the system is corrosive, under 6.0 there is a tendency for $CaCO_3$ to precipitate.

Using raw water without softening as make-up water for the cooling system may cause $CaCO_3$ precipitation in the system. It is known from experience that up to a Ryznar value of 4.0 the precipitation of $CaCO_3$ can be inhibited by using an appropriate antiscallant.

The new arrangement of the water treatment plant is shown in Figure 3; the composition of the individual streams markedly changed (Table 2).

ECONOMIC CONSIDERATIONS

a) The running costs in Table 3 were calculated for the following conditions:
   - Steam consumption: 5.0 tons per hour
   - Running time: 7000 hours per year
b) The personnel operation requirement has changed from daily regeneration of filtration and softening filters to supervising control.

CONCLUSION

Replacing softening by reverse osmosis for boiler make-up treatment as well as for condensate treatment brings the following advantages:

- The new equipment represents state-of-the-art technology
- Continuous production means low operator attendance
- The running costs are significantly lower because:

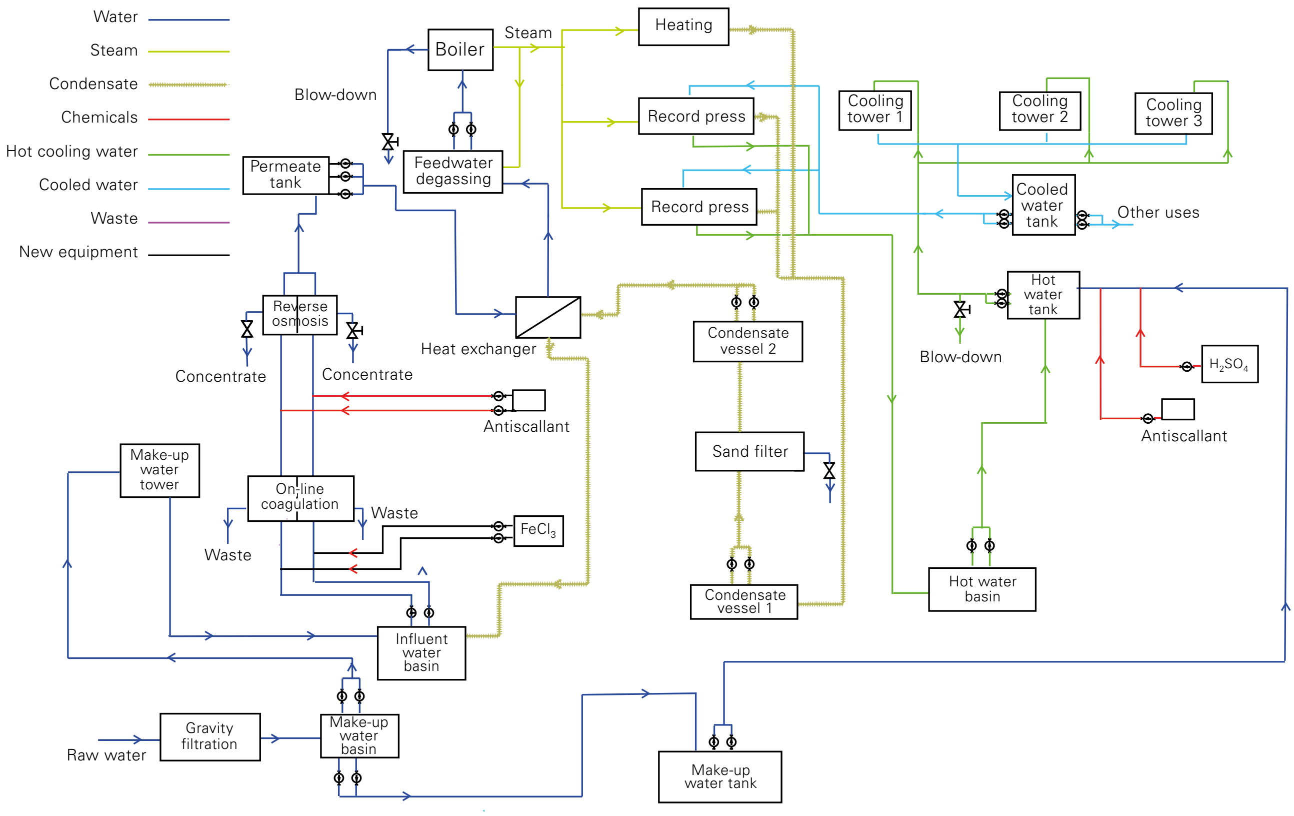

Figure 3:
New scheme of the water treatment plant.

	Euros per unit	Softening: Costs per year in Euros	Reverse osmosis: Costs per year in Euros
Phosphate for boiler	0.78	112.10	19.00
Na_2SO_3 for boiler	0.70	57.50	5.80
H_2SO_4 for raw water	0.06	72.00	–
NaCl for raw water	0.11	1365.80	–
NaCl for condensate	0.11	118.70	–
NaCl for cooling system	0.18	19932.30	–
Raw water for boiler	0.17	1173.70	2347.30
Raw water for cooling system	0.17	2347.30	2347.30
Antiscallant for RO	25.00	–	1509.00
Antiscallant for cooling system	12.00	–	251.50
H_2SO_4 for cooling system	0.06	43.00	–
Corrosion inhibitor	12.00	838.30	–
Energy	0.08	1128.90	3386.80
Heat loss	0.002	15186.20	1519.10
Wastewater	0.004	27.90	55.90
Total costs per year in Euros		42403.80	11441.70

Table 3:
Running cost comparison (Euros per year).

- reverse osmosis consumes a minimum of chemicals and represents an ecological advantage over wastewater from softening
- there is the possibility of omitting the softening of make-up water when controlling the corrosion activity in the cooling system by an appropriate antiscallant
- significantly lower blow-down of the boiler represents very low heat loss.

The only items which are higher (but not significantly so) are

- Higher raw water consumption
- Higher energy consumption.

REFERENCES

[1] *Manufacturing – Pressing*, **2020**. GZ Media, a.s., Loděnice, Czech Republic. Available from http://www.gzvinyl.com/.

THE AUTHOR

Pavel Hübner (M.S. and Ph.D., The Institute of Chemical Technology, Prague, Czech Republic) began his career in 1972 as a specialist for ion exchange at CKD DUKLA, Prague. He left in 1994 for the engineering company POLYTHERM and in 2003 he joined the company MEMSEP, specializing in reverse osmosis. From 2005, Pavel Hübner was with Energoproject Prague, a design company for the power industry, where he was responsible for technological processes in water treatment in power plants, including water treatment for boiler and cooling systems as well as the chemistry of water-steam cycles. In 2014 he retired, but he is still active as an expert in water treatment technology.

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