New Style Automatic Self-Cleaning Filters for Mill Cooling Water (Phase 1)

Marcus N. Allhands
Amiad Filtration Systems
2220 Celsius Avenue
Oxnard, CA 93030
Tel.: 805-377-8580
Fax: 805-988-3313
E-mail: marcus@amiadusa.com

Key words: Filters, Filtration, Hot Roll Cooling Water, Automatic Filters, Steel Mill Cooling Water

ABSTRACT

Replacement of hot-mill rolls is expensive and often requires production to cease during the process. Surface deterioration of rolls escalates as cooling water quality decreases. This manuscript will describe the installation and performance of a new cooling water filtration system in a northeast Ohio hot-roll mill that incorporates well proven suction scanning technology with wedge-wire screens for the first time. The advantage of this combination is to provide an efficient self-cleaning method with high strength screens to make a reliable filtration treatment system for maintaining high quality cooling water.

INTRODUCTION

The greatest of well-planned schedules (and technical papers) are often foiled by unforeseen circumstances. The topic of this manuscript was to have been installed and in full operation six months ago. Actually it was put into service only fourteen days before the writing of this paper. Construction delays happen! Therefore, this manuscript will be addressed as "Phase 1" giving a description of the system, its expectations and future fine-tuning steps. Phase 2 will be prepared for a future AIST Conference containing performance data, system robustness and operator comments.

BACKGROUND

The V&M Star Steel (formerly North Star Steel) facility in Youngstown, OH has an annual output of approximately 500,000 metric tons of finished product. That product being Oil Country Tubular Goods (OCTG), Line Pipe, Standard Pipe, Coupling Stock and Mechanical Tube. OCTG makes up about two-thirds of the output. Following the 85-ton electric arc furnace is a 3-strand continuous caster of 8¾ inch or 11¾ inch rounds. In 1987 a 6-strand retained mandrel hot roll mill was installed along with a walking beam reheat furnace to make the finished products previously listed. At the same time a new filtration system was incorporated into the mill to remove solid particles that could plug the spray nozzles used to cool the rolls. The 1/16th inch gapped wedge-wire filters were to be automatic self-cleaning but for most of their seventeen year life they were bypassed because they simply could not automatically self-clean. The method of self-cleaning used in these initial filters was simple back-flushing of the screens. Two years ago mill engineers decided to look at replacing the original filters with ones that could meet the challenge; they had to perform.

SYSTEM DESCRIPTION

V&M Star Steel cools and cleans the hot mill rolls with water spraying from nozzles with 1/8 to 1/4 inch orifices. If these orifices get plugged with debris, the rolls will not get proper cooling and their life will be greatly compromised. Water falling off these rolls gets collected into flumes in the mill floor along with all manner of dirt and debris off the floor, equipment and supporting structures. The flumes discharge into a scale pit where settling of the largest and heaviest particles occurs. A clamshell bucket is used to dip solids from the bottom of this pit every two or three days. Water from the scale pit is pumped to a cold well where it is picked up by the process pumps at the rate of 7000 gpm and pressurized to between 140 and 150 psi. This flow then passes through the subject filters before being delivered to the cooling nozzles once again. Lubricating oil lines can burst at any time dumping as much as 4000 gallons of oil into the floor flumes. Graphite is added continuously to the rolling process turning the cooling water to mud. Blowdown from the cold well and other areas of the plant as well as flush water from the filters goes into a sludge thickener (clarifier) where sludge is removed from the bottom and sent to a filter press to be trucked off-site. Oils and greases are skimmed off the top while the effluent is re-entrained into the system by being sent back to the scale pit. Polymers, ferric chloride, detergents and lime are added to the cooling water to facilitate the settling of particles in the scale pit, cold well and sludge thickener. The filtration system must deal with all these chemicals, solids, oils and greases without compromising the protection of the nozzles and its own hardiness. The next quest was to find the best filtration system for the application.

DISCUSSION

Screen Construction

There are three basic types of screen construction in the filtration industry. The first type of screen construction is the oldest type of screen made from metal. It is composed of perforated plate formed into a cylindrical shape. The diameter of the round perforations represents the nominal filtration degree. A segment from a simple perforated screen element is shown in Figure 1.

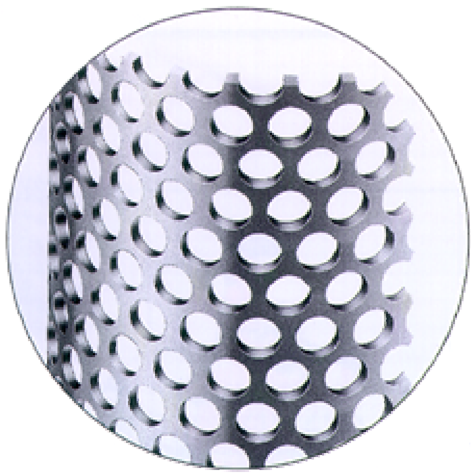

Figure 1 Perforated screen construction

The second construction type is called wedge-wire screen and is formed by laying stainless steel wires, having trapezoidal shaped cross-sections, parallel to one another with a small gap between each wire as shown in Figure 2. The openings therefore are long slots with the width of the slot being the nominal filtration degree normally expressed in microns. The assembly is usually formed into a cylindrical element with the wires running circumferentially. Wedge-wire screen elements are one of the strongest and most durable types of screens available for filtration.

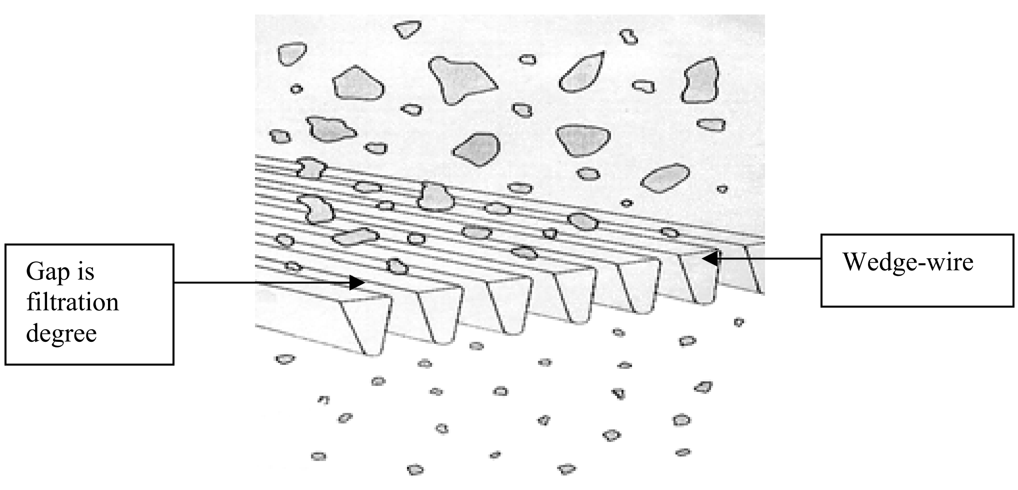

Figure 2 Typical wedge-wire screen construction

Weave-wire screens represent the third type of construction and, like perforated screens, have a discrete opening as opposed to the slot of wedge-wire screens. A simple two dimensional square-weave is shown in Figure 3. The shortest straight line dimension across a single rectangular opening would be the nominal filtration degree.

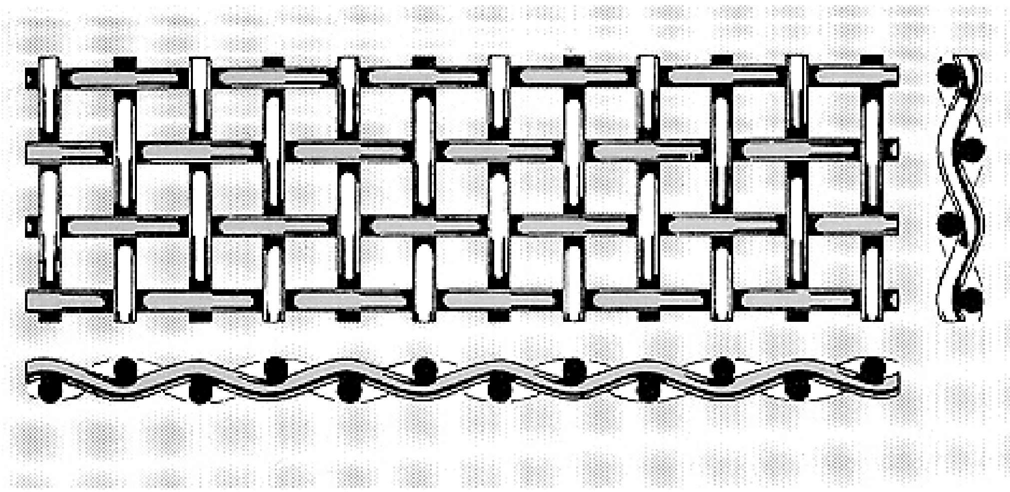

Figure 3 Typical square weave-wire screen construction

However, most weave-wire screens today do not use a square-weave but other weaves such as Dutch Weave and Double Dutch Weave. Figure 4 shows an example of Dutch Weave. Note that the openings are not rectangles but three dimensional warped triangular surfaces. The nominal filtration degree would be represented again by the shortest straight line distance across an opening. This type of weave is stronger and provides more dirt holding capacity at small filtration degrees (<500 microns) than a simple square weave.

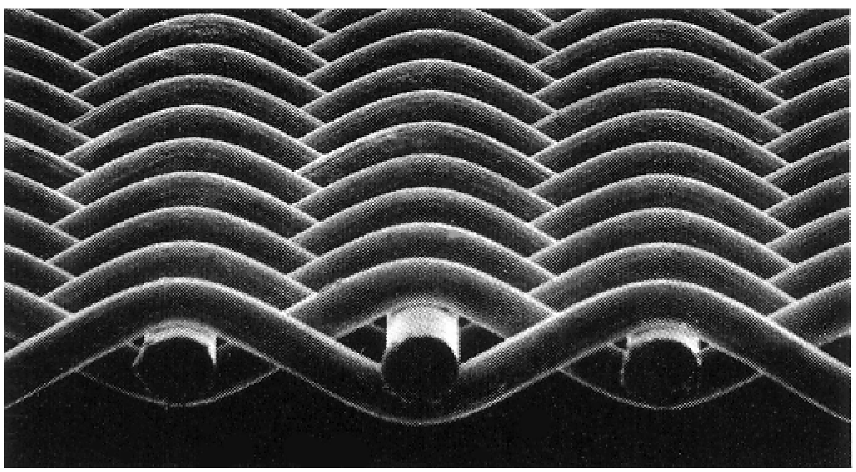

Figure 4 Dutch weave screen construction

Screen Cleaning Methods

Filters using perforated or wedge-wire screen elements typically clean the filter cake, or debris, automatically off the screen by one of two methods. The filter can be taken off-line and the flow reversed through the filter body, thus flowing backward through the screen, breaking the debris loose from the screen surface and carrying it through a flush-line to the outside of the filter body for discharge. This method is referred to as simple back-flushing. The second method is to rotate a brush or wiper mechanism to physically dislodge the debris from the screen surface and then open a flush valve to atmosphere and evacuate a quantity of water from the filter body to flush the debris from the system

The unique characterists of the best method to clean weave-wire screen elements is suction scanning technology as described in Appendix 1. This method of automatic screen cleaning is very reliable and capable of removing any type of debris from the screen surface whether organic such as algae or inorganic like sand. Suction scanning shows no preference for particle shape whether two dimensional like scale or three dimensional like grit. The particle adhesive characteristics also play little role in the effectiveness of the suction scanning cleaning method.

RESULTS

Water quality at this site can be quite variable but is almost always heavily laden with abrasive particles. Therefore, the best screen construction for the application at V&M Star Steel was to utilize wedge-wire for its strength and durability. However, the best cleaning method to assure that the all oils, greases and particulates were efficiently removed from the screen surface automatically was suction scanning technology. Engineers at V&M Star Steel soon discovered that no filter with this combination could be found on-the-shelf. A manufacturer was finally found that utilized both technologies but not in the same filter model. They agreed to build a unique filter incorporating the suction scanning cleaning method from one of their models and the wedge-wire screen construction used in another model for this particular application. This new combination resulted in a suction scanning filter with a 1500-micron wedge-wire screen element that maximized the ability of the self-cleaning function while assuring mechanical durability under harsh conditions.

Four of these newly designed filters were installed on 18 inch inlet and outlet manifolds at V&M Star Steel with blind flanges for a fifth filter if flows are increased in the future. The controller with a programmable logic control (PLC) was designed to handle all five filters. One pressure differential switch (PDS) was installed across the inlet and outlet manifolds. When the system senses a 7 psi pressure differential between the manifolds, the controller initiates the self-cleaning cycle by cleaning Filter 1 as explained in Appendix 1. When Filter 1 has completed its cycle, Filter 2 will begin its cleaning cycle. This continues sequentially until all filters are clean. The entire cleaning process takes less than three minutes. The controller also has an adjustable timer that allows cleaning cycles to be initiated on time as well as differential pressure. The frequency of cleaning cycles for a filtration system such as this depends upon the amount of debris in the cooling water making it very flexible over a large range of water quality values.

The system was started up at full capacity on June 4, 2004. The timer in the controller was initially set on one hour. During the first seven days of operation a differential pressure of 7 psi was never attained so the system cleaned on timer demand every hour. The controller timer was then set to every two hours and operated for another week. Still there were no cleaning cycles initiated by differential pressure. Also, nozzles have remained clean with no downtime due to cooling problems. Even though the system has been in operation for only a short time, its performance has exceeded expectations.

FUTURE RESULTS

As stated in the introduction, only the first few weeks of the system's operation can be expounded in this manuscript due to unforeseen construction delays. The Engineering Manager at V&M Star Steel has already set plans in motion to install wedge-wire screens in the four existing filters with much smaller filtration degrees to see if the quality of the cooling water can be improved beyond what is necessary just to prevent nozzle blockages. Water samples will be taken daily before and after the filters for TSS analyses at the on-site laboratory from which removal efficiencies can be calculated. Periodic cooling water samples over the next year will be collected and sent to an off-site laboratory for particle size distribution analyses to better understand the characteristics of the cooling system water. These data and information on equipment performance and dependability will be incorporated into a Phase 2 manuscript for presentation next year if given AIST permission.

ACKNOWLEDGMENTS

I am grateful to Frank Kowalczyk, Engineering Manager and Steve Tarka, Utilities Maintenance Team Leader at V&M Star Steel in Youngstown, OH, Allen Geist and Paul Fennema at Geist Associates in Warren, OH, Scotty Graybill at National Pump and Process, Inc. in Aurora, OH and Amiad Filtration Systems of Oxnard, CA. Each individual was gracious with his time and forthright in providing information and data throughout Phase 1 of this project. Advanced appreciation goes to all of those acknowledged for their future participation in Phase 2.

V&M Star Steel
2660 M. Luther King Jr. Blvd.
Youngstown, OH 44510
(330) 742-6413

Geist Associates
336 Perkinswood Blvd. SE
Warren, OH 44483-6220
(330) 394-9571

National Pump and Process, Inc.
180 Treat Road
Aurora, OH 44202
(330) 562-0220

Amiad Filtration Systems
2220 Celsius Avenue
Oxnard, CA 93030
(800) 969-4055

APPENDIX 1

The following is a brief description of how a suction scanning filter operates. Dirty water flows into the filter through the inlet flange at the bottom of the filter body as shown in Figure A-1. Water then proceeds through the cylindrical 316L screen element from the inside out causing particulates larger than the filtration degree (pore size) of the screen to accumulate on its inside surface forming a filter cake. Effluent leaves the filter body through the flanged opening on the side of the filter body. A pressure differential switch (PDS) continuously senses the pressure differential across the filter screen. The PDS signals the programmable logic control (PLC) to initiate the cleaning cycle of the filter screen when the filter cake causes a pressure differential of 7 psi. During the cleaning cycle, there is no interruption of flow downstream of the filter. Pressure loss through the entire filter containing a clean screen is less than 2 psi at maximum design flow rate and is usually less than 1 psi. This results in a total pressure drop across the filter remaining at less than 2 psi most of the time but building up to a maximum of 9 psi just before a cleaning cycle is initiated.

The filter screen cleaning mechanism is a suction scanner constructed of a 316 stainless steel assembly that rotates while also moving linearly. The suction scanner consists of a central tube with six tubular nozzles equally spaced along the length of the central tube positioned perpendicular to the longitudinal axis of the central tube. A 3" flush valve connects the internal cavity of the suction scanner to atmospheric pressure outside the filter body. By opening the flush valve, the differential gauge pressure between the water inside the filter body (35-150 psig) and the atmosphere (0 psig) outside the filter body creates high suction forces at the openings of each of the suction scanner nozzles. This suction force causes water to flow backward through the screen in a small area at very high velocity at each nozzle pulling the filter cake off the screen and sucking it into the suction scanner and out the exhaust valve to waste. The driving mechanism then rotates the suction scanner at a slow, fixed rotation while simultaneously moving the scanner linearly at a fixed speed. The combination of rotation and linear movement gives each suction scanner nozzle a spiral path along the inside surface of the filter screen. The cleaning cycle is completed in about 30 seconds, during which time the nozzles remove the filter cake from every square inch of the filter screen.

A 1/2-hp electric gear-head motor drives the suction scanner. The connection between the motor and suction scanner assembly consists of a threaded shaft traveling inside a fixed threaded bearing. This arrangement gives the suction scanner its rotational and linear movements; thereby, giving the suction scanner nozzles their slow spiral motion along the inside of the filter screen. The suction scanner has a rotational speed of about 24-rpm and a linear speed of around 12-ipm at 440vac and 60Hz. Two normally closed limit switches stop the electric motor and provide feedback to the PLC to control its direction of rotation.

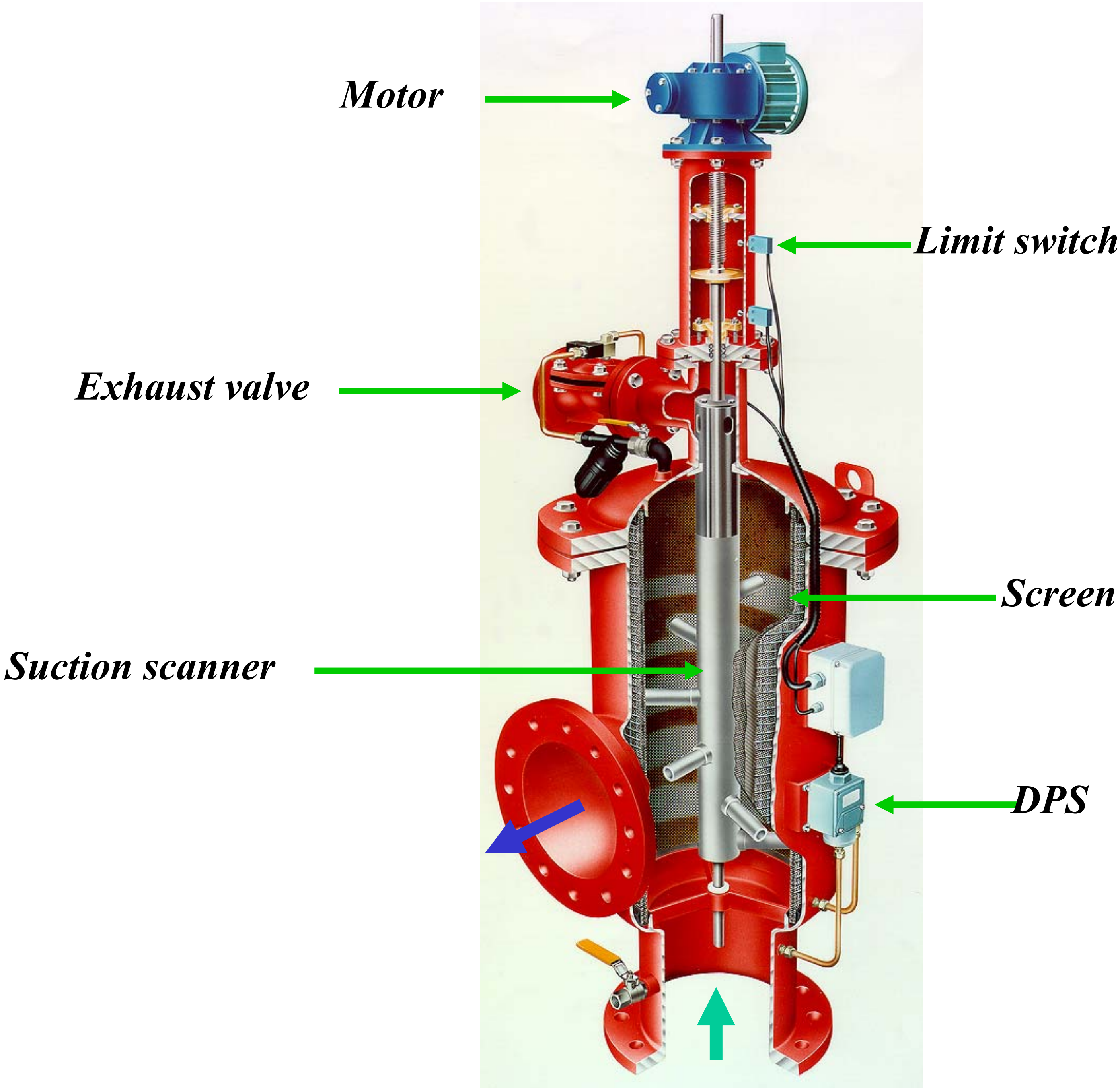

Figure A-1 Suction scanning mechanism