Handling cargo by rail and barge

FLSmidth's Docksider unloader is ideal for use unloading barges as well as ships.

technologies and equipment used in this market

Improving ship and barge unloading with optimization and upgrades from FLSmidth

Although we currently find ourselves in lean times, the cement market is cyclical and will inevitably turn positive once again, *writes Brian Warmkessel, application engineer/service engineer at FLSmidth.*

Those that do not prepare for this upswing may find themselves without the essential time and materials required for their machinery to operate as efficiently as possible. Due to the current supply and demand within the cement market many terminal facilities have been forced to cut maintenance budgets and work with reduced capital expenditures. This has, and will continue to have a detrimental effect on the equipment and subsequently the efficiency of overall terminal operations.

One of the most critical operations at the terminal level is the transfer of bulk material from ships and barges to storage locations for truck and rail loadout. It has become quite evident that the condition of many US-based unloaders has declined significantly over a period of just a few years. Imposed budget cuts have left many unloaders in a state of neglect by forcing operations to continue with minimal upkeep. Although immediate savings are witnessed, the long-term effects can be quite costly.

Under-performing unloaders result in higher power consumption, increased man hours required for offloading and demurrage costs. These all generate a ripple effect throughout the terminal and drive up the cost per tonne of material.

Introduction

This paper will focus on recommendations to help avoid costly decisions and also reduce the time it takes to revive as the market recovers. It will include commentary on improvements through proper maintenance, improvements through optimization and improvements through upgrades. It will also provide an understanding of how beneficial system audits can be and how they are executed.

Improvements through maintenance

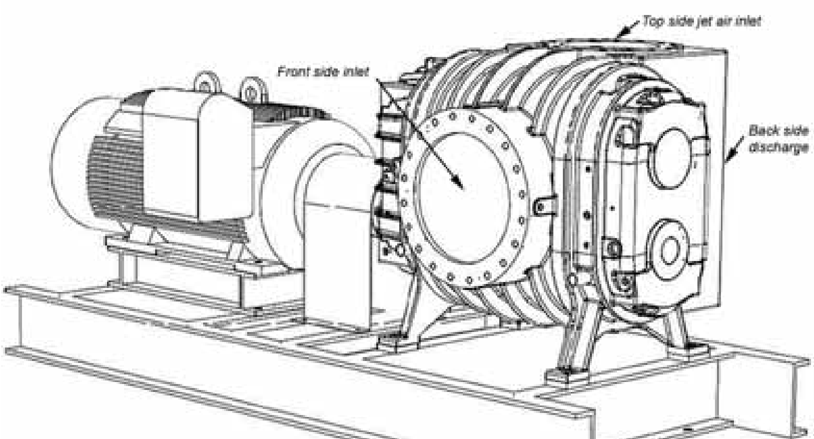
Inarguably, the long-term effect of poor maintenance will far outweigh the short-term cost savings. But understanding to what degree is paramount. Decisions on whether or not to perform maintenance on any given system are made daily, so understanding what key maintenance areas to focus on can help in minimizing unnecessary downtime.

By examining ship and barge unloaders in their simplest form it becomes more evident as to what maintenance actions should take priority. There are quite simply two sides of a pneumatic ship or barge unloading system: the vacuum and discharge.

One of the key components for the vacuum side includes the heart of the system, the vacuum blower. It is essential to the system that this blower be properly maintained to ensure the tolerances of the lobes are kept within specifications. This enables the blower to generate the higher pressures required for optimal operation. Dust-laden air or prolonged high temperature can have an irreversible negative effect on the blower.

The high temperature can be witnessed from elevated differential pressures across the blower resulting from plugged discharge and/or jet air inlet silencers. These should be routinely inspected and kept clean of debris. High temperature can also come from inadequate oil levels causing the drive and/or non-drive side bearings to overheat.

Another major component of the vacuum side of the system is the manipulating vacuum arm. This should be routinely inspected for fatigue/stress fractures to the arm sections.



Typical Vacuum Package Layout

Hydraulic power pack.

A few major reasons contributing to these fractures stem from over pressurization of the hydraulics, mechanical joints not properly lubricated and abuse from improper operation.

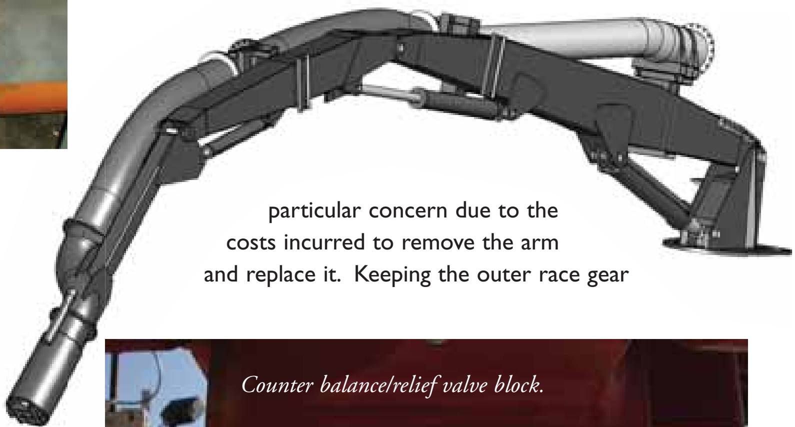
The hydraulic components should be adjusted to relieve pressure to minimize the stress to the arm. These components include the hydraulic power unit main compensator, proportional valve block assembly, counterbalance valves and pressure relief valves.

Proportional valve block assembly..

Routine inspection and adjustment of these components to manufacturer's specifications can greatly reduce the risk of damage to the arm.

If not properly lubricated the pin joints and slewing bearing can generate increased friction during operation. This friction not only causes excessive wear but increases the pressure required to operate the arm. The hydraulic pressure is a function of the friction generated by a lack of lubrication between the two surfaces and therefore needs to be incorporated into the routine maintenance programme. The main slewing bearing is of particular concern due to the costs incurred to remove the arm and replace it. Keeping the outer race gear face/pinion gears and the inner race properly lubricated will greatly extend the life expectancy.

60 foot Docksider unloader arm.

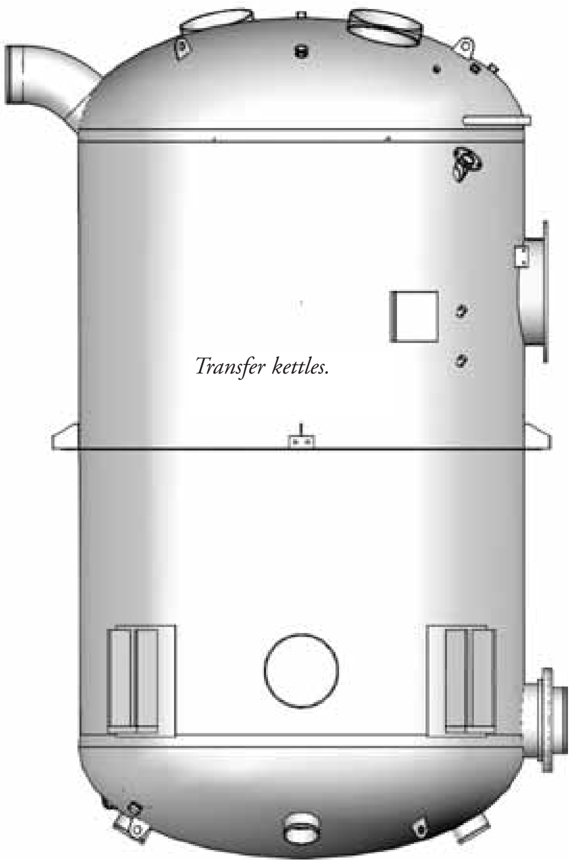


Counter balance/relief valve block.

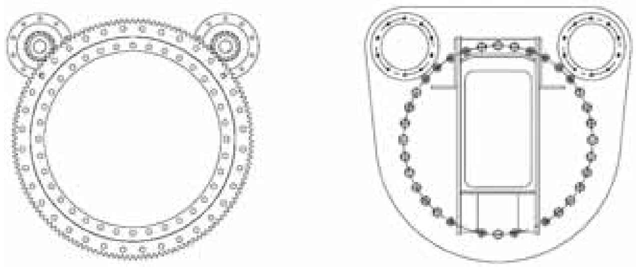
The transfer kettles provide temporary storage for the material. These tanks receive the material via the vacuum arm inlet piping and subsequently separate the material by means of an integral filtration system. Maintenance of the kettles is quite often overlooked and can result in declining machine rate. The rate at which the kettles oscillate between each other is a

function of many variables. From the maintenance perspective, the most significant aspects are adequate filtration, proper sealing of localized valves and aeration of the material within.

Routine inspections should include a visual of the kettles'

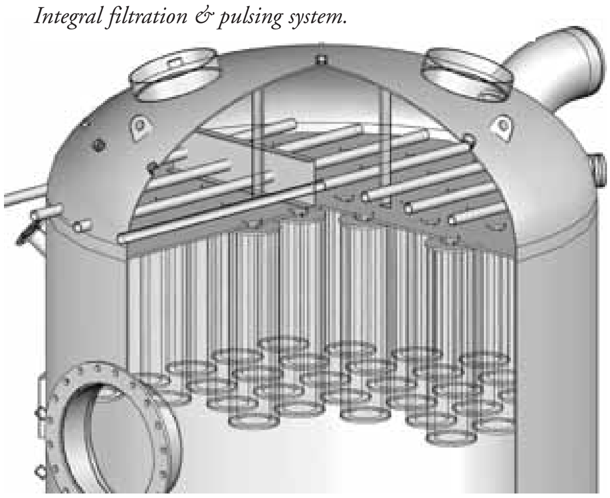


Transfer kettles.



internals (i.e. kettle filters and aeration pads). Isolated kettle pressurization tests will help identify any leakage across the discharge, inlet, pressurization and vacuum valves. Any amount of leakage across valves in the material path will result in air cutting of the disc, seat or bladder leading to premature failure. Valve leakage on the clean air side will result in the reduction of

Integral filtration & pulsing system.



rate due to lower vacuum levels and longer pressurization times.

During the vacuum process one of the most important components utilized is the dust detector (i.e. broken bag

Double dished head with aerators.

Heavy duty filter cartridges.

External pulsing solenoids & manifold.

Control air compressor & desiccant drying system.

Staged bypass system.

detector). The proper operation and sensitivity adjustment should be verified during routine inspections to ensure the air flow to the blower is free of dust particulates. Over time, small amounts of dust entering the vacuum blower can open the clearances on the lobes reducing the vacuum that the blower can generate.

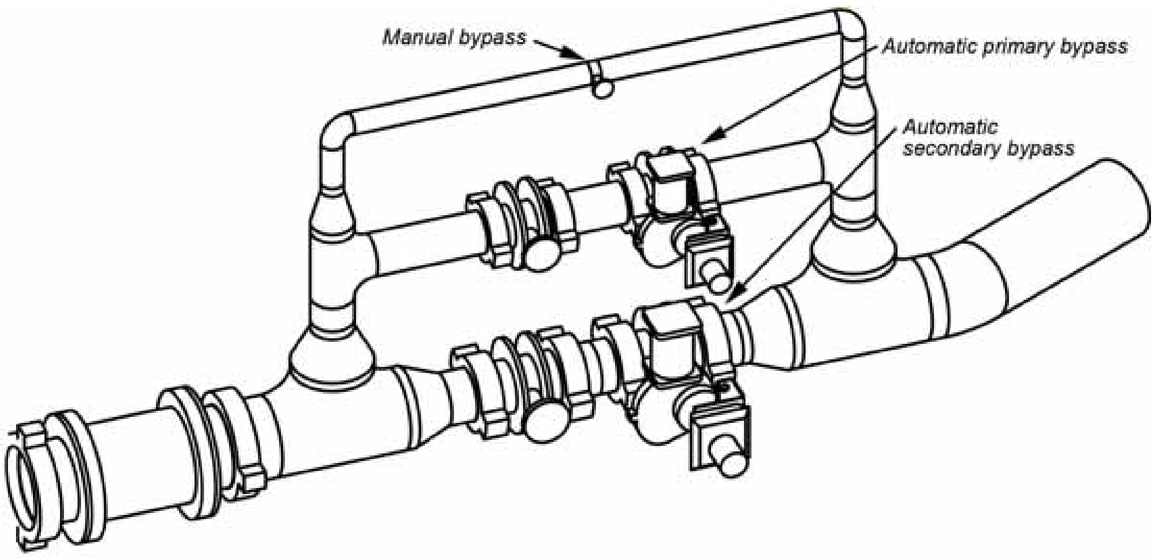
Another critical aspect of the system that is quite often overlooked is the supply of clean, dry control air. The entire system relies on the proper operation of the control air compressor and air dryer in order to operate the valves and the pulsing system. If the air contains moisture and/or oil the solenoid valves will not function properly (if at all). If the moisture contained in the system is abundant over a long duration it will most likely result in significant time spent on troubleshooting and in some cases mimic PLC trouble.

Moisture in the system can cause the filters to become partially blinded and drive up the differential pressure across the tube sheet. Oil-laden air can destroy the PTFE membrane coating on the filters causing the material to imbed in the spunbond polyester fibres also driving up the differential pressure.

Getting the material out of the kettles is just as important as getting it in. Once the vacuum side is operating efficiently, maintenance should shift to the discharge side of the system. The convey air compressor should be maintained to manufacturer's specifications and the relief valves checked for proper operation.

In any unloading system there is a precise balance of air/material mixture in order to optimize its peak rate. If the convey air compressor is lacking flow or pressure this balance can be thrown off, consequently causing lower rates. This balancing act is done by means of a bypass system that will circumvent the kettles in order to introduce air to the downstream pipeline. If these bypass valves do not operate properly the material will react erratically and may cause possible plugging of the pipeline.

As part of our efforts to help resolve some of the inefficiencies of the US-based unloaders, FLSmidth offers system



audits to help customers better identify the trouble spots on their machinery. As a major supplier of pneumatic conveying system design and supply, FLSmidth is in a valuable position to share expertise and to offer parts in a timely fashion through localized warehousing. These audits help flush out and rectify chronic trouble spots and ease customer concerns in areas of inexperience.

In these lean times customers are understandably reluctant to request expenditures for audits/service calls. FLSmidth's experience is that the return on investment (ROI) is witnessed in short order. An extremely high percentage of the responses from these audits are very positive and result in ROI's that range from a few weeks to a few months. They have resulted in a heightened awareness of what to focus on to reduce equipment and maintenance costs. Audits also provide customers with updates on the latest technology specific to their equipment so they may properly safeguard their investments and further reduce the chance of human error.

An outside audit of the machinery by someone with extensive knowledge of how the system works can be invaluable as shown in a few of the studies below:

❖ **Prompt for audit** — stress cracks forming in multiple areas of an ageing vacuum arm. This was causing excessive downtime of the machine due to weld repairs being performed not to mention a growing safety concern.

Result — the audit revealed that hydraulically, the arm was not properly safeguarded. The localized arm cylinder counterbalance and relief valves were set above what was required for normal operation. The slew function relief valves were also not balanced properly which induced unnecessary and excessive loads to the arm causing it to fatigue prematurely. After performing the proper adjustments there have not been any more issues with excessive structural fatigue to the arm.

❖ **Prompt for audit** — unloader rate has continually decreased over the last 8–12 months of service with no change in the type of material. The equipment seems to be operating normally.

Result — the audit revealed that the use of the fill timer was masking the fact that the kettles were not being fully utilized. It was found that the sustained vacuum levels were less than optimal caused by the annulus area of the nozzle being plugged and the snorkels being improperly orificed. During the audit it was also determined that the slew function of the arm was too slow causing the operator to waste precious time getting in and out of the hold. The proper adjustments were made and the customer indicated that the rate has returned to that which was witnessed previously.

❖ **Prompt for audit** — the operator could not raise the arm from the hold of the ship. This issue has been gradually getting worse over time and ultimately led to an inoperable arm. This caused a significant loss in rate due to the slow movement and also cost the customer two days of demurrage on the vessel.

Result — the audit revealed that the main inlet relief valve spring was weak and the poppet was not seating properly, allowing fluid to bypass the proportional valve control block. The main inlet relief was replaced and the arm functioned as required. This enabled the customer to offload the vessel at a through-the-ship rate not witnessed for over a year.

❖ **Prompt for audit** — vacuum side of the system is suddenly dominant over the discharge on one of the kettles. After inspecting the interior of the suspect transfer kettle the customer found nothing out of the ordinary.

Result — the audit revealed that the lower pressurization valve was not operating correctly. The coupler from the actuator to the valve had become weak and broken due to corrosion. This allowed the valve to remain closed when the actuator functioned as normal permitting the open/close contacts to be made on the limit switches. Therefore the PLC would not alarm for any reason and no air was being supplied to the kettle bottom for proper aeration of the material during the discharge cycle.

These situations, among others, were the result of a lack of proper maintenance or proper inspection procedures and could have been avoided. Yearly audits by a system expert can greatly reduce the risk of unnecessary downtime and assist in rate improvement further increasing the profit margin at the terminal level.

A basic equipment/system audit includes the following, at a minimum:

❖ first and foremost address any areas of concern that the customer may have identified since the last visit (or that have not yet been addressed);

❖ perform a visual inspection of the equipment to identify any potential trouble spots;

❖ observe/test the unloading process to make sure all the ancillary equipment is operating at optimal performance and subsequently make any adjustments necessary to ensure the machinery is running as efficiently as possible;

❖ if possible, operate the vacuum arm to personally verify that it is running correctly without any mechanical binding;

❖ extend the arm and adjust the hydraulic counterbalance and

relief valves to minimize the chance of overloading;
❖ mechanically adjust the arm hydraulics and programme the remote control to ensure it reacts optimally;
❖ run the PLC programme and confirm the set-points for the system are properly set to safeguard the machine;
❖ provide information on potential upgrades;
❖ provide basic training or instruction to site personnel if required; and
❖ supply the terminal manager/supervisor with verbal recommendations based on the findings and then follow up with a hard copy trip report for record.

Improvements through optimization

During the course of operation it is necessary to periodically re-calibrate the system. This should be done by qualified personnel that are intimate with the equipment, through a series of evaluations and testing to determine weak spots in the process. This evaluation will expose any underperforming equipment in the system so it may be corrected and optimal rates attained once again.

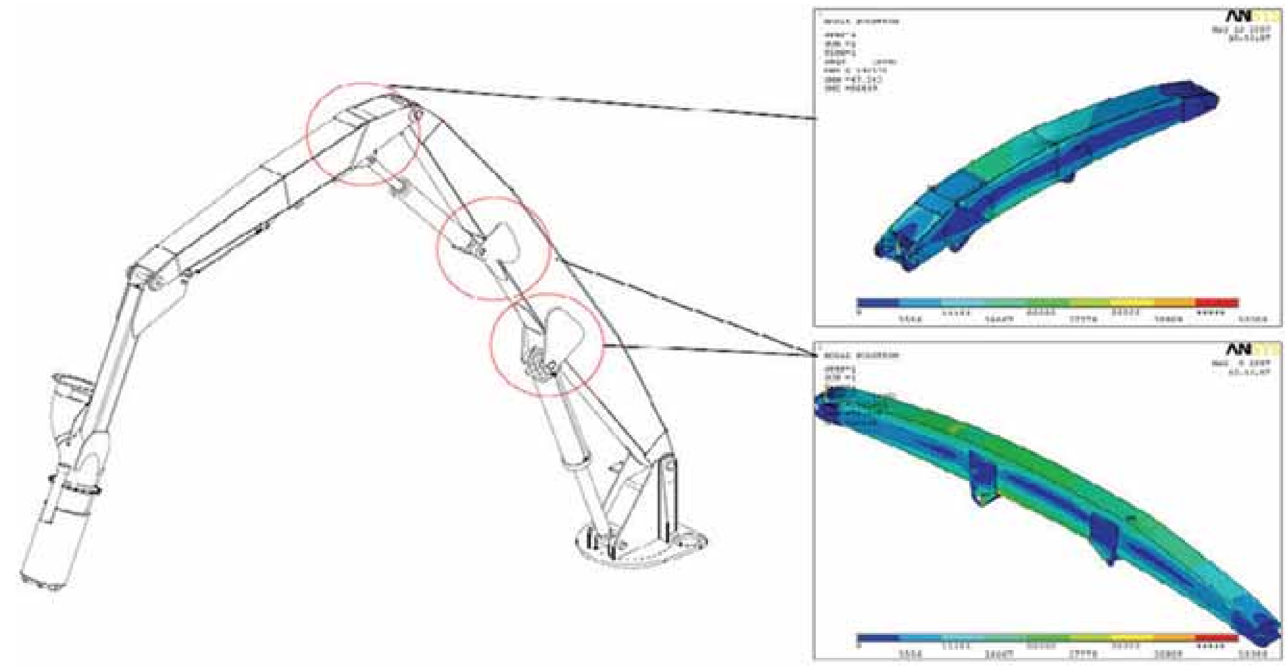
There are numerous reasons for unloaders not operating within their original design parameters. Other than the lack of maintenance mentioned above, a few of the more common reasons listed are:
❖ even with proper routine maintenance, as a system ages, so does the comprised equipment and associated tolerances or set points. Any equipment utilizing or relying on controls that include working components need to be re calibrated to ensure proper feedback and protection is being attained;
❖ sometimes an unloader is transferred from one location to another. This is often observed with older machines but typically limited to road mobile and barge mounted units. All unloaders are designed and sized based on the layout of a specific terminal. If the equipment is to be relocated, a performance study should be obtained through the manufacturer to ensure the proper pressure and flow can be achieved to keep the machine operating efficiently;
❖ once the study has been completed there are still system-specific adjustments that will need to be made based on the new location. These may include minor adjustments to programme set points up to and including changes to the Programmable Logic Controller;
❖ any changes to the original design or ancillary equipment may have a negative effect on the performance and could potentially cause damage to the system. It is imperative that any major change(s) be addressed with the manufacturer prior to performing equipment swap outs and/or any design changes; and
❖ one of the most significant effects on rate is the efficiency of the operators. Some terminals cycle through personnel frequently and therefore suffer due to the learning curve associated with these new operators. Provided a machine is operating in the upper levels of its efficiency curve, the operator's efficiency can have far more of an effect on rate than any optimization/upgrades to the system itself.

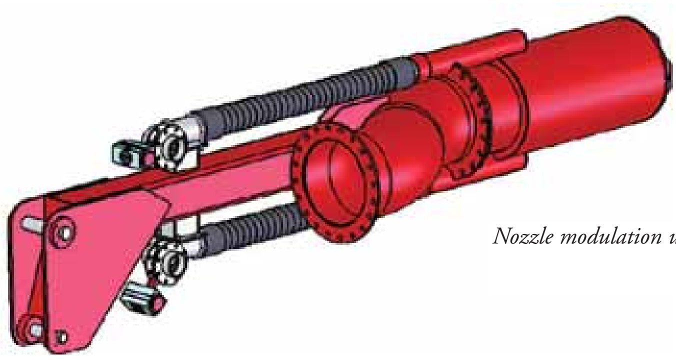
Routine audits provide a means for improvement through optimization. Additional options to the Basic Audit (if required) may include:
❖ Pac Set testing of the material being conveyed;
❖ pipe map the terminal and equipment for evaluation;
❖ provide a detailed engineering report of the operation based on the above listed items;
❖ provide programme changes to incorporate safeguards, upgrades or alterations to the system;
❖ provide a detailed training presentation of the equipment and educate personnel on proper operation of the equipment; and
❖ provide data-logging to confirm rates and operating conditions of the system.

Improvements through upgrades

Research and development is a top priority for FLSmidth with the primary driving force being customer needs. Purchasing new systems is not the only option to benefit from this R&D — equipment can often be upgraded to maximize efficiency. Some of the more recent upgrades are listed below and are the result of FLSmidth's extensive knowledge coupled with customer input.

FLSmidth has received valued feedback from customers with older unloaders who have discovered small fatigue stress cracks on isolated sections of vacuum arms that have met or exceeded

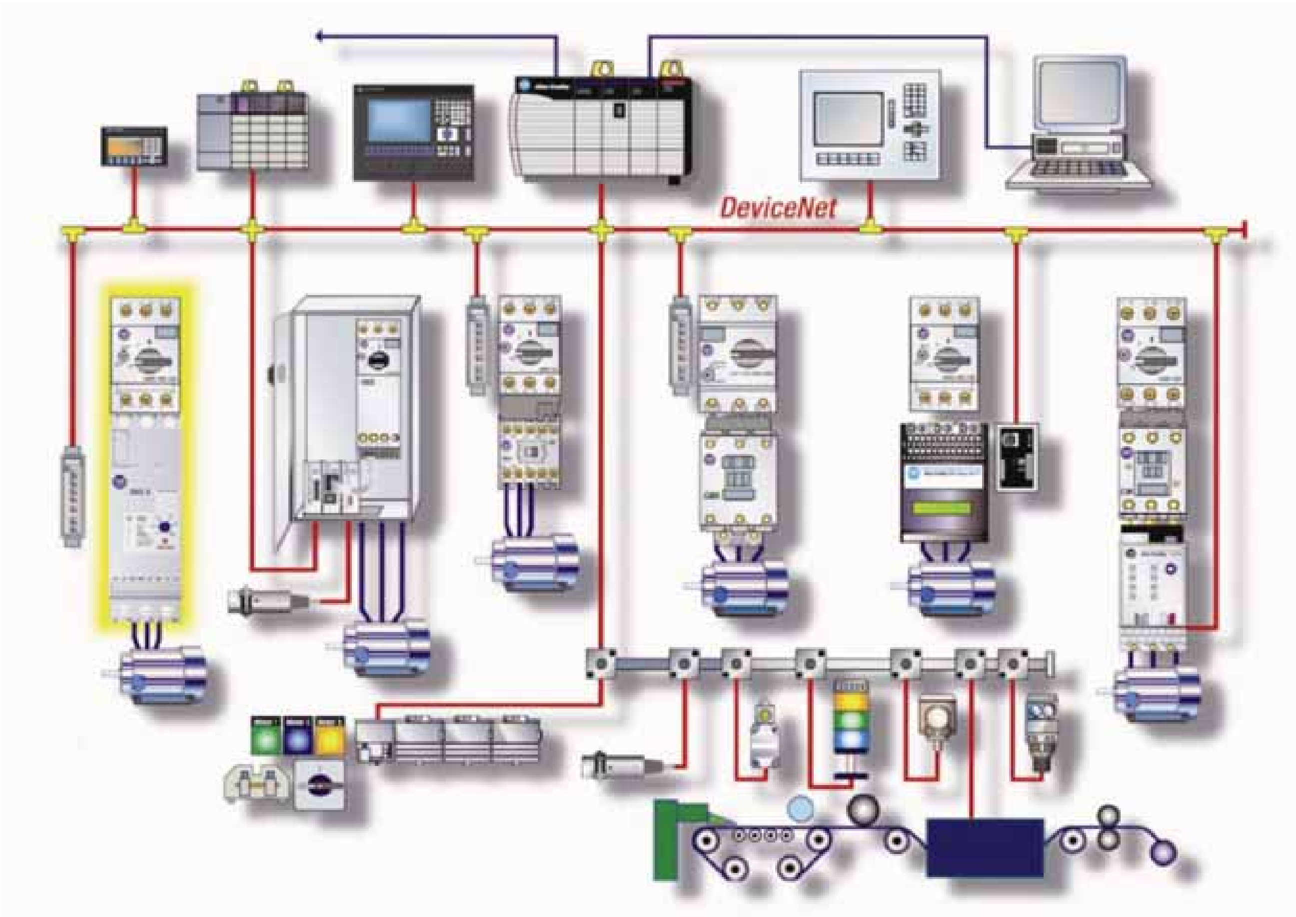




Nozzle modulation upgrade.

their designed life expectancy. By performing a finite element analysis (FEA) on the entire arm, FLSmidth has been able to incorporate design changes that have greatly reduced or eliminated the stress risers in the structure. These analyses have led FLSmidth to the development of stronger and more durable generations of ship and barge unloading arms.

Recently FLSmidth has developed a nozzle snorkel upgrade system. The old nozzle design incorporates fixed orifice snorkels



DeviceNet™ communication network.

that allow too much bypass air at low pressure during clean-up and often not enough at high levels during free dig situations. Another major concern is dust emission during the offloading process. This happens most often when free digging at high pressure forcing the vacuum vent valve (VVV) to open. This brings the system to atmospheric pressure allowing the live load of material to back feed through the arm into the barge causing dust emission.

This upgrade is designed to optimize the airflow through the static nozzle used with the typical unloading arm. This can be designed for any system with a static nozzle through a detailed analysis of the specific flow rates and pressures. This design is used as a staged bypass to increase the efficiency of the machine via the nozzle. This will allow for shorter free dig and clean-up times, reduce dusting and smooth out the pressure curves further decreasing lag time. This design uses butterfly valves to help regulate the pressure within the system based upon the pressure transmitters within the kettles.

These butterfly valves respond to conditions at the inlet nozzle to optimize the air & material mixing, maintaining maximum throughput with minimum power. This bypass system will allow for high flow through the nozzle for the clean-up process by forcing all the air through the nozzle tip. During the free dig process the system will help tighten the operating gap by smoothing out the pressure fluctuations due to operator inconsistency. At high vacuum levels (before hitting the main VVV) this will allow most, if not all the material in the arm to enter the kettle before the main VVV opens bringing the system to atmosphere causing unwanted dusting through the nozzle.

Efficient operation relies on precise adjustment capabilities, however this is only as good as the quality of the information feed back. The incorporation of DeviceNetTM has provided the means for this feed back through the utilization of localized nodes and one main trunk line. This main trunk line serves as a bus to transfer large amounts of information back and forth to provide better diagnostics of the system. This enables personnel to view additional information through the OIT to better identify the cause of the problem and not waste time with random troubleshooting. The quality and quantity of the information flow is key when fine tuning the machinery. The DeviceNetTM system also eliminates the need for numerous bundles of multi-conductor cables routed throughout the machine.

As mentioned previously, the vacuum blower is not only the heart of the system but has a significant associated cost and should be protected in anyway possible. One of the best ways to ensure the oil levels are properly maintained is to incorporate oil level switches as a backup to relying on routine personnel inspections. Should the oil level drop below a pre-determined point on either side of the blower, the float switches will make contact and the blower shuts down providing a 'vacuum pump low oil level' alarm. This ensures the proper oil level to the bearings is being maintained constantly should anything happen during operation.

Eventually, there comes a time to ask "should I buy a new unloader?" One good indication is, after you have invested in the applicable upgrades and optimization audits, you still require a rate increase to sustain the market demand. With the exception of the obvious financial aspect one other factor may include the life expectancy of the equipment.

There are always estimated operational figures used during the design of ship and barge unloaders. Understanding what these estimations are, especially for the more critical components like the vacuum arms, can help provide a better understanding of when an unloader has reached or exceeded its life expectancy. These are most often not guarantees but assumptions/experience based on anticipated throughput operating conditions.

Remember that simply achieving the desired rates for a specific terminal does not necessarily indicate that the unloader is operating efficiently and optimally, because maintenance costs may offset the end result. If repairs are on the increase with no viable retrofits for a solution then the machinery may be heavily taxed, shortening its lifespan.

Summary

Whether the issue is poor maintenance, less than optimal configuration or system design, the effect will always be realized in decreased capacity that can easily be equated to operational costs. Consider the two scenarios below that compare time/costs for operation at design capacity with time costs for operation at just a 20% deficiency:

Scenario #1: barge unloading terminal

- ❖ throughput: 5 barges/week @ 1,500dwt x 46 weeks/year = 345,000 tonnes/year;
- ❖ Power costs: ** $.075kW/hour x 1,055 kW/hour ~ $80/hour;
- ❖ labour costs (3 persons): $108/hour;
- ❖ total operational costs: $188/hour.

	100% Efficiency	80% Efficiency
Design capacity	400tph	320tph
Nominal capacity (TTB)*	280tph	224tph
Unloading time/year	1,232hrs	1,540hrs
Operating cost/year	$231,616	$289,520
Additional operating cost/year	N/A	$57,904
Demurrage (12 days @ $1,800/day)	N/A	$21,600
TOTAL ADDITIONAL COST/YEAR	$0	$79,504

Scenario #2: ship unloading terminal

❖ throughput: 15 ships/year @ 35,000dwt = 525,000 tonnes/year;

❖ power costs: ** $.075/kW hour x 2,585 kW/hour = $195/hour;

❖ labour costs (3 persons): $240/hour;

❖ total operational costs: $435/hour

	100% Efficiency	**80% Efficiency**
Design capacity	600tph	480tph
Nominal capacity (TTS)*	420tph	336tph
Unloading time/year	1,250hrs	1,563hrs
Operating cost/year	$543,750	$679,905
Additional operating cost/year	N/A	$136,155
Demurrage (15 days @ $25,000/day)	N/A	$375,000
TOTAL ADDITIONAL COST/YEAR	$0	$511,155

** The nominal capacity accounts for operational inefficiencies resulting from vessel movement, hold clean-up, minor maintenance/adjustment, etc.*

*** Source: Energy Information Administration, Form EIA-826, "Monthly Electric Sales and Revenue Report with State Distributions Report."*

It is easy to see how investments in maintenance, optimization and upgrade can pay for themselves over a very short period.

Conclusion

It is understandable, particularly in lean economic times, that terminal owners and operators need to be frugal with their capital and maintenance budgets. It is inarguable, however that continued operation of a ship or barge unloader without proper and regular maintenance will reduce performance efficiency (increasing the cost per offloaded tonne of material) and ultimately result in even higher costs to repair or replace failed equipment.

The same can be said for operating under less than optimal conditions and for operating without the benefit of basic upgrades that can improve performance.

It becomes quite evident that routine audits performed by qualified personnel simply make sense on every level. This proactive approach will save money in the long run, while helping to solidify a position in the front of the pack as the market recovers.

About the author

Brian Warmkessel joined the FLSmidth Pneumatic Transport Department in 2005. He served four years in the United States Air Force and achieved a Bachelors degree in Mechanical Engineering from Temple University. He has an extensive background in both the electro-mechanical and fluid power disciplines. He is currently employed with FLSmidth as an Application Engineer, assisting in design, proposal and execution of river and marine terminal projects and managing the aftermarket sales, service work and technical support for all ship and barge unloaders in the Americas.

Warmkessel has commissioned new units and performed service work throughout the world and is the acting liaison between Kovako and FLS-PT. Among his concentrations has been developing upgrades and performing optimization audits for both Docksider and Kovako unloading equipment.