Outotec Service Portfolio and Recent Development in Managing Asset Performance

Juha-Pekka Lempainen* **and Markku Lindeman**

Service Offering & Concepts Development, Outotec, Espoo, Finland

**Corresponding author: juha-pekka.lempainen@outotec.com*

Maintaining and operating mining and metallurgical plants efficiently throughout their life-cycle is essential to the plant availability, productivity and total cost of ownership. In addition, by choosing a correct set of service activities that are performed on the sites, it will improve the safety and environmental issues and resource utilization. The services efficiency can be further leveraged by digital solutions and continuous optimization. The Outotec modularized service portfolio contains various elements, extending from the early phase of the plant design to the construction and commissioning phases and operation and decommissioning phases. These elements can be combined to respond to the actual customer need. The flexibility and adaptability of the service portfolio is demonstrated by customer case studies from Yamana Gold, Boliden Tara, Yara Siilinjärvi and African Rainbow Minerals plants. Recent developments in Outotec Services have been focused on supporting customers on how to manage and maximize the performance of their assets. By creating holistic and far-reaching maintenance and asset life-cycle plans in the early phase of the project and continuously reviewing them, the future needs of service activities can better be anticipated, resulting in lower total cost of ownership.

INTRODUCTION

Asset management is a trend that has been accelerating with business trends. Customers prefer to get the most out of their assets with minimum or optimum resources. Conventional asset management describes the way an organization works, and consists of policies, strategies and plans to realize the organizational objectives. Managing the asset performance mostly focuses on optimizing the operation and maintenance practices of the physical assets. Outotec, having a long history in equipment and service supply, is able to provide support to operations from a production point of view throughout the life-cycle of the production facility.

Asset management is an organization-wide activity that covers, for example, operations, maintenance, logistics and support operations (ISO 55000, 2014). Asset management is the coordinating activity that realizes the value from the existing assets. Outotec, as a service provider, cannot manage the whole asset management, unless all operations are outsourced to the service provider; however, service providers are able to give a second opinion on how asset management is taken care of and give advice for equipment, process island or plant-wide asset performance improvements. The Outotec asset performance service helps site management to identify low-hanging fruits, where the overall performance of the assets can be improved.

THEORETICAL BACKGROUND

The ISO 55000 standard family for asset management was published 2014. The main differentiator from its predecessor (PAS 55 standard from 2004) is that instead of focusing on equipment, the focus is on the value that the equipment brings to the organization. The key message in the standard family is that it is essential to align the organizational objectives with the asset management objectives. When defining the asset management objectives, the main elements include reviewing the risks and the importance of single assets. The importance of the assets is an essential part of managing the asset performance, as it affects their prioritization, which in turn determines the investment needs. One of the key documents is the Strategic Asset Management Plan (SAMP) (ISO 55000, 2014; ISO 55001, 2014 and ISO 55002, 2014). The core of Outotec's managing the asset performance concept is highly based on the ISO 55000 standard family.

Moving towards an asset management way of thinking is mostly about cultural change, aiming for "the life cycle management of physical assets to achieve the stated outputs of the enterprise". (AMBoK Publication 000: Framework for Asset Management, 2014). The assets play the main role in the standard, but many other functions and systems in the organization support the efficient use of the assets.

Depending on the project type and life cycle phase, the needs for managing the assets can vary. A typical way to categorize facilities' life-cycle phases is to divide them into i) business need analysis, ii) design, iii) create, iv) operate, maintain, upgrade/modify, v) dispose (O'Hanlon, 2014). These phases and respective tasks for the production and maintenance organizations are illustrated in Figure 1.

Every project starts with evaluation of the initial situation and defining the business goals. In this stage, the feasibility of the possible project is determined, as well as a rough design and cost estimation of the production facility. Typically, preliminary plans of the processing method and the way to maintain the plant are also set up in this phase.

In the next phase, design, a maintenance strategy and maintenance philosophy are established. For the production perspective, the research work, as well as plant design and engineering work are started. In the create phase, the maintenance strategy is brought to a more detailed maintenance plan level, based on the strategy, hierarchies and criticalities. In this phase, the plant is constructed and started up and a database and structure for managing the asset information and asset plans are set up.

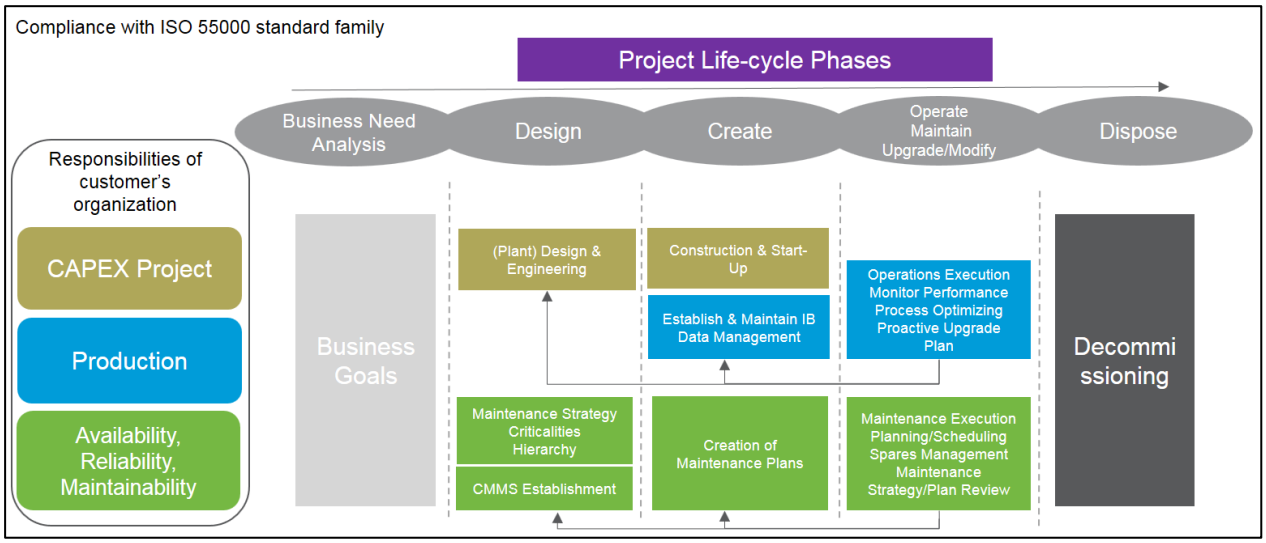

Figure 1: Managing asset performance framework.

After the production has started, the project moves to the operate – maintain – upgrade/modify phase. Here, the plant is maintained as defined in the maintenance strategy and plans. Other dimensions include spare parts and materials management. From the production point of view, it is important to monitor the performance of single assets, as well as the entire process. The performance of the maintenance and production must be followed-up, and the maintenance strategies and life-cycle plans need to be reviewed and updated (O'Hanlon, 2014).

Digitalization opens new opportunities for optimization of the assets' performance. Various remote services, online measurements and data gathering, and processing from multiple sources enable faster response to the needs and more thorough monitoring of the asset condition. (McKinsey & Company Insight, 2015).

MANAGING ASSET PERFORMANCE FRAMEWORK

Players in the mining and metallurgy industry can face various challenges. In the ISO 55002 standard, the issues are categorized as those of asset management, asset portfolios, asset systems and assets. From the business point of view, most if not all issues are related to i) environmental and safety performance, ii) availability, iii) productivity or iv) total cost of ownership, but the nature of the actual challenges can take very different forms. Therefore, it is important that every challenge is approached systematically and treated as an individual challenge.

Outotec's solution to these challenges in brownfield plants is to offer a second opinion on the maintenance and production practices and suggestion how to improve the operations. Typically, with minor changes in, for example, optimizing the processing parameters, reviewing maintenance instructions and maintenance execution and improving process and equipment follow-up, improvements in environmental efficiency, safety and financial performance can be achieved.

The asset performance framework can be applied in the case of upgrades or modernizations as well. Once an upgrade or modernization is installed and ramped up to production, it is very important to monitor its performance. If the upgrade only improves a functionality within an equipment or process island, but the value of the improved functionality cannot be realized, its benefits remain modest. Extracting value from the upgraded functionality can be supported through asset performance services, such as on-line condition monitoring, process optimization, remote services or preventative maintenance services. Verifying that the measures taken are correct and the desired outcome is achieved are also core elements in the asset performance framework.

Having asset performance practices in place for greenfield plants can bring value from the early phase of the plant life-cycle. During the project's design and create phases, detailed maintenance philosophy and practices can be defined in coordination with the capital project. By determining measurable Key Performance Indicators (KPI) and continuously following and analysing the maintenance and production performance, it is possible to quickly ramp-up the production and keep the Overall Equipment Efficiency (OEE) on a high level through reviewing the maintenance and production practices.

One key element in successful asset performance improvement is continuity. It is of utmost importance to constantly follow-up the process parameters, as well as the condition of the assets. Only by being up-to-date with the plant conditions is it possible to extract the most value from the assets. On the maintenance side, continuity is expressed as respecting the maintenance schedules and the review of the schedules, as well as continuously having sufficient inventory levels. Managing the asset performance cannot be seen as a project with start and end days, but as a process, which is continuously updating and improving the performance. Interaction and discussion between

customers, employees and service providers is essential to keep the performance of the assets at a high level. The asset performance management model is not static and asset prioritization must continuously be practiced. (AMBoK Publication 000: Framework for Asset Management, 2014; O'Hanlon, 2014). Using digital and remote capabilities for monitoring and analysing the process and equipment-related information offers a powerful tool to be used as basis for the continuous improvement actions, as is demonstrated in the Yara Siilinjärvi case.

Another substantial aspect in successful operations is managing the asset life-cycle. Information that is collected during the operations must be reflected on the life-cycle plan. This plan is part of the SAMP and the plan needs to be continuously updated. An updated life-cycle plan allows the required upgrades and modernizations to be performed at the right time for optimized plant output and also facilitates the budgeting activities when the impending investments are known and planned in advance. When using asset prioritization together with the life-cycle planning, the financials can be targeted more accurately to the value-generating assets and activities (O'Hanlon, 2014).

Much emphasis should also be put on defining the KPIs correctly. The traditional way of measuring only production or asset down-time does not give an accurate image of the true performance of the assets; therefore, KPIs, such as mean-time-between-failures (MTBF), maintenance cost and failure modes should be considered. (Dutra & Hupp, 2013).

Outotec's solution for optimizing performance of assets is to utilize much of the existing portfolios and methods in a new way. The main building blocks in in Outotec asset performance are:

- the Outotec service portfolio;
- the performance solution approach;
- the reliability-focused maintenance.

By selectively picking elements from these building blocks, a tailored solution to improve the customer's asset performance can be created for small or large scopes. Further, digital solutions can leverage the asset performance, as data can be collected and analysed in real time from the plants and equipment. In the following, a summary of these building blocks is given.

Service Portfolio and Performance Solution Approach

The performance solution is an approach and delivery method, where the challenges are evaluated in detail, and the optimum solution is composed and delivered. The performance solutions are combinations of standardized service products from the service portfolio, which lay the foundation for a successful service delivery. The key in delivering performance improvement to the customers is understanding, assessing and benchmarking the customer's current situation and then designing the performance solution to meet the requirements and asset needs. The process consists of four steps: assess; design; deliver; verify (Outotec, 2017a). The performance solution procedure is illustrated in Figure 2.

Reliability-Focused Maintenance

The reliability-focused maintenance philosophy concentrates on three main themes: reliability, availability and maintainability. The foundation of the reliability-focused maintenance lies in the reliability-centred maintenance (RCM), as per Moubray (1997), and the main themes are defined as follows:

- reliability: the probability that equipment will perform its intended function without failure for a specified time under specified conditions'
- availability: the probability that equipment will, when used under specified conditions, operate satisfactorily and effectively;
- maintainability: an inherent characteristic of a design or installation that determines the ease, economy, safety and accuracy with which maintenance actions can be performed.

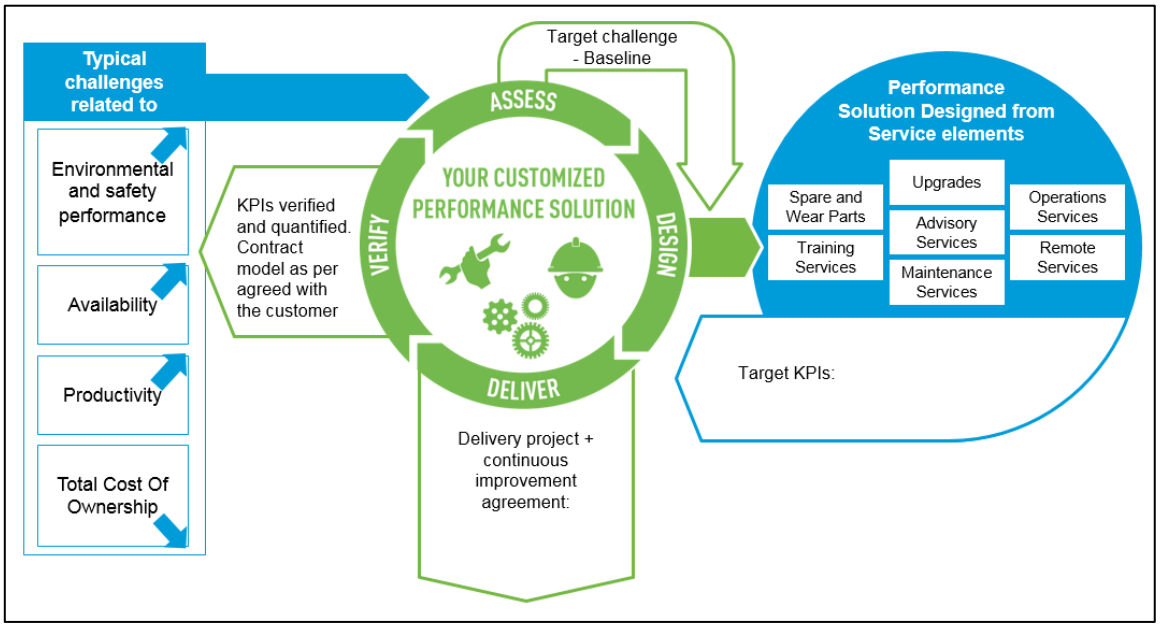

Figure 2: The performance solution framework.

The Outotec reliability-focused maintenance consists of six steps, starting from hierarchy structures to equipment criticality analysis to reliability monitoring and a continuous maintenance improvement programme. Maintainability of the equipment already starts from the hardware design and delivery, because the equipment and plant layout can be designed in a way that the maintenance work is easy, fast and safe to execute. The reliability focused maintenance framework is illustrated in Figure 3 (Outotec, 2017b).

Figure 3: Reliability-focused maintenance.

The main target for the reliability-focused maintenance services is to avoid the six big losses, and thus improve the OEE (Bamber *et al.*, 2003):

- breakdown losses;
- setup and adjustments losses;
- idling and minor stoppage losses;
- reduced speed losses;
- quality defects losses;
- start-up losses.

CASE EXAMPLES

Yamana Gold

Yamana Gold is a Canadian-based gold producer, with mines and operations in Canada, Mexico, Brazil, Argentina and Chile. The Chapada open pit gold-copper mine in Brazil began production in 2007 and in 2015, Yamana operators detected that they were losing valuables to tailings. In addition, the flotation circuit suffered from poor availability that was caused by heavy sanding. Together with the customer, it was decided to develop a solution to solve the operation challenges, and in March 2016 Outotec began turn-key retrofit of ten existing 160 m^3 flotation cells with Outotec TankCell® and FloatForce® technology.

At the beginning of the project Outotec completed an in-depth metallurgical assessment of the flotation circuit and identified potential for improvement in the flotation plant, which could positively affect the overall copper and gold recoveries. The project scope also included computational fluid dynamics (CFD) studies, basic and detailed engineering, shutdown planning, delivery of proprietary equipment, turn-key installation, commissioning, assisted operation and advanced virtual experience training of on-site personnel.

The upgrade resulted in more stable flotation process with higher recoveries in copper and gold, 40% energy savings and increased availability through prevention of sanding in the flotation cells (Outotec, 2016).

Boliden Tara

Tara Mine was established in the late 1970s and the mine has gone through several developments and modernizations over the years. The flotation was updated in the early 1990s and the filtration replaced in 2006. In 2009 the crushing and grinding circuits were replaced by a new autogenous (AG) mill.

In 2005, a long-term service agreement was established with Tara Mines, with the target to minimize analyser downtime and to obtain more reliable results for process control. The service scope was modular and consisted of preventative and corrective maintenance activities. Much emphasis was put on careful planning of the maintenance activities, as the cost of unplanned maintenance is significantly higher than planned maintenance. It was essential to identify problems before they occur and to plan repairs in such a way that time and money were not wasted. Even small failures can affect the entire process and therefore unexpected component or equipment failures need to be prevented.

With the agreement, the customer managed to reduce the overall maintenance and operation costs, as well as improving the equipment uptime. The agreement also released the use of the customer's own expertise to other activities and helped to identify other improvement opportunities to support the optimum usage of the asset (Outotec 2013a).

African Rainbow Minerals
The Two Rivers Platinum Mine is located in in South Africa, near the town of Steelport. Apart from platinum, the mine also produces palladium, rhodium, gold, ruthenium, iridium, platinum-group metals (PGM), nickel and copper. In 2006, the designers installed an Outotec Larox® PF60 filter in the refining plant, and in 2008 the filter capacity was further enhanced with a plate pack expansion.
From the beginning, it was important to prevent potential problems with Outotec maintenance services. Almost every week since the plant opened, an Outotec technician has visited the African Rainbow Minerals-operated plant to conduct eight hours of checks and regular maintenance. When something occasionally happens between those visits, Outotec is supporting the customer with 24/7 availability for service, guaranteed emergency response times and spare parts. Although a maintenance service agreement helps to add years of life to industrial equipment and lower maintenance costs, it can be even more effective when a close partnership exists between the maintenance team and the customer. Much of the maintenance work is done by the customer, for example, washing and housekeeping. Proper tools, such as overhead cranes and maintenance tables and tools, facilitate the maintenance work. The joint target is that the filter availability can be increased to 95% (Outotec 2013b).

Yara Siilinjärvi
The Yara Siilinjärvi plant is located in Finland and is owned by Yara International ASA, a Norwegian fertilizer company and it produces apatite concentrate mainly for its Siilinjärvi phosphoric acid plant. The mine had a challenge with its tailings area filling up and the customer decided to solve the issue with a paste plant that increased tailings solids content, improved tailings beaching properties and extended the capacity and lifetime of the existing tailings storage facility. The new plant's objective was to achieve a high solids underflow and thus extending the tailings pond lifespan from 2020 to 2035. Factors such as the plant's location, changing mineralogy and tailings feed fluctuations made it challenging to reach these solids underflow and beach slopes targets.

The operation of the new plant was optimized by implementing an advanced control tools (ACT) thickener optimizer, which is based on the ACT platform. The thickener control application uses the model predictive control (MPC) algorithm, which is a well-suited method for controlling processes with a multivariable character and complex response dynamics. The ACT thickener optimizer system also included a remote connection to the Outotec network, so that the controller performance monitoring, tuning and support could also be performed remotely.

With the Outotec ACT thickener optimizer, the paste thickeners can consistently run with a high, stable underflow solids content and thus lengthening the tailings storage's lifetime. Additionally, the control optimizes the use of flocculant, delivering 10–20% savings in flocculant costs. The solution has also contributed to high availability (>97%) of the plant and ability for partial remote operation of the process (Outotec 2017c).

These cases are demonstrations of how the service portfolio, the performance solution approach, reliability-focused maintenance and digital services are utilized to create value. The case examples have different focus technologies and the ways to solve the challenges are different: the Yamana case used the performance solution approach; in the Boliden and African Rainbow Minerals cases, reliability-focused maintenance; and, in Yara, a digital solution was used. However, the core of every solution was to improve the performance of the existing assets by upgrades, or refining the operation and maintenance practices, delivering more value.

The methods demonstrated in the case examples are also not exclusionary and, for example, the Boliden Tara and African Rainbow Minerals cases could have further been leveraged with digital services; having accurate, real-time information of the equipment condition should facilitate maintenance activities. The collected information could also be used for further improving the

maintenance practices and optimizing the spare parts consumption. If thinking forward in terms of asset performance, it could be considered what is the role of the analyser in the whole plant value chain - how the plant productivity and availability can be enhanced with a well-working analyser and could, for example, the milling circuit or flotation grade be further optimized? As for the Yamana Gold case, a continuous service agreement with digital services could have leveraged the benefits from the upgrade. Through a continuous improvement programme, additional bottlenecks both upstream and downstream could have been identified and solved. In the Yara Siilinjärvi case, the next steps will be to move to remote operation of the plant and maximizing the availability.

With an extended set of services, the requirements set in the ISO 55000 standard family are also better met. Following the standard should not be a project, but a continuously moving and improving process. Typically, the scope of an asset performance solution extends to the whole plant or plant island; improved functionalities of single equipment remain irrelevant if not all the process steps are working as designed.

Outotec's statement is that if more of the service elements are used in conjunction with each other, even more value can be created. The service portfolio contains the most important service products and upgrades that lay the foundation for the service delivery. The performance solution approach ensures that the right challenges are targeted and correct KPIs are set and the reliability-focused maintenance targets high availability and reliability of the equipment or plant. Digital solutions provide a way for quicker support in troubleshooting cases and possibilities to optimize the operations and maintenance with the assistance of collected information.

DISCUSSION

The ISO 55000 standard family was released in 2014, but advanced players had taken many of the issues mentioned in the standard into account much earlier. Through standardization, the focus on the performance of the assets has gained importance and more operators in the field of mining and metallurgy have started to pay more attention to asset management.

Outotec is able to support operators in sustaining high asset performance through the entire project and plant life-cycle. Tools and methodologies exist in our portfolio, but the way in which they are used in conjunction with each other is recently developed. The case examples from Yamana Gold, Boliden Tara, African Rainbow Minerals and Yara Siilinjärvi demonstrate how the elements work together and how value can be created by combining the different products and methods. These cases achieved productivity leaps or capital savings, with sustained value creation from the existing assets. In future cases, it will be important to focus more on the continuous improvement and ensure that the SAMP and life-cycle plans are regularly revised and updated.

However, the customers' challenges need to be considered as individual tasks and therefore *productising* or *standardising* a single approach to improving asset performance is meaningless. It is more important to evaluate the challenge itself, the possible solutions and the generated value in a systematic manner and using the best available tools and products to find the optimal solution. In this way, it is more likely that the benefits from existing or upgraded functionalities are targeted correctly to improve the entire plant safety, productivity and availability. The asset performance method also enables that the benefits can be sustained and the enhancements in maintenance and production practices can be standardized and improved in the maintenance strategy and life-cycle plan.

REFERENCES

AMBoK Publication 000 (2014). Framework for Asset Management. 2nd edition. Asset Management Council Ltd. Oakleigh, Victoria, Australia.

Bamber, C.J., Castka, P., Sharp, J.M., Motara, Y. (2003). Cross-functional team working for overall equipment effectiveness (OEE). *Journal of Quality in Maintenance Engineering*, 9 (3), 223–238.

Dutra, L.A. (2013). Asset management in mining: a practical case on obtaining a reliable performance, risk and cost measurements. *IAM Asset Management Conference 2013*. Institution of Engineering and Technology, London. pp. 1–8.

ISO (2014a). *ISO 55000: Asset Management – Overview, Principles and Terminology*. International Organization of Standardization, Geneva.

ISO (2014b). *ISO 55001: Asset Management – Management Systems - Requirements*. International Organization of Standardization, Geneva.

ISO (2014c). *ISO 55002: Asset Management – Management Systems – Guidelines for the application of ISO 55001*. International Organization of Standardization, Geneva.

Durrant-Whyte, H., Geraghty, R., Pujol, F., Sellschop, R. (2015). ow digital innovation can improve mining productivity. *Our Insights.* McKinsey. (https://www.mckinsey.com/industries/metals-and-mining/our-insights/how-digital-innovation-can-improve-mining-productivity [accessed 14 Mar 2018).

Moubray, J. (1997). *Reliability-Centered Maintenance*. 2nd edition. Industrial Press IncPlease give place of publication.

O'Hanlon, T. (2014). *The (New) Asset Management Handbook. A Guide to ISO55000*. BEWAS Belgium Maintenance Association, Antwerp.

Outotec (2013a). *Outotec Service Agreement for Courier® Analyzers.* http://www.outotec.com/globalassets/references/ote_oia_outotec_service_agreement_for_courier_analyzers_eng.pdf [accessed 20 May 2018].

Outotec (2013b). How Maintenance Service Agreement maximizes your availability - servicing an Outotec Larox® filter in South Africa. https://www.outotec.com/globalassets/references/ote_oia_maintenance_service_agreement_eng.pdf [accessed 20 May 2018].

Outotec (2016). Success story: Turn-key flotation retrofit with fast turnaround for Yamana Gold in Brazil. https://www.outotec.com/globalassets/newsletters/minerva/2016-2/ote_turn-key_flotation-retrofit_with_fast_turnaround_for_yamana_gold_in_brazil.pdf [accessed 14 Mar 2018].

Outotec (2017a). *Internal Training Material: Outotec Performance Solutions.* Outotec, Helsinki.

Outotec (2017b). *Internal Training Material: Reliability Focused Maintenance*. Outotec, Helsinki

Outotec (2017c). Success story: Enhanced paste plant control with ACT thickener Ooptimizer at Yara Siilinjärvi. http://www.outotec.com/globalassets/references/yara-act-thickener-control/ote_case-study _yara-act-optimized-paste-plant-control.pdf [accessed 20 May 2018].