CONVEYOR MAINTENANCE – STRATEGIES AND OUTSOURCING

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INTRODUCTION

At Beltcon 11, Mr. Arnold Matthee presented a paper with the title 'Practical Outsourcing Of Engineering Support And Maintenance'. Although not in so many words, his conclusion during the presentation alluded to the fact that although such a concept could add value to the mining operations, he doubted whether industry was indeed 'ready' for such a paradigm shift, thereby implying that change was necessary, that the norm of using conveyor equipment till it fails should be addressed, and that something should happen towards ensuring that the total cost of ownership of conveyor equipment be addressed and improved. This concept is cardinal to the survival of the mining industry. With commodity prices being at an all-time low, at the height of arguably the most intense labour issues this country has ever experienced, the time to firmly reconsider those arguments put forward at Beltcon 11 has come. This paper touches on different maintenance strategies and the benefits of utilizing external resources to perform maintenance on conveyors.

THE CURRENT STATE OF AFFAIRS REGARDING MAINTENANCE

According to some economists, commodity prices have stabilized, but remain low, and the mines are under increasing pressure to become more cost effective in their production methods in order to reduce overheads and to decrease the total cost of ownership related to the operation of conveyors. On the other hand, due to limited or suitably skilled resources, the very core of the attempts to save on operational costs is eroded by the fact that inspections and maintenance on the equipment are not performed.

From a study '2016 Maintenance Study: Seven key findings' performed by Amanda Peliccione the following four important points were extracted:-

a. That 76% of manufacturing facilities follow at least some form of preventive maintenance strategy on some equipment. 61% still has a run-to-failure method and 51% use some form of Computerized Maintenance Management System (CMMS – more about this later).
b. It is reported that preventive maintenance, reactive maintenance, and predictive maintenance are three strategies that most reduce the probability of failure.
c. It is reported that materials handling equipment is typically shut down four to six times each year.
d. The report implies that rotating equipment receives the most maintenance support, followed by plant automation and fluid power systems.

TOTAL COST OF OWNERSHIP

In order to see the value of maintenance in perspective, it is important to understand the concept of Total Cost of Ownership (TCO).

Total cost of ownership can be defined as a financial estimate intended to help buyers or users to determine the *direct* and *indirect* costs of a product or system. In this instance, TCO refers to the cost to supply a product, install it, and operate the conveyor system until the particular piece of equipment is removed because it is no longer fit for use. Should such cost then be compared to the material it moved, the user can express a TCO value in terms of Cost / ton. Such could be for the conveyor belt alone, the drives, any piece of conveyor equipment, or the conveyor as a unit, where the cost of all the equipment would then be combined and related back to the material conveyed.

Direct costs

- Complete finished product delivered to site
- Installation
- Commissioning

Indirect costs, also referred to as hidden costs

- Equipment selection, procurement services – vendor recommendation.
- Installation delays due to false vendor promises
- Belt cleaning – poorly adjusted scraper / to prevent damage to the belt.
- Condition of the belt cover
- Idler maintenance – to prevent damage to covers.
- Pulley lagging – to ensure belt traction / protection of covers.
- Power consumption – How heavy is the belt?
- Quality of manufacture / splicing / repair on site.
- Spillage or lack of maintenance resulting in stoppages.
- Cost of spares.
- Downtime.

An indirect cost, if not attended to, will shorten the time of a piece of equipment to the next replacement, thereby **increasing** the TCO value. TCO therefore becomes an asset management process, focused on keeping total operating costs as low as possible, without impacting on production.

How could a third party (outsourced service) contribute towards reducing indirect costs and reducing TCO on a conveyor belt system?

- Belt cleaning – supply a scraper, or a maintenance service to ensure proper adjustment. Belt cleaning, or the lack thereof, is the cause of a very high percentage of problems experienced on site.
    - Idler failure due to ingress of dirt into bearings.
    - Pulley bearing failure, due to ingress of dirt.
    - Belt damage due ineffective cleaning or poor chute design - spillage
    - Take-up not operating due to spillage preventing carriage from moving.
    - Drive failure, due to being covered in spillage.
- Idler maintenance – supply idlers, or a maintenance service to ensure belt safety and limit energy cost.
- Pulley lagging – Supply new, or perform a maintenance service to monitor condition.
- Power consumption – Ensure that the correct belt is selected for a particular application, with the correct cover thickness and grade to optimize belt life over the life of the mine. Selecting a too thick cover will add mass to the belt, increasing rolling resistance, and thereby increasing capital cost in terms of belting, power packs and power consumption. Too thick a cover for the required application will just add mass, and not add real value in the longer term.
- Quality of manufacture – Ensure equipment is sourced from reputable suppliers that can provide backup to their product.
- Downtime – Increased reliability due to using a quality product and managing it efficiently will result in reduced potential downtime.

WHY MAINTAIN ASSETS?

Figure 1. Cessna Citation Mustang.

The Cessna Citation Mustang aircraft is a small jet, and cost in the region of $3 500 000.00.

For aircraft such as this, maintenance is compulsory and failure to do so could end up in major legal issues should the lack thereof result in physical harm or worse to those on board. In summary, the owner of an aircraft such as this is highly likely to maintain it in accordance with manufacturer specifications. One therefore has to question why a company would spend more money than the cost of an airplane on a conveyor, and then not maintain it. Consider this in the light that a possible failure due to a lack of maintenance may result in loss of life.

Maintenance discipline is of some importance for any facility operating conveyors. In the past maintenance was typically considered an expense in an attempt to reduce downtime. However, the realization that maintenance should be considered an investment, and that it would be impossible to execute it well without implementing a well thought through maintenance strategy is at last manifesting itself.

a. The first and most important role of maintenance around any conveyor, is to ensure safety. Safety should be the highest priority in any asset management strategy.
b. The prevention of functional failures, which requires an appreciation of the fact that a component on a conveyor may have failed, yet the conveyor is operating, resulting in risk of downtime, risk to the environment, facility flexibility and naturally production throughput, which in turn will threaten other business objectives.
c. To correct failures. It is impossible to prevent all failures, and in fact, some should be allowed as the cost of prevention may exceed the cost of replacing a component after it has failed. Note that even a good preventive maintenance program will not have a 100% success rate.
d. To optimize the life of the equipment. It has to be noted that optimizing the life of equipment is different from maximizing life of equipment. This is because obsolete equipment may no longer deliver competitive performance.
e. To ensure that equipment performs in accordance with its design specifications. This is related to prevention of failure, but also includes the prevention of equipment modifications that may threaten the integrity of the original design.
f. To achieve the above at minimum cost, limiting TCO.

MAINTENANCE PHILOSOPHIES

Typically a maintenance strategy does not consist of a single philosophy, but rather a variety thereof, depending on the installation and their priorities.

Herewith some different approaches, explaining their impact on productivity and system sustainability.

Run-to-failure (RTF) / Reactive Maintenance

A run-to-failure philosophy is one in which failures are allowed to occur and are then dealt with after they have been detected (also known as reactive maintenance). The philosophy is sometimes referred to as ‘breakdown maintenance’ which is incorrect, RTF is different from breakdown maintenance since a component may have failed without a breakdown actually occurring i.e. the failure does not stop the equipment from running (a failed idler for instance). This is essentially the base from which all preventive maintenance philosophies were ultimately developed. It is not a preventive philosophy, but a reactive one. If adopted as the dominant philosophy, it has many risks and can be expensive due to consequential damage that may occur as a result of component failure, much of which can be far more extensive than that incurred through the original failure itself. Often, since spares may not be held for all components, the approach leads to potentially long periods of downtime as the site waits for delivery of the required components (consider some ripped steel cord belting). Important to note is that it is unlikely that stable operating performance will be achieved with this philosophy.

From a sustainability perspective, there are obvious economic drawbacks and also risks to safety and the environment that arise from use of this approach, and it would be unwise to adopt it as the primary philosophy. There is however room for limited application of the philosophy within the context of a wider preventive maintenance program. This is the case for when the consequences of failure of an individual component or sub-component are very low, and the costs of prevention of the failure exceed the costs of the consequences of failure. A further criterion is that the failure must be readily detectable once it occurs. In this case the component may be allowed to fail and then repaired without incurring risks of multiple failures occurring at the same time, which may have far more serious consequences than the original failure. For conveyor systems, this particular philosophy is not recommended.

The disadvantages of a reactive maintenance regime outweighs the advantages:-

- Increased costs due to unplanned downtime and broken equipment.
- Increased labour cost especially in the event of overtime being required.
- Reactive maintenance normally follows some catastrophic failure, therefore cost involved to repair or replace equipment would be high.
- Risk of secondary equipment damage due to equipment failure (For example, a pulley bearing fails, belt tension is not evenly distributed and the belt fails.)
- Inefficient use of staff resources.

Hollow advantages to the use of a reactive maintenance regime are as follows:-

- Low cost (Short-sighted!)
- Fewer personnel involved.

Time/age/based Preventive Maintenance (PM)

Preventive maintenance involves taking action before failures occur to prevent the failures from occurring. With time-based PM, components are replaced or reworked at defined frequencies, independent of their condition. Consider an activity such as changing the oil in one’s car. It is changed at say 10 000 km intervals, and is based on equipment run time. No consideration is given to the actual condition and performance capability of the oil. It is changed because it is time. The initial philosophy was based on the age of components, and involved replacing components when they reached a fixed period in service. The approach was pioneered in arms manufacturing companies during WW2.

For this approach to be viable, components would have to display distinct wear characteristics that would allow some prediction as to when they would be expected to fail or would be completely worn. The approach would then be to replace them as they approached this failure point, which would be determined by their operating hours. Normally the decision to replace would be confirmed by visual inspection. It may be that technology has advanced to a point where the original life prediction is no longer valid.

The American airline industry, with its strong focus on safety, pioneered many of the approaches that form the basis for much of modern maintenance practice, and research into component failure conducted in the 1960's shows that greater than 90% of components in the industry did not exhibit a predictable probability of failure with age. Maintenance tasks driven by time of use hence are not generally effective, and maintenance programmes using this philosophy will therefore not prevent functional failures. Infant mortality represents a simple example of why the philosophy is flawed. Even new components have some probability of early-life failure, and hence replacement of a working used component may in fact reduce the reliability of a piece of equipment. Maintenance-induced failures may also occur due to dis-assembly and re-assembly of complex equipment, particularly by unskilled artisans.

This approach, while potentially better than a run-to-failure philosophy, cannot guarantee improved productivity and sustainability, simply because most components do not wear in a predictable fashion. However, in replacing or reworking components, inspection of equipment is naturally carried out, and other potential problems may be detected and corrected before failure occurs. Reliability should therefore be somewhat improved over an approach comprising RTF.

The benefits of preventive maintenance are as follows:-

- Increase in the life of the equipment, thereby making it cost effective.
- Allows some flexibility towards when the maintenance is being performed. Reduce failures and breakdowns, thereby reducing costly downtime.
- Energy savings due to reduced rolling resistance and system drag.

On the other hand, there are some disadvantages also:-

- Catastrophic failures are still possible.
- Labour intensive – Personnel training is required.
- This may include performing some unneeded maintenance with the potential for incidental damage to components.

Although preventive maintenance is not the most favourable maintenance program, by using the necessary resources to perform maintenance activities, as intended by the equipment designer, equipment life is likely to be extended and reliability increased at the same time. Minimizing failures is likely to result in both maintenance and capital cost savings.

Predictive/Sensor based Predictive Maintenance

The primary goal of predictive maintenance is to minimize disruption of normal system operations, while allowing for budgeted, scheduled repairs. Predictive maintenance can be defined as follows: Measurements or techniques that detect the onset of system degradation (lower functional state), thereby allowing underlying risk to be eliminated or controlled prior to any significant deterioration in the component's physical state.

Results indicate current and future functional capability. Predictive maintenance differs from preventive maintenance by basing maintenance requirements on the actual condition of the machine or equipment rather than on a pre-set schedule. This method is typically used to define a required maintenance task based on a quantified condition of the equipment. There are many advantages of a predictive maintenance strategy and a well-orchestrated predictive maintenance program will virtually eliminate catastrophic equipment failures. Predictive maintenance is indeed nothing more than an inspection regime, and does not include the act of physically performing preventive maintenance. Examples of predictive maintenance are:-

- Vibration analysis
- Infrared Thermography
- Oil analysis
- Visual inspections
- Belt thickness monitoring
- Conveyor belt scanning (Steel cord reinforced) belting

One would be able to schedule maintenance activities or repairs to minimize or totally eliminate overtime cost. One will be able to minimize inventory and order parts, as required, well ahead of time to support the downstream maintenance Advantages of predictive maintenance are as follows:-

- It identifies trends, allowing users the opportunity to find a root cause.
- It shows the condition of in-service equipment and predicts when preventive maintenance should be performed.
- Provides increased operational life / availability.
- Potential to decrease unscheduled downtime.
- Allows for inclusion of repair costs in a budget.
- Allows the management of spares inventory.

And some less obvious benefits?

- Improves safety.
- Limits overtime cost.
- Energy savings.
- Improved morale.

Naturally there have to be disadvantages to such a strategy also:-

- Increased investment in diagnostic equipment would be required.
- Increased investment in personnel training or hiring of skilled personnel

- The potential to save on expenditure in the longer term is often not recognized by management.

Studies estimate that a properly functioning predictive maintenance program can provide savings over a program utilizing only preventive maintenance of between 8% and 12%.

‘Operation and Maintenance Best Practices Guide, Release 3’, implies that an independent study has shown that the following industrial average saving resulted from the initiation of a properly functional predictive maintenance programme:-

- Return on investment: 10 times
- Reduction in maintenance costs: 25% to 30%
- Elimination of breakdowns: 70% to 75%
- Reduction in downtime: 35% to 45%
- Increase in production: 20% to 25%.

Reliability Centred Maintenance (RCM)

RCM also originated in the airline industry, and was a product of a study commissioned to maximize availability and control costs, with primary consideration for safety. Its roots lie in a steering committee representing airlines and aircraft manufacturers which was formed in 1960 to study the effectiveness of preventive maintenance. The committee, known as the Maintenance Steering Group (MSG) developed a logic known as MSG-1, which after successive iterations and improvements developed into MSG-3 by 1978. This decision logic, applied with detailed knowledge of failure causes and consequences, is effectively RCM.

The RCM philosophy deals with key issues neglected by other maintenance programs by using a logical, structured framework for optimizing the availability and lifespan of equipment and systems. It recognizes that all equipment in a facility is not of equal importance to either the process or facility safety. It recognizes that equipment design and operation differs and that different equipment will have a higher probability to undergo failures from different degradation mechanisms than others. It also ensures that maintenance tasks are effective and economical. The following are core principles of the methodology:

- It seeks to preserve an item’s function – hence any failure which impacts on a component’s ability to function is addressed, not just those which cause plant stoppages;
- It focuses on the entire life (not to be confused with life cycle) of the system or item, making RCM a continuous process;
- It seeks to understand the failure characteristics of the item in question, and uses this to evaluate whether preventive maintenance is appropriate (i.e. should an item be allowed to fail or not?), and if so what type of preventive maintenance;

RCM is driven by safety and environmental considerations first, and then by economics; RCM acknowledges that an item has “inherent reliability” which cannot be improved through maintenance, but only through re-design.

RCM is a systematic approach to evaluate a facility’s equipment and resources to best mate the two and result in a high degree of facility reliability and cost-effectiveness. RCM is highly reliant on predictive maintenance but also recognizes that maintenance activities on equipment that is inexpensive and unimportant to facility reliability may best be left to a reactive maintenance approach. The following maintenance program breakdowns of continually top-performing facilities would echo the RCM approach to utilize all available maintenance approaches with the predominant methodology being predictive.

- Reactive maintenance – less than 10%
- Preventive maintenance – 25% to 35%
- Predictive maintenance – 45% to 55%

The primary difference between RCM and time/age-based maintenance is that RCM stresses the examination of the condition of an item, with tasks that are then defined based on this condition. The philosophy also differentiates between evident functions, whose failure can readily be detected by the operator of the equipment, and hidden functions, whose failure may not be readily apparent to the operator. In the case of hidden functions, there is the potential for exposure to multiple functional failures, and this is what the maintenance effort aims to prevent. The consequences of failure determine the options to be followed in terms of preventive maintenance tasks.

Advantages of an RCM based maintenance regime

- Can be the most efficient maintenance program.
- Lower costs by eliminating unnecessary maintenance or overhauls.
- Minimize frequency of overhauls.
- Reduced probability of sudden equipment failures.
- Able to focus maintenance activities on critical components.
- Increased component reliability.
- Incorporates root cause analysis.

Disadvantages can be as follows:

- Can have significant start - up cost, training, equipment, etc.
- Savings potential not readily seen by management.

EXPLANATION OF CMMS (COMPUTER MAINTENANCE MANAGEMENT SYSTEM)

CMMS is a product developed to make maintenance easy. Although it is a trade name, it is really the concept that is important, namely that an assessment is done and recorded using some form of electronic device. Such information is then stored on a database and can be accessed anytime for the client to ensure proposed corrections have been actioned and to be able to consistently compare new surveys against earlier versions. Typically this kind of software will allow the production of graphs, and would also be able to store photographs.

On the other hand, care has to be taken as very often reports generated are generic, and such a report could easily ramble on about things that are not particularly relevant to the client, tarnishing the good information concealed elsewhere in the report. As a user, once trust has been lost in a report, it would be difficult to regain. There is a further risk regarding personnel performing the inspections. As the system is considered to be user friendly and easy to use, often personnel performing the inspections are not qualified to detect real problems associated with the machine, making it difficult to produce high-quality reports of real value. Should a report be made, filled with irrelevant information, the person having prepared the report may not even realize such a mistake. The client however will become frustrated, and finding the report almost identical to the one he received 6 months ago, supports a perception that he is not getting value for money, and often the services of the company performing the inspections are terminated. Another challenge is that often customers object to an outsider highlighting inefficient methods and systems used at the mine. In this modern age, the concept of spending money in order to save money is well understood, but often an inconvenient truth, and therefore ignored. CMMS, although inherently a good predictive maintenance method, has to be performed by skilled and vigilant personnel.

Managing the information obtained through any computerized system has to be carefully set up, as when the results of an inspection is uploaded, the system could generate job-cards, and perform a lot of tedious work previously requiring human input.

OUTSOURCING OF MAINTENANCE

From the above, it can be seen that there are some advantages in maintaining equipment, resulting in potentially significant operational cost savings, increased production and improved safety.

Why outsource?

- Allow some outside company to consider the installation with experienced and fresh eyes, and together with the user, formulate a workable, affordable, long term maintenance and equipment replacement strategy, acceptable from both a technical and budgetary perspective. This would include regular inspections and execution of preventive maintenance during planned shutdown periods. As users typically do not have the luxury of enough skilled resources to perform this function, having somebody else come do the work, and accept responsibility thereof, has the ability to increase general reliability and availability of the facility, limiting potential downtime.
- Limit training of personnel – In order for any person to review the condition of a conveyor or its equipment, a particular level of training is required. Important issues are the use of senses, such as recognizing visible problems, or audibly

being able to detect some broken idlers. Feel is important, as a bearing or drive component emitting heat above its operating temperature may indeed be a sign of imminent failure. Alternatively, detecting an undue vibration early may indeed result in preventing costly repairs. Developing a ‘feel’ for such skills is not something that happens overnight, and typically requires extensive training or many years of experience, and most junior mine personnel required to do this work, do not have such skills or experience. There is a significant risk in letting unskilled personnel perform critical maintenance, not only to the equipment but also the person doing the work.

- Limit the investment in diagnostic equipment – Should the client be serious about maintenance and monitoring their equipment, they would require to invest in some diagnostic equipment. Such would include tools such as:-
  - Belt thickness monitor.
  - Steel cord scanner.
  - Infrared camera.
  - Equipment for vibration analysis.
  - Equipment for oil analysis.
  - Measuring equipment (distance, temperature).
  - Have a single body responsible for the monitoring and timeous reporting of potential issues that could influence production.

However, there are also disadvantages to complete outsourcing of maintenance. The first challenge that is likely to occur, is that the user may lose touch with his equipment, as to what is where, what is new, what is used and what is being done to the system to ensure it stays up and running. To manage such risk, because it is also a financial risk, the user is advised to not only make use of a reputable company, but also keep a finger on the pulse by insisting on regular usable reports, in a format easily understandable and able to implement.

There is always a risk that the contractor will not be honest with the user, taking advantage of or exploiting a situation for his own benefit. Once again the user would have to keep an eye on the contractor in order to ensure that when it is reported that particular equipment requires replacement, it is done not to keep the contractor in business but with the best interest of the user at heart.

The biggest risk faced by the user, is that the contractor does just enough to keep the installation in operation. This implies that the contractor is only attending to the problems as they occur, no matter which strategy is followed, rather than to eliminate the cause thereof. Once again, this would be a good ‘stay-in-business’ strategy for the contractor, but would be unacceptable to the user. The user requires not only that matters be resolved, but also that the root cause be addressed and removed. There is some risk associated with relying solely on a contractor to perform all maintenance tasks, and users are cautioned to ensure that contracts be written in a manner as to protect their assets and limit risk associated with contractors withdrawing from site for some reason. Leave matters, such as withdrawal from site over festive seasons should be clearly defined and agreed upon at the contract negotiation stage.

A second model of outsourcing is not addressed in this paper, but relates to a total handover of a conveying system to the successful contractor. This would imply that the user remunerates the contractor on a cents per ton basis to operate and maintain the equipment. Such a contract could be based on labour rates only or could include the supply and installation of equipment. This model is much more complex, leaving both the supplier and the user at risk if not formulated carefully.

NOTE REGARDING SAFETY

Through ensuring reliability and good housekeeping, safety is automatically improved. In terms of the Mines Health and Safety Act 29 of 1996, it is required that every mine has a code of practice, which would typically be based on risk assessments. In conjunction with the mine, a third party would be able to assist with the production of such a Code of Practice. The Code of Practice is likely to stipulate maintenance requirements to ensure safety, and if not abided by, will indicate that due care was not taken by the user.

CONCLUSION

In an economic climate where unnecessary spend at mines cannot be afforded, it has become necessary to look after and manage the assets at the mines. Conveyors, being the critical arteries to ensure a steady income, are often the most neglected pieces of equipment at the mine.

Conveyor maintenance, whether by the user or an outsourced party, is critical. It has been found that the practicing of a reactive maintenance regime is not particularly effective, while a preventive strategy, paired with a predictive maintenance plan, is likely to yield far better up-time of the production facility. Ideally, a reliability centred maintenance regime has the ability to actually save on expenses and also increase productivity by improving reliability and availability of equipment.

Users are obligated, by law, to ensure a safe working environment for their employees, and an unmaintained facility cannot offer such an environment.

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