Back to basics at Richards Bay Minerals’ mining operation: examples using Six Sigma methodology

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The phrase ‘back to basics’ is used to describe the fundamental principles and philosophies on which a successful mining operation is based. At Richards Bay Minerals (RBM), ‘back-to-basics’ (BTB) has been implemented as a continuous process to probe operational functions with a view to increase production without capital expenditure. It also ensures that the fundamentals of dredge mining are understood and adhered to.

BTB is based on the principle that people drive organizations, necessitating an interactive implementation approach. At the RBM mine this entails a three-pronged approach, namely practical training, teamwork initiatives and the use of lean Six Sigma methodology. It is the latter on which this paper will focus.

The lean Six Sigma methodology is successful in identifying, managing and documenting BTB projects, while teamwork initiatives are integral to successful project implementation. This paper describes two examples of how the Six Sigma methodology can be applied to a dredge mining operation.

The first example focuses on the improvement of Mining Pond Echo (MPE) plant throughput by reducing the lost opportunity (non-production) due to tails downtime. The project was successful in increasing plant throughput by 4.5%. This was achieved by increasing the tails disposal system availability by running MPE as a four tails lines operation and focusing on causes of tails production downtime. Subsequently, the tails system at MPE is no longer the production bottleneck.

Second, the Six Sigma methodology was successfully applied at Mining Pond Charlie (MPC) to increase the primary dredger throughput by 4.6% through focusing on the dredging technique and maintenance issues. This project highlighted the need for trend analyses to ensure an effective dredging technique, coupled with simple production documentation, which also ensures a focus on maintenance.

Keywords: Back to basics, Six Sigma, training, teamwork, throughput improvement, tails, dredger.

Introduction
Richards Bay Minerals (RBM) has been extracting economic heavy minerals from unconsolidated coastal dune sands in northern KwaZulu-Natal for more than three decades. Their current mining operation utilizes four dredge mining plants and two dry mining operations to produce a heavy mineral concentrate, from which rutile, zircon, titanium slag and pig-iron are produced.

In 2002 RBM completed an extensive business restructuring process. This process highlighted the value of intellectual property that people had accumulated. However, the information was residing with individuals and had not been effectively captured by RBM. This restructuring period coincided with numerous skilled operational individuals leaving their positions, resulting in a void of knowledge in the functions in which they had been involved. As a result, productivity declined and some of the fundamental operational principles and philosophies of dredge mining were forgotten. There was thus a need to get ‘back to basics’ (BTB) to ensure knowledge retention, personnel development and effective knowledge transfer.

Back to basics
BTB is used to describe the fundamental principles and philosophies on which a successful dredge mining operation is based. It has effectively been used at the RBM mine since 2004 as a means to put more heavy mineral concentrate (HMC) on the stockpiles without capital expenditure. It is built on the principle that people drive organizations and uses an interactive approach, focusing on operational level functions. It also serves to ensure that the fundamentals of dredger mining are understood and adhered to. BTB is built on a foundation of safety and driven through three interconnected initiatives: training, Mission Directed Work Teams and Six Sigma projects (Figure 1).

Training
Training comprised the construction of a variety of practical training modules focusing on the fundamentals of heavy mineral mining with emphasis on plant set-ups. Each module has been created to ensure that the attendees
approach aimed at optimizing processes using team-driven Six Sigma at RBM is required.

relationships. At higher levels, a focus on visible leadership solving abilities and on building customer/supplier 1 and Level 2 teams on improving the team’s problem-solving ability. Team meetings are held on a daily basis for Level 1 operational teams and more than one team. At the mine site, there are 30 Level 1 teams, 9 Level 2 teams, 3 Level 3 teams, and 1 Level 4 teams. Typically Level 1 teams focus on solving operational issues and Levels 3 and 4 on management issues. Team meetings are held on a daily basis for Level 1 operational teams and weekly for the other teams.

The teams are reviewed on a monthly basis to monitor the application of the process to enable achievement of team targets. Reviews show that more focus is required at Level 1 and Level 2 teams on improving the team’s problem-solving abilities and with building customer/supplier relationships. At higher levels, a focus on visible leadership is required.

Six Sigma at RBM

The Six Sigma methodology is a logical, data-driven approach aimed at optimizing processes using team-driven problem solving and best practice techniques. The methodology was a logical step to complement MDWT© and an effective means to identify training gaps and enable teamwork. A lean Six Sigma methodology was adopted in 2005 at RBM and has seen thirty-one green belts trained in three successive training waves. At the mine specifically, there have been six projects successfully completed and documented, of which two will be presented here. A black belt project wave is expected to be launched in 2008.

Improvement projects

Due to the nature of bulk mining, any small improvements in efficiency translate into multi-million rand bottom line value to the company. At RBM, efficiency projects are typically prioritized in terms of their value. The following two Six Sigma project examples represent significant value creation, with details being omitted due to the sensitivity of the data.

The first example comprises the tailings disposal system (tails) of Mining Pond Echo (MPE) that, prior to 2006, was causing a significant throughput bottleneck2. Unscheduled tails production downtime was identified as the focus area as it contributed to the largest portion (47% in 2005) of tails downtime. Pareto analysis revealed that tails stacker moves and polypipe/hose failures were the largest causes of production downtime (Figure 2). To achieve a reduction in tails downtimes, data quality on the tails system was firstly addressed by improving downtime coding and correcting system calculation errors. Data resolution was also improved by introducing polypipe/hose repair recording sheets, which revealed that bolting and slip rings (gaskets) were the largest contributors to downtime (Figure 3). There was thus a need to get BTB awareness, to ensure that the fundamentals of a slurry operation were adhered to.

Work instructions were then created (at operator level) to reduce both polypipe/hose failures and the time to move stackers. Stackers were also moved on-the-run when it was safe to do so and were set-up correctly during day shift so that only minor moves were required during night shift (Figure 4). Large improvements were also made through operator awareness by training them on the impact of equipment damage to production throughput. In other words, developing understanding on the impact of doing the tasks poorly. This was driven through teamwork initiatives and included within the relevant training modules.

The combined result was a reduction of unscheduled production downtime by 50% and total tails downtime of 30%. Production throughput was simultaneously addressed by running MPE as a four tails operation when there was capacity to do so, as the perceived risk of negatively affecting the water balance was invalid. These combined improvements have seen an increase in throughput at MPE of 4.5% and have been sustained for over a year. Numerous wastes were also addressed during the course of the project, resulting in annual monetary savings of R150 000.

The second Six Sigma example focused on the start of the dredger mining process, namely, the primary dredger at Mining Pond Charlie (MPC). The primary dredger at MPC has, over the last couple of years, battled to run consistently and included within the relevant training modules. The data. The creation, with details being omitted due to the sensitivity of the data.

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The second Six Sigma example focused on the start of the dredger mining process, namely, the primary dredger at Mining Pond Charlie (MPC). The primary dredger at MPC has, over the last couple of years, battled to run consistently at concentrator capacity. A Six Sigma project initiated in Q4 2007 indicated that the dredging technique was partly responsible for sub-optimal dredger throughput. An effective dredging technique is difficult to quantify due to the plethora of variables involved and the lack of an assessment between operators and conditions. However, the
largest contributors to inconsistent throughput were found to be inappropriate swinging, maintaining centre lines, inefficient water monitor usage and ineffective lost opportunity reporting. Again, these are the fundamentals of a dredging operation and had been relaxed over time. This is indicative of either a lack of focus or skills migration. Work instructions were created (Figure 5) coupled with real time trends to help educate the dredger operators in understanding the variables and the interactions that these variables have on throughput.

Poor swinging techniques and not maintaining centre lines were not primarily a result of operator error, but were caused by not having the auxiliary spud available. This resulted in drifting of the dredge during channel moves and carriage repositioning. This led to inappropriate winch rope angles, leading to the dredge operators being unable to
Figure 4. Stacker positioning work instructions

- Position 1: Move the back position towards position 3—not too far otherwise the front position will go over the edge when moved.
- Position 2: Move front pontoon with 2 dozers forward until no. 3 cyclone discharge is above the edge of the tailing pile created in position 1.
- Position 3: Stacker facing down-slope, hoses not in H-frame.

How to position a stacker:
1. Move the back position towards position 3—not too far otherwise the front position will go over the edge when moved.
2. Move front pontoon with 2 dozers forward until no. 3 cyclone discharge is above the edge of the tailing pile created in position 1.
3. Ensure there is enough level space in front of the stacker, 1.5 times the width of the dozer's blade.
4. Level-off and remove excess sand from around the stacker. Avoid dozing tails forward.

Poor swinging due to operator error for 30% of available time.

Figure 5. Work instruction showing the effects on production of poor dredge swinging
maintain 25 metre left and right swings respectively. Furthermore, excessive wear on the winching kit, ropes and ladder wase caused resulting in increased dredge downtime. The auxiliary spud was subsequently restored but the investigation revealed that the ‘basics’ of the need for an auxiliary spud had been forgotten.

The work instructions thus had two outcomes: they provided the operators with a tool better to understand the dredging process and as a means to understand the negative impact that poor maintenance has on production. A dredger log sheet was introduced to track lost opportunity reporting so as to create a shift-by-shift record of operating conditions, dredge set-up and dredge operator requests (Figure 6). The latter was of paramount importance as the operators often complained that they requested anchor moves but these were not performed (anchor moves cannot be done during the night). This was often due to poor communications and lack of understanding of the production importance of correct anchor positions. The log sheet also ensured that operators were accountable for safety and production on each shift and allowed for smooth shift handovers.

Dredger water monitors are integral to the dredging process and without them dredge throughput was shown, through experimentation, to be restricted by as much as 41%. The latter experiments also showed that it was imperative to keep the water monitor nozzles well maintained as feathering reduces their effectiveness in slurrying the face. Correction during swings is also important to ensure effective slumping, thereby maximizing dredge throughput. Again, these are the basics of efficient dredging.

The project was successful in increasing the throughput of the dredge by 4.6% and simultaneously decreased the variation in the process. It is difficult to proportion the improvements to either ensuring correct maintenance was performed or on operator focus, as both causes were tackled simultaneously. However, the knowledge gained from sharing these findings on other production ponds with operating auxiliary spuds suggest that operator refocusing is attributed to at least 3% of the improvement. Annual hard savings at MPC of R94 000 were also achieved.

The project also identified the need for practical off-the-job training for dredge operators. Consequently, the
purchase of a dredger simulator is being investigated to provide theoretical and practical training prior to mining an area. This will allow an effective dredge operator evaluation to be conducted without interfering with production and safety.

Conclusions

BTB is currently under development at RBM and is starting to show benefits in safety, production and cost efficiencies. The Six Sigma projects have been highly successful in identifying operational bottlenecks and training deficiencies, yet Six Sigma is still to be entrenched within the RBM organizational culture. Mission Directed Work Teams remains the single most important factor in ensuring and sustaining Six Sigma project gains and is currently the catalyst to change to a data focused culture. Mission Directed Work Teams are also fundamental in driving leadership goals and expectations to the teams. 

Retaining the ‘basics’ are of paramount importance in ensuring an efficient mining operation. Effectively capturing this knowledge is the biggest challenge for RBM for which Six Sigma and training modules have gone a long way to address. However, a cultural shift is still required whereby employees feel more empowered to take ownership of these initiatives.

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