Challenge and Experience with Implementation of New Wastewater Treatment/Water Reuse Process

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The Manufacturing of wire for aerospace, medical and telecommunication industries employs reel-to-reel plating operations. The wastewater generated from the wire plating was treated by a labor intensive method in an aging wastewater treatment system. The approaching renewal of their town discharge permit inspired management to review their wastewater treatment operation and environmental obligations. Scrapping of the old wastewater treatment system and installing a new wastewater treatment process enabled Phelps Dodge to purify and recycle 80% of their wastewater. Implementation of a new filtration technology for wastewater treatment/water reuse process brought a challenge to the employees.

A new wastewater treatment/water reuse system was installed to meet the City of Inman's POTW. However, it required familiarization and retraining of employees in three shifts to new demands related to supervision of new automated treatment systems, water conservation, water quality criteria for plating operation, etc.

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Background Overview

The manufacturing of high performance conductor wires involves the use of plating processes which include nickel, silver, and tin. The wastewater generated from the wire plating operations needs to be treated for the removal of regulated pollutants prior to discharge to the local publicly owned treatment works (POTW).

In the old wastewater treatment plant, the wastewater streams were segregated according to the nature of the contaminants and their treatment compatibility. The wastewater treatment operations were handled in a central location within the building and in the middle of the manufacturing operation. The wastewater was processed by traditional treatment methods employing cyanide destruction by the alkaline chlorination technique, metal removal by hydroxide precipitation, and separation of precipitated heavy metals by gravity settling. One licensed wastewater treatment operator handled the complete wastewater treatment operation and the management of the wastewater generated in the three manufacturing shifts ($\leq$ 35,000 gal/day).

The old equipment, with increasing maintenance cost and labor intensive processes lead to the retirement the old wastewater treatment set-up and the replacement with a modernized wastewater treatment operation, utilizing up-to-date treatment techniques, materials and standards. Water conservation and the implementation of a water recycling step was part of the strategy.

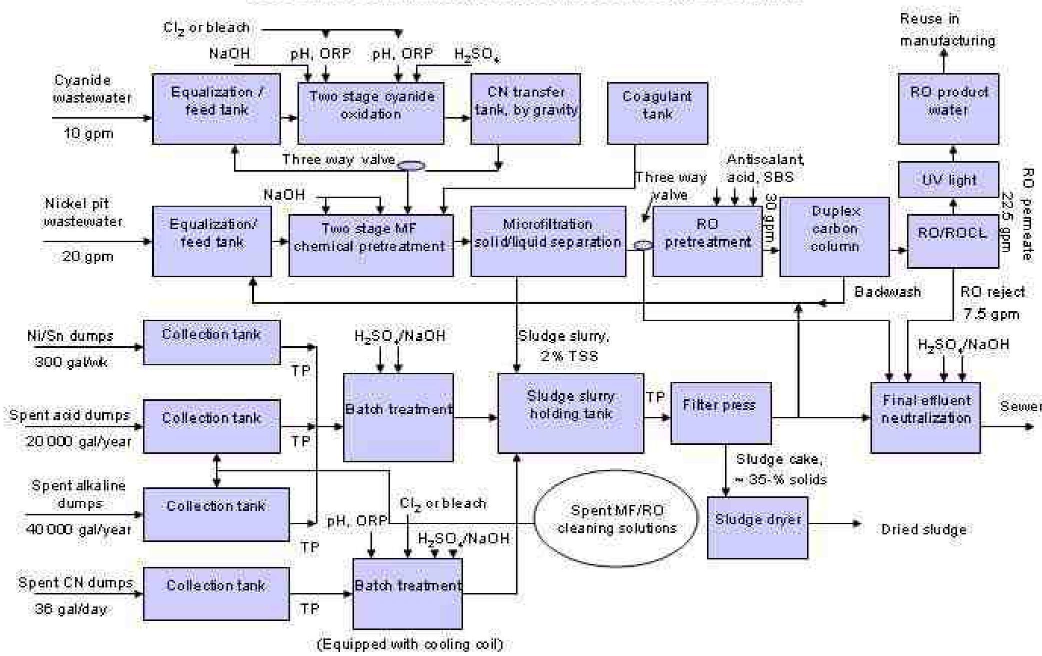
Execution of Plan

The management and environmental engineers undertook the evaluation of wastewater treatment/water reuse technology for their South Carolina plant. The target was set to recycle 80% of their wastewater generated by the manufacturing operation.

The engineers were attracted by the filtration approach of handling wastewater treatment and water purification tasks, since this technique would produce the water quality required for process and also meet the targeted hydraulic flow rates for reuse.

The overall evaluation stage of a suitable technology and discussions with technology providers resulted in the selection of a chemical precipitation and microfiltration (MF) wastewater treatment followed by reverse osmosis (RO) water purification for the recycling of the wastewater. An alternative source of on-site generation of oxidizers for cyanide destruction was rejected due to unsafe operating conditions and unfavorable economics. The chosen treatment of cyanide-bearing waste was to use the time proven two-stage cyanide oxidation process for rinse streams, and dedicated batch treatment for destruction of the spent silver cyanide solution. The treatment scheme also applied a new batch treatment reactor for the handling of non-cyanide bath dumps. The waste management design directed batch treated solutions and solid slurry from the microfiltration system to the sludge slurry holding tank for further solid concentration by a filter press. In order to increase the percentage of recycled water, the filter press effluent would be returned to the main wastewater treatment system for reprocessing and subsequent purification for water reuse. To accommodate this new process, a new location inside the manufacturing building for the wastewater treatment operation was selected.

Wastewater Treatment / Water Reuse Process Flow Diagram



System and Process Start-Up

Initiation of wastewater treatment operation appeared to be slower than expected. Start-up of hardware such as mixers, pump, chemicals feeds and other components were straightforward tasks accomplished in a short time frame. However, transforming to a computerized operation, synchronization of all components, and controls by vendors caused delays. With the excellent cooperation of the customer during the system start-up and shake-out phase, the system was placed into full operation in a short time achieving the recycle and compliance goals.

The system was designed to handle a mixture of waste streams (cyanide and non-cyanide streams, and the effluent from the two batch treatment operations). The suitable treatment chemistry was determined during the treatability study, which was conducted during technology selection stage. Actual system start-up required minor optimization of the pretreatment chemistry.

Difficulties encountered were related to new processes and equipment. Cyanide oxidation, precipitation of heavy metals and its separation by gravity settling and filter press were all known processes. The new approach utilized membrane microfiltration for solid/liquid separation, water purification by reverse osmosis, system and the process was managed by a PLC controlled system with a number of new settings and alarms. New batch treatment recipes, etc. were handled by a first shift operator and shift supervisors for the afternoon and night shifts. The operator training was implemented gradually, introducing every unit operation one step at a time, with each piece of equipment, treatment concept, and operational parameter, explained in detail, in order to avoid information overload. The equipment provider and customer operator trained supervisors in each shift as well.

Learning Period

Operator and shift supervisors managing the new wastewater treatment/water purification equipment and process needed to understand the new equipment, new water management concept and newly applied technology of water for reuse. The new major concepts that were required for the successful implementation of this project are as follows.

- *Terminology and Parameters.* The implementation of wastewater recycle process involved the introduction of new terminology and a new vocabulary, such as total dissolved solids (TDS), conductivity/conductivity meter, flux (GFD units), pressure values, back pulse, backwash, UV light intensity, recovery ratios, SDI index, anti-scalant, brine seal, new chemical names, programmable logic controller (PLC), control loop, etc.

- Since microfiltration technology was utilized for wastewater treatment and water purification, in place of conventional settling, different operation practices needed to be applied for each system, such as:

  - *Continuous and alternating operation*. The membrane microfiltration system does not run continuously. High filtration rates after membrane cleaning results in on and off operation due to high output of the membrane portion of the system causing the wastewater in the circulation tank to deplete and then the need for the system to wait for this tank to refill. On the other hand the reverse osmosis filtration works best under a continuous feed operation. Properly sizing the tank between the microfilter and the RO unit allowed for these specifics to be accommodated.

  - *Membrane cleaning*. Microfiltration and reverse osmosis membranes require periodical cleaning. The cleaning techniques are about the same, but the cleaning chemicals and its strength differ greatly. The MF membrane will tolerant strong acid (pH <1), caustic (pH >13), and oxidizers (bleach, hydrogen peroxide). The RO membrane is sensitive to pH (pH limits of 2 and 12) and oxidizers.

  - *Membrane cleaning criteria.* These are different as well. Typically the RO membrane cleaning requirement is when the filtration output declines by 10 to 15% or the differential pressure increases by 15%. The MF membrane cleaning is needed only when filtrate flow volume is lower than the wastewater feed flow.

- *Planning of batch treatment operation*. The performance of the water purification system and produced water quality depends on feed flow characteristics and TDS (conductivity) values. Spent bath solutions contain high TDS concentrations, therefore, treatment needs to be properly organized to minimize the negative impact on the RO performance (lower recovery rate, higher conductivity of product water). This can be achieved by carefully scheduling the batch treatment of spent bath solutions and slowly introducing the introduction of batch treated concentrated solutions to the main wastewater flow.

The primary treatment of spent cyanide solution was an issue for the operator. Excessive treatment time (up to 1-2 days in a dedicated cyanide reactor), coloration of RO feed water, elevated conductivity of the RO product water and the reduced MF filtration performance puzzled the operator, until a full understanding of the mass balances, equipment tolerance, and operation limits were attained. Once these were achieved and the planned and controlled batch treatment operations were implemented, the performance of the wastewater treatment and recycle plant was significantly improved.

- *Control and alarms*. The new generation of wastewater treatment/water reuse systems are controlled by PLCs and touch screen (panel view) or computers. The age of making knob and screw adjustments on instruments and analog devices is history. Modification of operation parameters or setting requires knowledge of the provider's panel view or computer graphics. In this instance, the PLC was also set up to accept input from a laptop or phone line connected to the appropriate computer in equipment provider facility.

- *Compatibility issue.* Certain chemicals and applied parameters, which are beneficial at one operation step, can be harmful in another process step. An example of this is the oxidizers used to destroy the cyanide. Cyanide is destroyed by a two-stage oxidation process to form nitrogen and carbon dioxide using bleach. Residual bleach, however, is incompatible with reverse osmosis membranes. A properly applied RO pretreatment step and even placement of the carbon column prior to the RO system eliminates potential problems with the life of RO elements (membranes) and their performance. Operator knowledge of compatibility issues and the focus on adequate operating parameters result in good system performance and operation economics.

- *Personal approach*. The fact is that the conversion from an older wastewater treatment process and concept using basic design that was relatively labor intensive to a new automatic wastewater treatment/water purification system and process required a learning period. A positive attitude and willingness of the operator and other employees to gain knowledge and understanding of the new technologies, equipment function, and control philosophy shortened the time needed for familiarization and confidence to handle the new operation. Once the new tasks were understood, the overall operational management of the system proceeded smoothly, bringing an easy and stress free working environment.

System Operation

The traditional removal of regulated contaminants prior to discharge to the sewer was changed to utilize a more sophisticated water recycling concept. The water purification process removes impurities (pollutants) from water, which due to the rejection of the contaminants, such as regulated heavy metals in the RO unit, wind up concentrated in the RO reject stream. This is the only stream sent to the sewer. Since the reject stream is directed to the sewer, contaminant levels cannot exceed discharge limits. In order to produce good quality of water for reuse and compliance, quality effluent and an efficient wastewater treatment process is needed. At 80% of water recovery for reuse, contaminants are concentrated 5 times in the final effluent. It is not difficult to meet even stringent discharge criteria on continuous base by using appropriate technology, optimized pretreatment chemistries and the operator understanding the process and equipment.

This plant reuses ~80% of the treated wastewater in their operations. Wastewater characteristics and effluent are shown below.

Parameter (mg/L)	Cyanide Rinse	Non-Cyanide Rinse	Spent Cyanide Solution	* Mixture of Spent Solutions	Final Average Monthly Effluent
Chromium	0.0717	0.543	0.693	2.1	<0.010
Cadmium	0.0847	<0.050	<1.0	<1.25	<0.0050
Copper	33.6	20.4	580	336	0.036
Lead	0.135	<0.050	<1.0	<0.250	<0.0050
Nickel	1.49	184	10.1	21.9	0.49
Silver	0.211	0.288	<1.0	0.774	0.024
Zinc	0.211	0.288	<1.0	0.774	0.024
Cyanide	7.7	N/A	3,010	N/A	<0.010
Oil and Grease	<5	<5	121	<5	<5

* Spent concentrated tin/nickle solution, spent acid, alkaline cleaner

The criteria for product water to be reused in the manufacturing operation is a conductivity value of <300 µS/cm. The RO system is programmed in case the product water exceeds a value of 300 µS/cm. An alarm will sound and the stream will be directed to the sewer instead of the product water collection tank.

Discussion

The new wastewater treatment/water purification, reuse system transformed the plant water management and environmental standing to up-to-date category. The change required a learning stage, involving employees to dedicate a portion of their time to observe and learn the operation. Periodical communication with the system and process provider to answer questions and provide directions was also part of the familiarization with the novel operation. Once the operator, engineers and employees gained confidence and discovered that the operation was user-friendly, they valued the system's stable performance with minimal maintenance requirements, a constant source of good water quality for manufacturing operation and a stable effluent meeting compliance criteria. In this plant, wastewater treatment/water reuse operation is managed by just one operator in the first shift with the assistance of second and third shift supervisors. They periodically check the system status and respond to alarms if they occur.

