Outotec Pressure Oxidation – More out of Sulfide Ore
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ABSTRACT
Outotec is today capable of providing technologies, process equipment and engineering for the construction of pressure oxidation leaching (POX) plants in any location in the world. Outotec works with customers from mine to pure metal, participating in plant design from the process development phase (including test work execution/supervision) to plant commissioning and operations. Either key equipment technology packages with basic engineering or entire POX plants can be supplied.

The addition of pressure oxidation equipment to Outotec’s product portfolio adds to and complements already existing significant experience in general hydrometallurgical process and proprietary equipment design and supply.

In addition to providing key pressure vessels, piping and valves to a POX plant, Outotec can offer an enhanced and proven autoclave agitation system that maximises oxygen mass transfer and utilisation. Novel energy and water recovery technology can also be tailored to a customer’s specific needs. Importantly Outotec owns and operates extensive test work facilities and can provide test work to ensure the optimum POX flow sheet and materials of construction. Outotec ensures that best available technology (BAT) concepts are used in POX design to improve the availability of the process and minimise unpredicted shutdowns.

INTRODUCTION
Outotec has a long history of developing and supplying process solutions, technologies and services for the mining and metallurgical industries. Outotec can develop a project from conceptual study phase to detailed engineering and Outotec’s scope of supply can vary from single equipment to complete plant. With significant metallurgical process experience in two in-house research centres, Outotec continuously develops new process concepts and technologies. Batch testing as well as full continuous pilot testing facilities are available. In addition continuous equipment development and corrosion testing are available to support selected process designs. In many cases this equipment development is supported by computational fluid dynamics (CFD) validation and design.

An Outotec pressure oxidation (POX) technology package can include the whole process chain from ore milling and beneficiation to autoclave oxidation and final gold recovery. In this article, some details of Outotec’s innovative approach to pressure oxidation are highlighted, specifically autoclave agitation and gas dispersion as well as a novel energy and water recovery system.

OUTOTEC PRESSURE EQUIPMENT TECHNOLOGY – BACKGROUND
Outokumpu Engineering and now Outotec has extensive experience in autoclave technology and autoclave equipment design and supply mainly for matte leaching in Finland both at Kókkola and Harjavalta plants.

Today Outotec is an independent technology company and is capable of supplying pressure hydrometallurgical equipment and technology into other commodities and outside Finland. Recently Outotec has supplied engineering, process equipment and technology to PetroPlovsk PCL, the second largest gold producer in Russia with assets located in the Far East. Outotec supplied all major equipment for both the Malomir concentrator and Pokrovskiy pressure oxidation plant (Zaytsev et al., 2013). Outotec’s engineering expertise and proprietary process equipment were combined together with PetroPlovsk’s process know-how.

In addition to the Pokrovskiy autoclaves, Outotec has been recently awarded a contract for the supply of two autoclaves for a matte treatment plant in South Korea continuing a long history of matte leaching. A summary of autoclave installations is shown in Table 1.

Historically, Outotec has put substantial effort into improving gas-liquid mass transfer rates in autoclaves in order to maximise both autoclave capacity and utilisation of gaseous reagent. It has been proven by both laboratory-scale measurements and industrial experience (Outokumpu/Outotec) that head space gas incorporation has significant impact on gas-liquid mass transfer rate in an autoclave. To maximise reincorporation of head space oxygen, Outotec

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pressures twin impeller combination of OKTOP® agitators. Gas mass transfer performance of OKTOP impellers has been measured to be more efficient compared to standard autoclave solutions (Rushton turbine or Rushton/Pitch blade turbine combination). Outokumpu has successfully applied modern impeller design with enhanced head space gas reincorporation in many metallurgical processes, mainly in the former Outokumpu plants in Finland.

PRESSURE OXIDATION OF PYRITE AND ARSENOPYRITE

Pressure oxidation of refractory gold ores and concentrates made its commercial breakthrough in the mid-1980s. In acidic pressure oxidation the sulfide mineral matrix, mainly pyrite and arsenopyrite is destroyed and dissolved at high temperature and pressure using gaseous oxygen. Gold is liberated for leaching and recovery.

Multiphase reaction systems are complex in nature involving several parallel and consecutive reactions occurring at the same time. Also many physical phenomena such as interfacial mass transfer between gas and liquid phases as well as liquid and solid phase diffusion of reactants in the porous media increase the inherent complexity of the reaction system. Main overall chemical reactions occurring in the pressure oxidation autoclave are shown below.

\[ 2 \text{FeS}_2 + 7 \text{O}_2 + 2 \text{H}_2\text{O} \rightarrow 2 \text{FeSO}_4 + 2 \text{H}_2\text{SO}_4 \]  

\[ \text{FeS}_2 + 7 \text{Fe}_2\text{(SO}_4)_3 + 8 \text{H}_2\text{O} \rightarrow 15 \text{FeSO}_4 + 8 \text{H}_2\text{SO}_4 \]  

\[ 4 \text{FeAsS} + 13 \text{O}_2 + 6 \text{H}_2\text{O} \rightarrow 4 \text{H}_2\text{AsO}_4 + 4 \text{FeSO}_4 \]  

\[ 2 \text{FeAsS} + 13 \text{Fe}_2\text{(SO}_4)_3 + 16 \text{H}_2\text{O} \rightarrow 2 \text{H}_2\text{AsO}_4 + 28 \text{FeSO}_4 + 13 \text{H}_2\text{SO}_4 \]  

\[ 2 \text{H}_2\text{AsO}_4(a) + \text{Fe}_2\text{(SO}_4)_3(a) \rightarrow 2 \text{FeAsO}_4(a) + 3 \text{H}_2\text{SO}_4(a) \]  

\[ \text{Fe}_2\text{(SO}_4)_3 + 3 \text{H}_2\text{O} \rightarrow \text{Fe}_2\text{O}_3(a) + 3 \text{H}_2\text{SO}_4(a) \]  

\[ \text{Fe}_2\text{(SO}_4)_3 + 2 \text{H}_2\text{O} \rightarrow 2 \text{FeOH}_2\text{(SO}_4)_2(a) + \text{H}_2\text{SO}_4(a) \]  

Only a small amount of elemental sulfur is formed at temperature above 190°C, and the main products are ferric and ferrous sulfate and sulfuric acid.

Ferrous ion formed in the reactions is oxidised by molecular oxygen back to ferric ion, as seen in Reaction 8. Oxidation-reduction of iron plays an important role in the reaction system.

\[ 4 \text{FeSO}_4(a) + \text{O}_2(g) + 2 \text{H}_2\text{SO}_4(a) \rightarrow 2 \text{Fe}_2\text{(SO}_4)_3(a) + 2 \text{H}_2\text{O} \]  

Determining the predominant reaction mechanism and reaction kinetics of such a complex reaction system is not a straightforward task. Aqueous oxidation of pyrite has been reviewed by Lowson (1982), Papangelakis and Demopoulos (1991) and Long (2000). In spite of extensive research activity a unanimous consensus about predominant reaction mechanisms and kinetics of acidic oxidation has not been achieved among researchers.

Long (2000) noted that most of the published research has been carried out at temperatures below 180°C. Only limited data on the kinetics of pyrite and arsenopyrite dissolution in acid pressure oxidation is available at temperatures used in industrial applications, i.e. 190 - 230°C.

Long (2000) studied the behaviour of pyrite in acidic pressure oxidation at temperature 170 - 230°C and proposed that pyrite is initially oxidised to ferric sulfate by molecular oxygen according to reaction 9. Formed ferric ion oxidises sulfide in the pyrite according to reaction 2.

\[ 4 \text{FeSO}_4 + 15 \text{O}_2 + 2 \text{H}_2\text{O} \rightarrow 2 \text{Fe}_2\text{(SO}_4)_3 + 2 \text{H}_2\text{SO}_4 \]  

Long (2000) also reported that ferrous ion oxidation by molecular oxygen (Reaction 8) significantly affects the reaction rate of pyrite oxidation. Long (2000) discovered that
the overall initial reaction rate of pyrite dissolution is one half
order with respect to oxygen partial pressure, ie dissolved
oxygen concentration.

It has been reported by Lowson (1982) that the oxidation
rate of ferrous ion to ferric ion in sulfuric acid media is second
order with respect to ferrous ion and first order with respect
to dissolved oxygen concentration. Copper is also reported to
catalyse the oxidation rate of ferrous ion to ferric form.

Generally the reaction rate of pyrite in experiments
conducted in small laboratory-scale autoclaves is not limited
by interfacial mass transfer rates. However, in industrial-scale
applications, interfacial gas-liquid mass transfer rate plays an
important role and understanding and improving gas-liquid
mass transfer is a primary focus for Outotec agitation design.

AUTOCLAVE AGITATION

Outotec has two in-house R&D centres located in Pori, Finland
and Frankfurt, Germany. These centres are specialised in
process and equipment technology development for minerals
and metals production and are equipped with state-of-the-art
laboratories and pilot plants.

Outotec autoclave research activities include fluid dynamic
studies and equipment design as well as overall process
design. For example, nickel and cobalt reduction, nickel
and cobalt sulfide leaching and matte leaching have been
extensively studied. Complete technology solutions have
been delivered to Kokkola cobalt and Harjavalta nickel plants
in Finland. Recently autoclave technology and equipment
has been delivered for a matte leaching plant in South Korea
and for a refractory gold concentrate POX plant in Russia
(Petrovpolovks PLC).

Experimental

Outotec OKTOP impeller configurations have been tested
and compared against conventional Rushton impeller
systems. Both single and dual impeller combinations were
tested. Photographs of tested impeller types are shown in
Figure 1 and tested configurations in Table 2. Gas dispersion,
gas-liquid mass transfer rate and solid suspension properties
were compared in laboratory scale reactors. Tests were done
in two reactors with impellers having diameter of 74 mm and
130 - 136 mm.

Dispersion and suspension tests were performed in a
plastic Outotec style horizontal autoclave one compartment
model (see Figure 2), which replicates the industrial autoclave
compartment design. The horizontal autoclave model was
filled with 25.5 - 27.5 L of water. Gas dispersion tests were done
with 11 m³/h air feed at room temperature corresponding to a
superficial velocity (U) of 2.5 cm/s. The agitation power input
was defined with torque measurements during tests.

Different parameters were observed during the dispersion
tests in the horizontal autoclave model. Gas holdup was
measured by comparing the liquid level during agitation to
the unagitated condition. Impeller speed required for full
dispersion was recorded. Full dispersion occurs when gas is
dispersed throughout the entire reactor volume.

During solid suspension tests the just suspended (Np) speed
and suspension height at Np were determined with and
without air feed. Np is the agitation speed where all particles
at the bottom of the tank are moving within one to two second
interval. The origin of the Np definition is from Zweitering
further explained in Chudacek (1988). Quartz sand at a
concentration of 400 g/L and size of 100 - 125 µm was used.

Power input was measured also at ungassed conditions.
Ungassed power number was calculated from power input with
Equation 10:

\[ P = N_p \rho N^3 D^5 \]  

where:

- \( P \) is power input (W)
- \( N_p \) is power number (-)
- \( \rho \) is slurry density (kg/m³)
- \( N \) is agitation speed (1/s)
- \( D \) is impeller diameter (m)

Ungassed power numbers were used in power input
calculations at different agitation speeds, when ungassed
power was compared to gassed power. The number was
determined by completely filling the reactor with water with
no gas feed. In this way the mixing of gas into solution was
minimised. The determined power number values are shown
in Table 2.

The mass transfer tests were done at the SRC
Hydrometallurgy laboratory in St Petersburg to support
the Petrovpolovks autoclave design. Tests were conducted
in a vertical autoclave with an effective volume of 4 L and
diameter of 176 mm. The reactor had four baffles. A Rushton
turbine having eight blades was compared with a twin
OKTOP impeller set-up. The impeller diameters were 74 mm.
Impeller speed was 500 - 900 rev/min. Tests were done at
2.2 bar and 20°C. Pressure was controlled by oxygen addition.
Oxygen flow rate varied between 0.04 and 0.36 m³/h. Power
input was measured during the tests.

The mass transfer tests were based on the well-known
sodium sulfite oxidation reaction. A small amount of catalyst
such as cobalt or copper is needed to promote the reaction
as indicated by Linek, Benes and Sinkule (1990) and Vilaca
et al (2000). Oxygen mass transfer can be characterised with
liquid-side volumetric mass transfer coefficient, \( k_a \). When
assuming a well-mixed liquid phase the mass balance of
dissolved oxygen can be given in Equation 11:

\[ \frac{dC}{dt} = k_a(C^* - C) \]  

where:

- \( C^* \) is the saturation concentration of the gas in liquid
  (mol/m³)
### TABLE 2

Impeller configurations used in gas dispersion, solid suspension and mass transfer tests.

<table>
<thead>
<tr>
<th>Test type</th>
<th>Power number</th>
<th>Upper impeller</th>
<th>Bottom impeller</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Diameter (blades = blade angle (mm))</td>
<td>Location from surface (mm)</td>
</tr>
<tr>
<td>Dispersion</td>
<td>8.0</td>
<td></td>
<td>OKTOP2200</td>
</tr>
<tr>
<td>Dispersion</td>
<td>5.2</td>
<td></td>
<td>Rushton</td>
</tr>
<tr>
<td>Dispersion</td>
<td>9.1</td>
<td>136 (4 - 45°)</td>
<td>55</td>
</tr>
<tr>
<td>Dispersion</td>
<td>6.3</td>
<td>136 (4 - 45°)</td>
<td>55</td>
</tr>
<tr>
<td>Suspension</td>
<td></td>
<td></td>
<td>OKTOP2200</td>
</tr>
<tr>
<td>Suspension</td>
<td></td>
<td></td>
<td>Rushton</td>
</tr>
<tr>
<td>Suspension</td>
<td>OKTOP1000</td>
<td>136 (4 - 45°)</td>
<td>55</td>
</tr>
<tr>
<td>Suspension</td>
<td>OKTOP1000</td>
<td>136 (4 - 45°)</td>
<td>55</td>
</tr>
<tr>
<td>Mass transfer</td>
<td>OKTOP1000</td>
<td>74 (4 - 45°)</td>
<td>74</td>
</tr>
<tr>
<td>Mass transfer</td>
<td></td>
<td></td>
<td>Rushton</td>
</tr>
</tbody>
</table>

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**Experimental results and discussion**

OKTOP and Rushton agitator gas dispersion performance was compared and results are shown in Table 3 and Figure 3. Dispersion tests proved that OKTOP agitators out-perform Rushton agitators. Results show that full gas dispersion was achieved at ten to 20 per cent lower tip speed with OKTOP impellers. In an industrial scale autoclave, lower impeller tip speed would result in lower wear rates with lower maintenance cost and increased autoclave uptime.

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**TABLE 3**

Full dispersion agitation limits at air superficial velocity (Uₐ) of 2.5 cm/s.

<table>
<thead>
<tr>
<th>Impeller</th>
<th>Agitation (rev/min)</th>
<th>Relative tip speed (%)</th>
<th>Gas hold up (%)</th>
<th>Relative power P(gas) / P(ungas) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OKTOP</td>
<td>450</td>
<td>78</td>
<td>16</td>
<td>56</td>
</tr>
<tr>
<td>Rushton</td>
<td>550</td>
<td>100</td>
<td>20</td>
<td>44</td>
</tr>
<tr>
<td>Dual OKTOP</td>
<td>450</td>
<td>82/78</td>
<td>18</td>
<td>52</td>
</tr>
<tr>
<td>Dual Rushton</td>
<td>500</td>
<td>91</td>
<td>16</td>
<td>43</td>
</tr>
</tbody>
</table>

*Compared to un-gassed water volume.

Mass transfer performance was compared for Dual OKTOP and Rushton agitators. Volumetric gas-liquid mass transfer coefficient as a function impeller tip-speed is shown in Figure 4. This figure shows that at the same agitation intensity, gas-liquid mass transfer is 24 - 40 per cent more favourable for OKTOP impellers. Conversely for the same kₐ power consumption is lower with OKTOP impellers. Part of the difference can be explained by the enhanced head space gas reincorporation performance of the OKTOP design.

OKTOP and Rushton agitator solid suspension performance was compared and results are shown in Table 4. The suspension test results showed strong difference in required power input of just suspended point (Nₛ) between impellers and measured conditions as seen from Table 4. It is clearly seen that OKTOP overcomes Rushton in all cases.

Results show that the point of just suspension can be achieved with 15 - 53 per cent lower agitator speed with OKTOP impeller combinations gassed or ungassed. Also measured power input is respectively 40 - 130 per cent lower with OKTOP impellers. The above results show that higher
agitation intensity is required to disperse gas into liquid rather than suspend solids. Conversely, solid suspension is critical in systems having low gas feed rates.

### Computational fluid dynamics

CFD simulations are extensively utilised to support process development at Outotec. An example is presented below comparing OKTOP and Rushton agitators in an industrial scale autoclave compartment.

The velocity profiles and mixing times of OKTOP2200 and Rushton were simulated in 2.81 m long and 2.44 m diameter horizontal autoclave compartment with a volume of 9.8 m³. Impeller diameter was 850 mm located 595 mm from the bottom. OKTOP and Rushton impellers were compared with the same power input levels. The rotation speed of OKTOP was 95.5 rev/min and Rushton was 108 rev/min. A schematic picture of the calculation volume is shown in Figure 5.

Turbulence was modelled with realisable k-ε-model and agitation rotation with moving reference frame method. Free surface was modelled as a friction less wall. Simulation fluid was water at 20°C. Tracer value is monitored as a function of time at discrete points in the simulation volume. The fully mixed condition was determined by the point when tracer value was at most 0.5 per cent away from theoretical fully mixed value. Mixing times were monitored in six vertical and in seven horizontal level points. The total number of monitoring points was 18.

The velocity profiles seen from compartment head and side for both impellers are shown in Figure 6. Mixing times and flow numbers are shown in Table 5. Simulation results show that with the same power consumption and 12 per cent lower agitation speed the OKTOP impeller gives higher velocity and shorter mixing time than Rushton. The pumping number is 29 per cent higher and average mixing time 6 per cent shorter with OKTOP impeller than with Rushton.
**Agitator scale-up**

Scaling up the laboratory and pilot scale results to industrial size solutions is a difficult task. Outotec’s in-house developed agitation scale-up rules have been validated at industrial scale at Harjavalta and Kokkola plants ensuring efficient and economical autoclave designs. Based on in-house knowledge and experience Outotec is prepared to offer process guarantees for oxygen utilisation.

**HEAT RECOVERY SYSTEM**

**Outotec energy and water recovery system**

In the POX of sulfidic ores and concentrates autoclaves are often used whereby allowing high operating temperature and high oxygen partial pressure. The oxidation of these ores and concentrates is often highly exothermic and large amounts of excess energy can be generated.

Once leached the discharge of the autoclaves is commonly reduced in temperature and pressure by allowing the autoclave discharge slurry to flash, that is, to convert the sensible heat of the slurry at high temperature into a flash steam thereby cooling the leach slurry. Unfortunately the flash steam generated is dirty and contains often considerable ‘carryover’ slurry as explained in Nakai et al (2006).

The energy of sulfur oxidation can provide all the energy required to operate an autoclave at temperature with no additional energy input required. This point, often described as autothermal operation typically occurs with >5 per cent (w/w) sulfur in feed solids. In some applications, particularly for low sulfur ores, autothermal operation is not possible and fresh steam or recycled flash steam is contacted with incoming fresh feed slurry to preheat slurry, Mason and Gulyas (1999).

However in applications where there is an excess of sulfur (eg sulfide concentrates) above the autothermal limit, typically >8 per cent (w/w) sulfur, recycling of flash steam is not required and the autoclave must be cooled to maintain operating temperature. In these cases flash steam and the contained energy and water is wasted to atmosphere.

Outotec has developed process equipment and technology (Finnish Patent application no 20126354) to allow recovery of usable energy and water from autoclave flash steam. A flow sheet showing a typical application of the Outotec EWR system is shown below in Figure 7. Importantly the individual equipment components that make up the Outotec EWR are well-known technologies eg direct contact condensers, heat...
exchangers, pressure control valves, etc. The combination of these technologies allows efficient and flexible heat recovery tailored to the needs of the end-user.

The key features of the Outotec EWRS systems are:

- Direct contact tray-type condensers (e.g., E, F and G in Figure 7) are used to contact dirty flash steam with recirculating cooled condensate/slurry. Indirect condenser heat exchangers like shell and tube exchangers are avoided due to the potential of scaling and blockages.

- The condenser is fully integrated into the autoclave flash system with the corresponding flash vessel and condenser operating as one isobaric unit with pressure controlled on the outlet of each condenser. Fluctuations in autoclave operation can be readily accommodated with direct pressure control thereby minimising the impact on autoclave operations. Cool condensate flowrate can also be controlled to allow energy recovery to match the throughput of the autoclave.

- The direct contact condenser is a proven and highly efficient heat exchanger which operates counter-currently and can achieve very low approach temperatures enabling high temperature condensates to be produced.

- Non-condensables, if present, are continuously vented with the excess flash steam.

- By re-circulating condensate which already contains solids then nucleation sites for precipitation are provided which will help minimise scale on condenser trays and walls. However, even if scale formation occurs, then the internal trays are known to operate effectively even in a heavily scaled condition.

- Energy in hot condensate is transferred via indirect heat exchangers (e.g., H, I and J in Figure 7).

- These heat exchangers could be open plate type or spiral and they are designed for easy cleaning if and as required.

- Spare heat exchangers can also be provided enabling continued operation while off-line exchangers are cleaned.

- Using a condenser-heat exchanger combination allows the energy recovery to be decoupled from the direct pressure control required to maintain stable autoclave flash vessel operation.

- Transfer of energy from recirculating condensate allows broad possibilities for the utilisation of recovered energy and recirculation of the condensate to the condenser. For example, high-grade energy recovered from the high temperature stage (e.g., condenser E and heat exchanger H in Figure 7) could be used for generating clean, low- to medium-pressure steam in a boiler. Medium-grade energy (e.g., condenser F and heat exchanger I in Figure 7) could be used for example in district heating of buildings in cold climates, water desalination or could possibly be used internally within the metal recovery process plant itself.

- Importantly the pressure and hence temperature of each stage in the EWRS can be tailored and configured to the grade of energy required by varying the flash vessel-condenser design pressure.

- Also with appropriate pressure control (using pressure control valves e.g., L, M and N in Figure 7) the amount of energy transferred to the heat exchangers (e.g., H, I and J) can be varied within a predetermined range.

- Since steam is condensed some water is recovered and this water could be used within an existing process thus offsetting the use of additional fresh water.

**Example of energy and water recovery system**

Outotec has designed and is supplying equipment for an EWRS installation in far eastern Russia as presented in Zaytsev et al (2013). Commissioning of the plant at the Pokrovskoye site of Petropavlovsk Gold is expected in early 2014 and a flow sheet is shown in Figure 8. The description of the system follows.

Partial energy recovery from the oxidation of sulfide sulfur from gold concentrates will be installed with approximately 24 MW of energy recovered into a district heating system. This will reduce the significant cost of building heating during cold winter months.
At Pokrovskly high temperature slurry (at 225 - 230°C) from each autoclave will be flashed in two stages.

The energy from high-pressure (HP) flash steam will be converted into useful energy for district heating purposes. HP flash steam is at high temperature and provides a large driving force for energy transfer.

Flash steam generated from each HP flash vessel on each autoclave ‘train’ is directed to direct contact tray type HP condenser. There will be four autoclave trains and each train has a dedicated HP condenser associated with each HP flash vessel.

Recirculating low temperature condensate is pumped to the top of each condenser to partially condense flash steam. Excess flash steam is vented and pressure is controlled in both the HP flash vessel and the HP condenser via a pressure control valve on the vent line exit the condenser.

Since flash steam is partially condensed, water is recovered and recycled to a chloride washing circuit hence minimising fresh water usage for chloride removal. Chloride removal is critical to maximise gold recovery in POX circuits especially in the presence of organic carbon as explained in more details in Zaytsev et al. (2013).

Excess vent steam from each condenser is combined with the autoclave vent and atmospheric flash vessel steam and directed to a dedicated Outotec Venturi gas scrubber. There are separate scrubbers for each autoclave. Final steam and non-condensable gases discharged to the environment from the scrubber will be clean and essentially acid and solids free. During summer the heating system can be bypassed and all flash steam will be directed to the Venturi Scrubber.

Recovered high temperature condensate from the bottom of the condenser is directed to a primary heat exchanger (PHEX). There will be separate PHEXs for each condenser for each autoclave. Discharge from each PHEX is directed to a common condensate tank for all four autoclaves. This tank will be at atmospheric pressure and approximately 85 - 90°C in normal operation.

On the other (clean) side of the PHEX is a pressurised closed circuit circulating clean water operating on the hydronic principle using a separate expansion tank. By operating as a pressurised closed loop the electrical energy for pumping circulating water is minimised. The system is designed to prevent acidic contamination of the closed circuit circulating water system by operating at a higher pressure to the HP condenser-PHEX loop.

Heated recirculating water from the PHEX is then directed to a Secondary Heat Exchanger (SHEX). On the other side of the SHEX is pressurised cool water from a district heating system, which is heated from 70°C to 95°C. With this design the district heating water is isolated from acidic slurry/water.

CONCLUSIONS

With in-house research capabilities and engineering expertise Outotec can develop a project from conceptual study phase to detailed engineering and Outotec’s scope of supply can vary from single equipment to complete plant.

In addition to supplying key equipment, Outotec can design, supply, install and commission entire POX plants; this adds to and complements already existing significant experience in other hydrometallurgical process and proprietary equipment.

Outotec can offer enhanced and proven autoclave agitation systems that maximises oxygen mass transfer and utilisation while minimising wear.

Outotec can provide tailor-made solutions to specific client needs. As an example an innovative energy and water recovery process technology was developed and supplied for Petropavlovsk.
REFERENCES


