ENGINEERING, CONSTRUCTION AND COMMISSIONING OF 84 CONVEYORS ON THE 10MTPA BKM IRON ORE MINE PHASE 1 PROJECT FOR ASSMANG LIMITED

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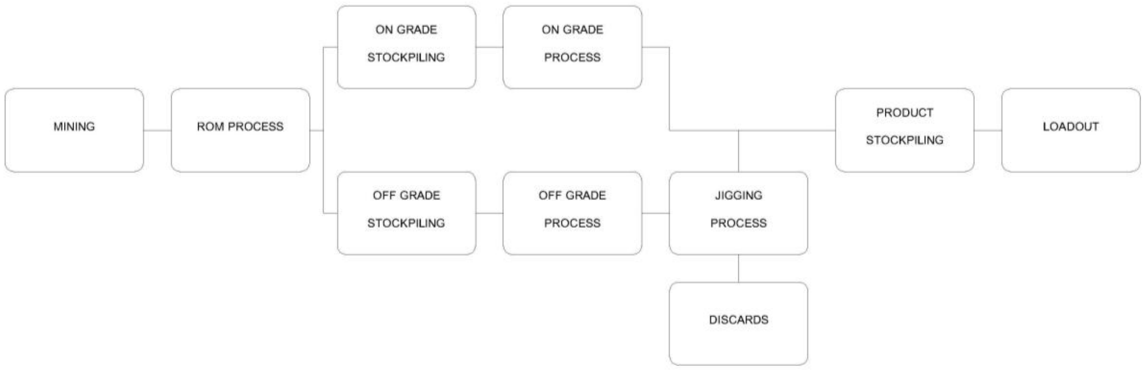
SYNOPSIS

The Khumani Iron Ore Mine was a project undertaken by DRA Mineral Projects for Assmang Limited, which is jointly managed and controlled by African Rainbow Minerals Limited and Assore Limited where the objective was to design a modular plant that beneficiated 16 MTPA of ironoOre. The mine is situated in the Northern Cape, 30 km's south of the town of Kathu and is built on four previously privately owned farms called Bruce, King, Mokaning and Parson. The first letter of the first 3 farm names forms the acronym name for Phase 1, The BKM Project. The execution and commissioning of the project was split into two phases; Phase 1 would construct and commission enough modules and infrastructure to beneficiate 10 MTPA of iron and Phase 2 is to be a future phase where the remainder of the modules are completed thus achieving 16 MTPA. The sellable Iron Ore commodity comprises of three products namely; fines, medium size and lumpy iron ore. Primary, secondary, tertiary and HPGR crushing circuits inter-linked with Washing & Screening and De-Watering Plants produce the required products. An off grade iron ore circuit further utilizes an additional beneficiation process called jigging to improve the grade of the ore by removal of waste. Product is loaded onto trains by means of an automated rapid load out station, railed to Saldanha and stockpiled before being loaded onto ships bound for overseas clients. Figure 1 shows a simple process flow diagram for the BKM Project.

Figure 1: Process Flow



The integration of the various circuits was done by the use of 84 conveyors of varying widths, lengths and speeds. This paper follows a path from conceptual design to commissioning, stopping to take a view at procurement, planning, logistical management, quality control and safety. Commissioning triumphs and challenges are presented as well as looking at some valuable first time start-up trends for conveyors.

STATISTICS

Below are a few statistics outlining the project's conveying requirements:

General:

Number of conveyors on the project	84
Shortest conveyor	9 m
Longest conveyor	4 832 m
Total conveyor length	27 858 m
Smallest throughput	20 tph
Largest throughput	7400 tph
Smallest installed power	15 kW
Largest installed power	1 260 kW
Total combined installed power	16 695 kW

Mechanicals:

Belting:

Total length of steel cord belting	19 625 m
Total length of fabric belting	32 938 m
Number of rolls of belting	203

Drives:

Number of drives	102
Number of DOL Ddives	15
Number of VVVF Drives	52

Number of drives with fluid coupling	60

Pulleys:

Number of pulleys	435
Number of split bearings	108

Idlers:

Total number of rolls	91 727

DESIGN AND RATIONALIZATION

A conveyor calculation can easily be done as long as basic design parameters such as conveyed tonnage, length, lift and speed are identified. One would follow the same process when designing 84 conveyors only the time to do the task shall be proportionally longer. Component selection is an essential byproduct of the conveyor calculation and is further refined by documents such as design criteria or design specifications. But what if the design criteria and specifications that govern the selection of equipment are still open ended enough to allow the designer to select equipment leading to undesirable amounts of spare holding.

It is soon obvious that the business of conveyor design has been swept into the background and mainly used as an indicative tool furnishing design values, mapping a path through a rationalization pick and choose matrix. The number of options available are determined by one of two traditional routes 1) The project is cash sensitive so apply cost effective design to reduce capital cost and select critical spares holding only, or, 2) Operations and maintenance issues far outweigh capital expenditure and therefore conveyors are to be designed in such a way that a small spares holding exists.

So the very first task, especially when undertaking a large conveying project, is to establish what the overall project criteria is in terms of capital and time. This shall set the precedent for the following step which is to do some conveyor calculations and determine what range of equipment shall be used. A selection chart can be drawn up, albeit preliminary, to help with the rationalization process upfront. Large cash flush projects shall have smaller and less complicated selection charts as opposed to cash strapped projects where the selection charts are longer and more detailed.

Below is an example of a selection chart that can be used using the following flow criteria [initial conveyor calculations] - [belt width] – [belt strength] – [pulley diameters] – [drive selection]. This is a simple version of a chart but there are other ways of structuring selection charts.

Figure 2: Proposed Selection Chart Flow

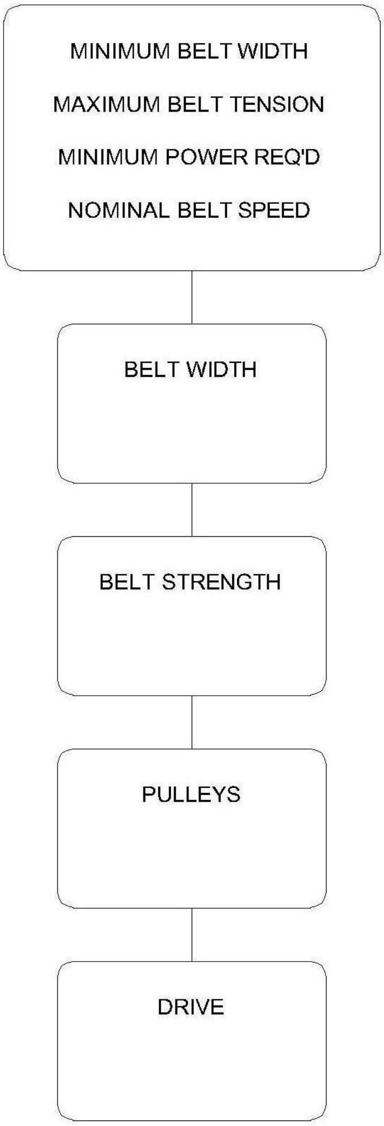
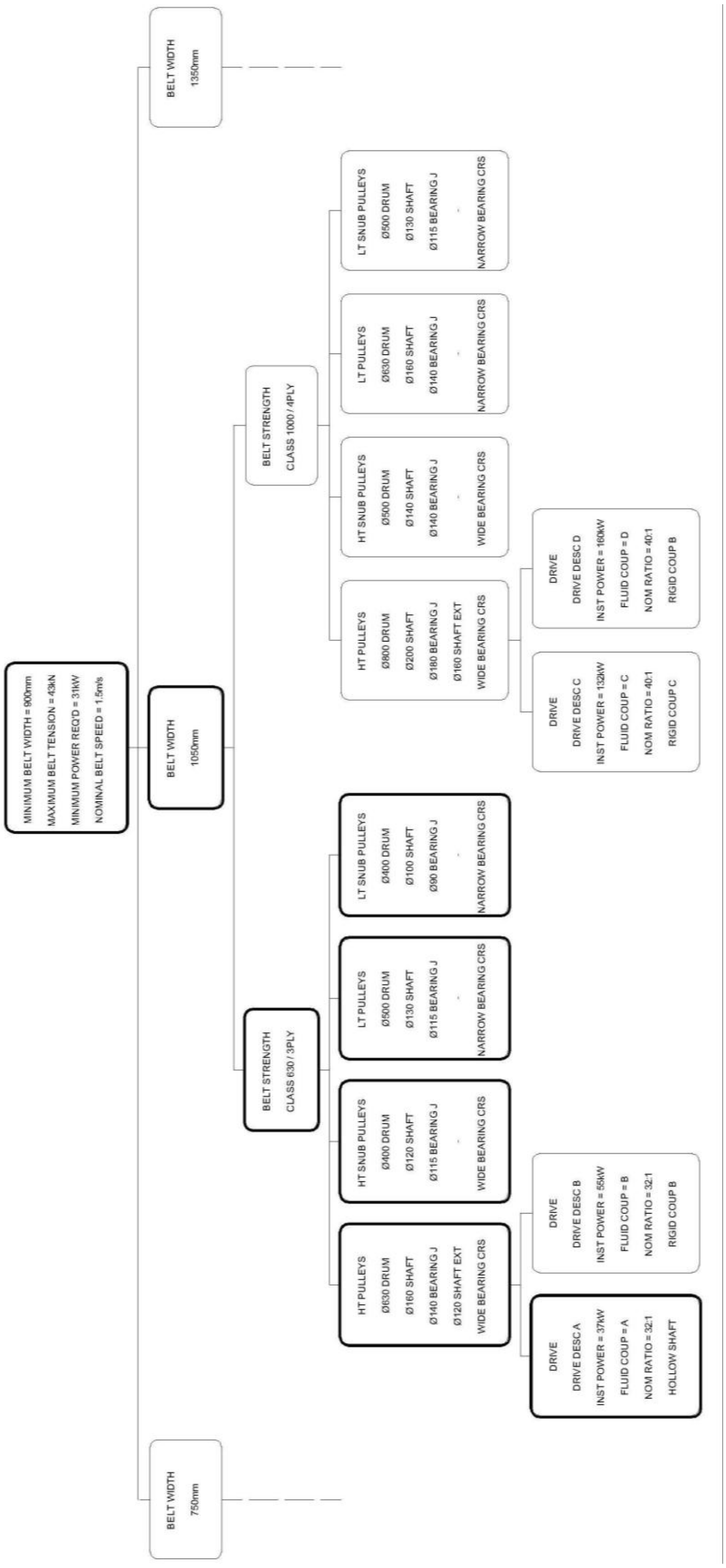


Figure 3: Selection Chart Example



CONTRACTS, EXPEDITING, PLANNING AND DELIVERY TO SITE

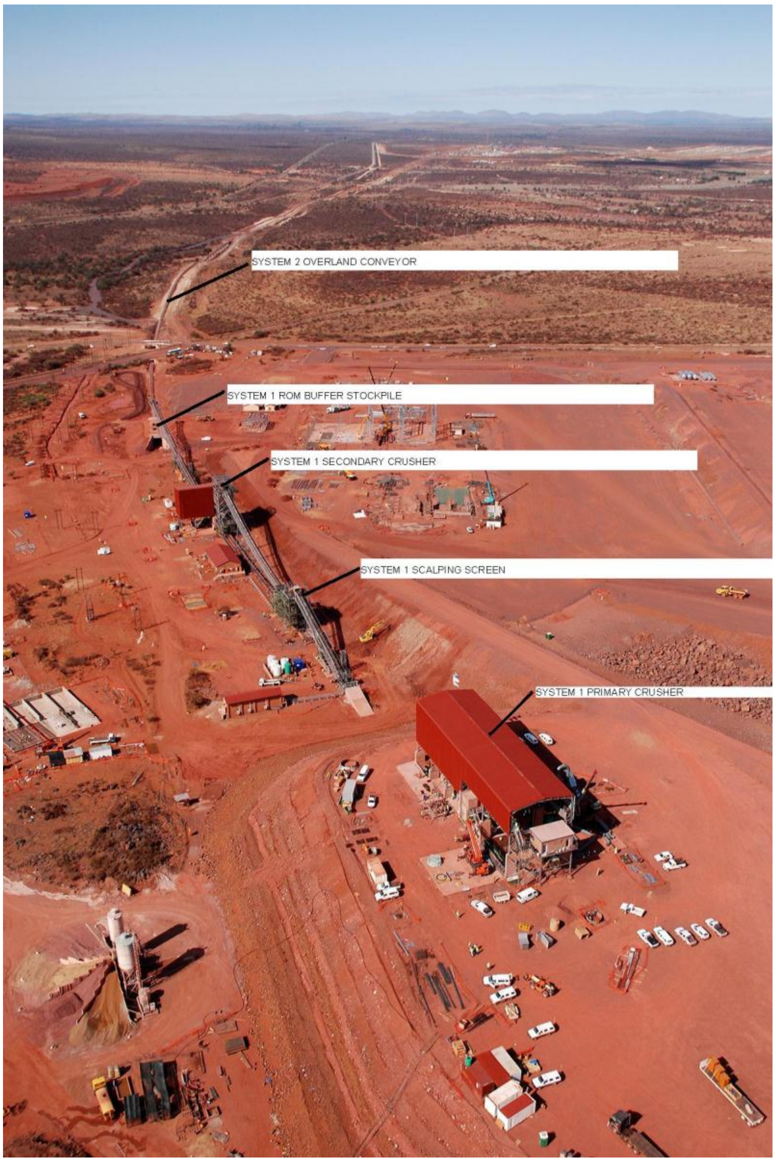
The objective of a project is to design and build a system that delivers an expected outcome and does so for an expected period of time. Sound design ethics and good engineering practice are the foundation blocks delivering this outcome, but there are additional criteria, that if met, turns the project into a successful one. Time and money, as the cliché goes, on time and under budget. The foundation block for this aspect of the project is a contract, if set up and administered correctly very little can go wrong. It was these fundamentals that were applied for the BKM Project and as a result earned the award of Mining Weekly Project of the Year for 2008.

It is often the case that a project manager or project engineer is the administrator of a contract, and technical input, when required, is delivered by a design engineer. In many instances, the contract administrator has many contracts to handle and larger more exciting pieces of equipment such as crushers or stackers push the conveyor contracts into the background. For large conveying projects that require lots of attention, it is advantageous to appoint the conveyor Design Engineer as the contract administrator for the conveyor contracts. For the inexperienced there are a number of courses offered by facilitators that can offer the required education and guidelines on how to administer a contract successfully.

Terms and conditions of most contracts are standard but the Scope of Works, Bill of Quantities, Specifications, Terms of Payment and Milestone Schedules have to be tailored to suit the project's requirements. If time is taken to correctly write up these sections then contracts management becomes easy.

Expediting, planning and delivery to site are individual tasks but integrated and interdependent on one another. All can be successfully managed if a simple systems based approach is used. For the BKM Project the following systems based approach was used; the 84 conveyors were split up into nine commissionable systems, (a commissionable system is a selection of equipment that make up a single stand alone process cell within the project). A good example of this is System 1 on the BKM project, the ROM handling section that had primary crushing, scalping, secondary crushing and buffer stockpiling included. For hot commissioning with material, ROM product could not be fed into any individual item unless all four were ready. Below is an illustration of System 1 with System 2’s overland conveyor in the background.

Illustration 1: System 1



Below is a description of all nine systems:

System 1:	ROM handling
	3 conveyors
System 2:	Overland conveying and stockpiling
	3 conveyors
System 3:	Off grade stockpiling
	3 conveyors
System 4:	On grade reclaiming and process plant including product stockpiling
	5 conveyors to bins
	17 Conveyors through process
System 5:	Off grade reclaiming and process
	4 Conveyors to bins
	9 Conveyors through process plant

System 6: Product reclaim and load out station

5 Conveyors

System 7: HPGR crushing

7 Conveyors

System 8: Lumpy and fines jigs including discards

3 Conveyors to fines bins

3 Conveyors through fines jig process

3 Conveyors to lumpy bins

16 Conveyors through lumpy jigs process including nine discard donveyors

System 9: Sampling plant

3 Conveyors

The BKM project plan showed that each individual system had milestones that were set about 3-4 weeks apart. As a result bite-size pieces of the project were managed individually and the task of expediting, for example, 435 pulleys. was made easier by expediting 9 batches of about 50 pulleys over 7-8 months.

Delivery to site followed the same process which in turn helped manufacturers optimally load trucks destined to site. The fewer fuller trucks meant good cost effectiveness and materials' handling on site more manageable. The weak link of delivery to site, however, was the goods receiving yard which was too small and as a result equipment was uncontrollably scattered making it difficult to find and issue equipment to the erectors.

CONSTRUCTION

Successful discipline-to-discipline hand over is critical for the completion of a conveyor. General flow of this can be seen in Figure 4; notice the number of times a survey was done:

Figure 4: Construction Handover Work Flow

On the BKM project, focus was placed on the quality management of earthworks and civils. For both of these disciplines quality is born from accurate surveying. There are many projects today that due to the lack of surveying, find themselves over running expenditure and losing time because of the amount of site re-work on structural steel and mechanicals.

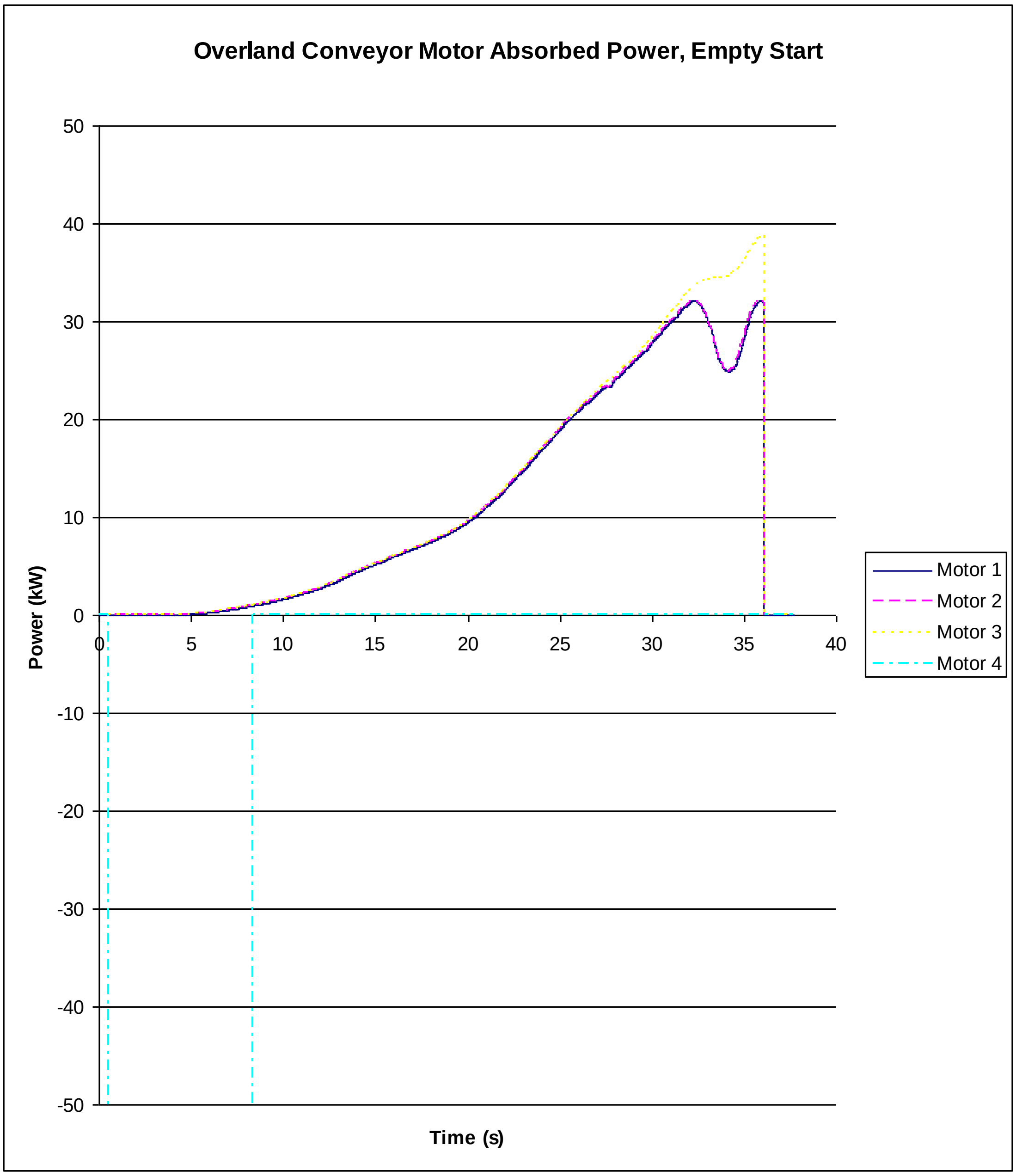
Prior to these site functions, quality from the drawing office is also paramount. Having the correct people working to their strengths helps sustain a high level of quality. Materials handling draughtsmen should keep to conveyors and piping draughtsmen to piping. There are instances where due to resource restraints, draughtsmen produce detail drawings outside of their field of expertise and almost every time site re-work is required to correct mistakes.

Although costly, the BKM project's major construction steelwork contractor had an abundance of mobile cranes and personnel. This enabled the timeous start and completion of the 9 systems buildings and conveyors. A strong client team presence kept the contractors focused on priority items and upheld the high standard of quality.

COMMISSIONING

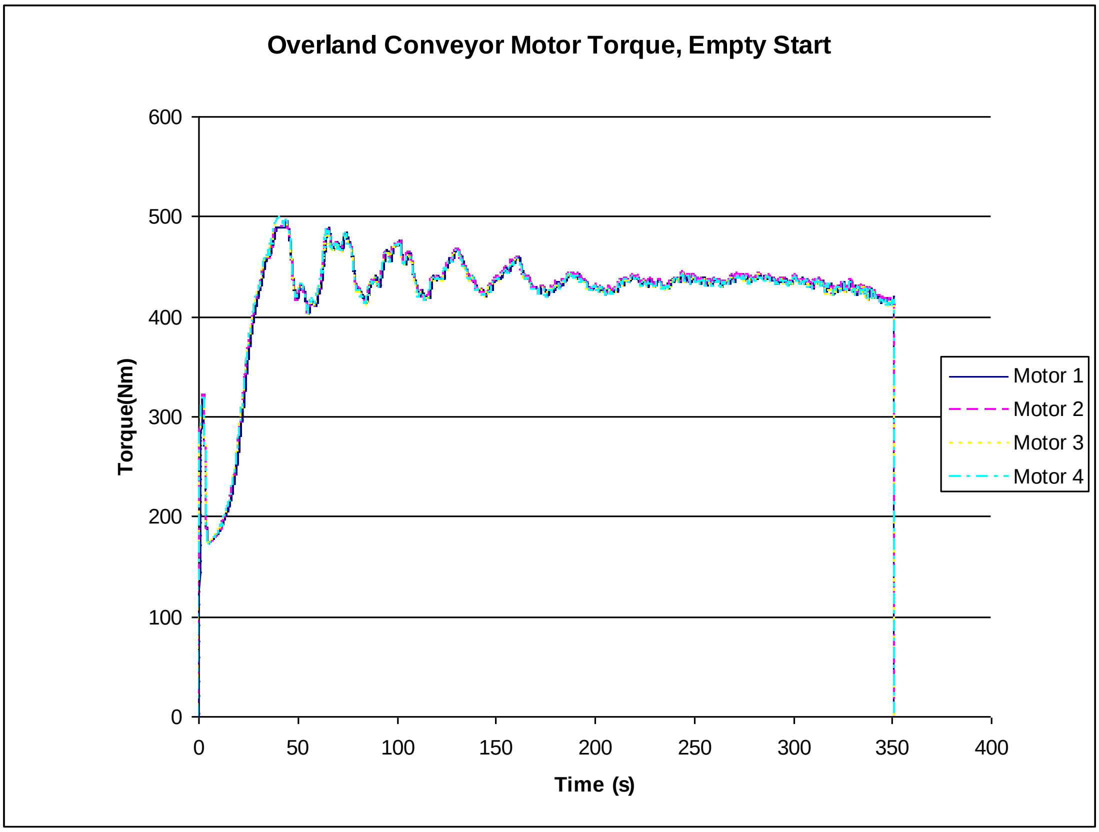
Commissioning ended up being a simple task because of the good ground work that was done in the earlier stages of the project. The only difficulty came in the amount of time, 10 months, required to fully commission all 9 systems.

The technology employed by the electrical, control and instrumentation team allowed for the capture of valuable first time trends through the SCADA system. Graph 1 shows some examples of the information gathered:



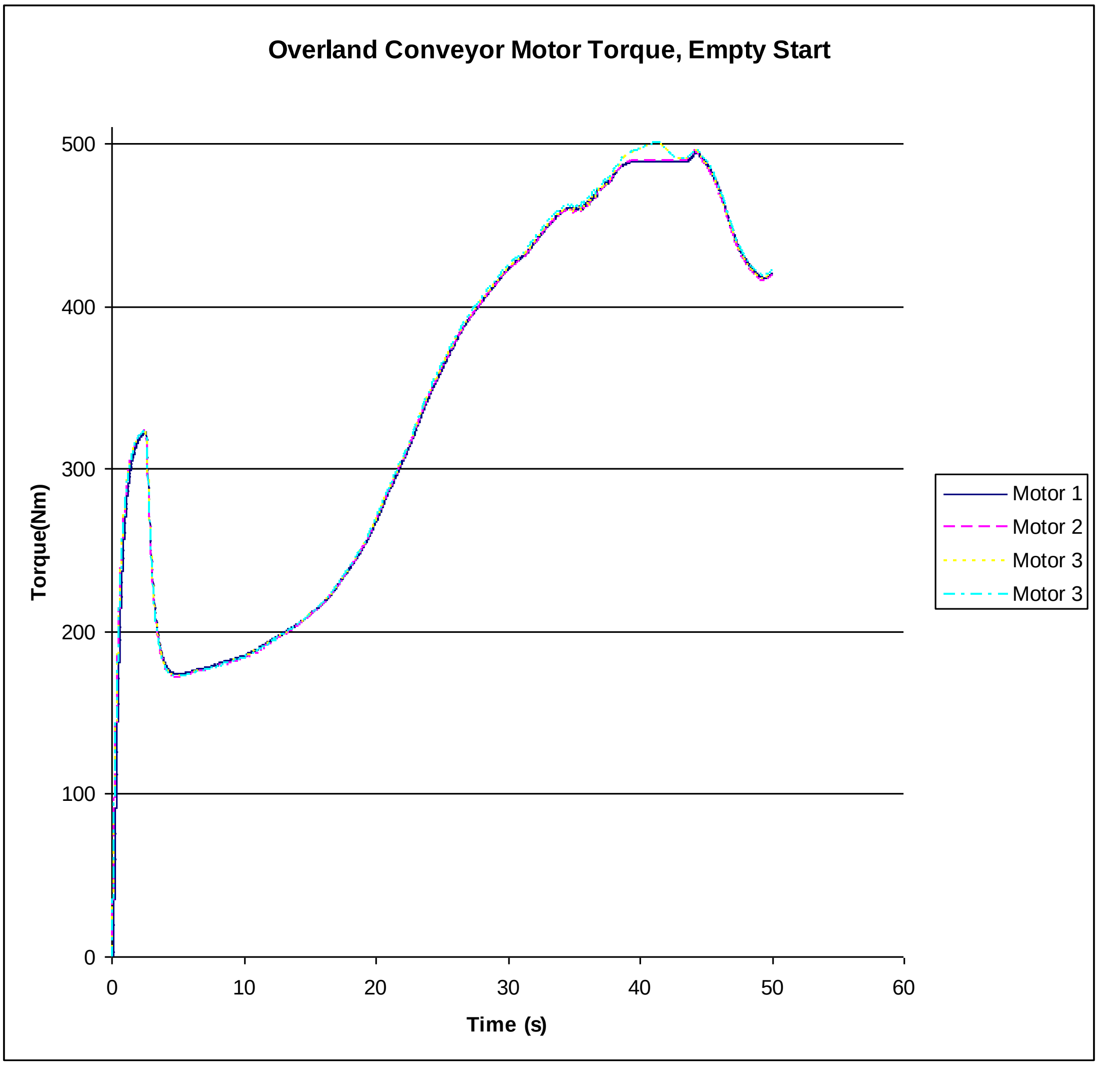
Graph 1: Overland Conveyor Motor Absorbed Power, Empty Start

Commissioning trouble: the graph shows us motor 1,2 and 3 starting up and sharing load but Motor 4 going into regenerative mode and counteracting. This was as a result of a negative feed back from the speed encoder to the VVVF.



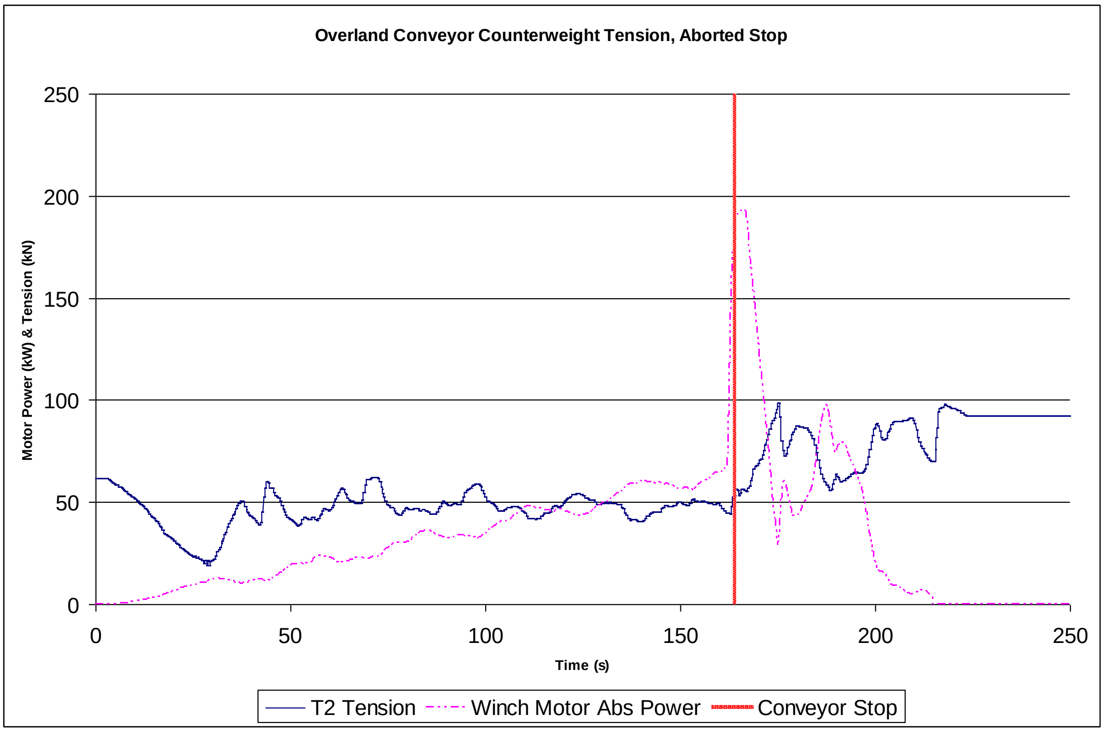
Graph 2: Overland Conveyor Motor Torque, Empty Start

Above can be seen the start up torque characteristics of the overland conveyor motors for the full start up time period.



Graph 3: Overland Conveyor Motor Torque, Empty Start

Above is a zoomed in image of Graph 3 showing the start up characteristics of a motor controlled by a VVVF drive.



Graph 4: T2 Tension behavior during an aborted start

STUMBLING BLOCKS

ENGINEERING AND DESIGN

Due to lack of drawing office resources in the marketplace at the time of design some conveyor structural design packages were split to outside design houses. The outside design houses were pushed to bursting point as they too, were experiencing staff shortage problems and as a result major setbacks were experienced in this phase with regards to quality, timing and professionalism. These setbacks continued through shop detailing where an endless amount of clarification was required. On site, major interference clashes were experienced and many conveyors required third party structural audits due to visibly overstressed members.

EARTHWORKS AND CIVILS

Problems were experienced with the quality of the earthworks for the longer overland conveyors which did not form part of the plant platforms. An early decision to only clear and grub conveying routes proves to be disastrous as some areas remained impassable with normal forms of transport and in some instances designed radii for vertical concave curves were unachievable. Again a resource constrained market in the civil contractors sector led to poor performance and in many areas the steelwork contractors had late starts.

MECHANICALS

Conveyors that horizontal take ups and a gravity counterweight tower for T2 tension requirements had hand winches fitted for positioning the counterweight box. The amount of force required to turn the handle and the sheer number of revolutions required to lift or lower the counterweight box made the exercise intolerable. In some instances a three man crew would spend hours positioning the counterweight box. It is recommended that these winches be upgraded to models with an electric motor where a push of a button and a few minutes of time gets you the end result.

The long overland conveyor was fitted with a 7.5 kW, 5.5 tonnes mechanical winch with a high reduction in place of a gravity counterweight because of the expected dynamic whips during aborted starts. The problem with the selected winch was that if the dynamic whip struck when the winch was releasing tension then the pay of the rope would be in the same direction as the force of the whip. This combined with the high reduction gearbox, would overspeed the motor causing the brake and the motor bearings to disintegrate. It was estimated that the 4 pole motor, during this phenomenon, would reach speeds of 6500 – 7000 rpm.

Other long conveyors were fitted with similar mechanical winches, this time due to a lack of space, and similar problems were found. All of the mechanical winches, including the one on the overland conveyor, were successfully replaced with more robust 55 kW, 5 tonne Eddy Current Winches.

4.6 km's of 600 mm wide, 3 ply, class 630 conveyor belt with 6 mm of top cover and 3 mm of bottom cover was installed on the project. This belt proved un-troughable and as a result tracking and training was impossible. A decision to run a large amount of production over a period of time was taken in the hope that the conveyor belts would become more supple and therefore more troughable, but even after 1 million tonnes of material had passed over these belts they remained stiff. Had the project specification for the minimum class of belt to be used been class 400 then this problem would not have existed.
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Commissioning

During hot commissioning of System 6, it was found that load out station feed conveyor could not do a fully loaded start. The conveyor was fitted with three 300 kW VVVF drives and arguments on where the fault lay ensued. Two items were short listed; the conveyor design and or the VVVF unit feeding the drives. The final answer was never found but an additional 300 kW drive resolved the problem.

CONCLUSION AND LOOKING INTO THE FUTURE

Assmang Limited, at the time of writing this paper, is expanding the plant to the design tonnage of 16 MTPA. Studies are being being conducted to further expand the Khumani Iron Mine to 22 MTPA. To achieve these expansions it expected that about 125 additional conveyors will be required as well as upgrades to 20 existing conveyors, ultimately making the Khumkani Iron Ore Mine a haven for conveyor equipment suppliers.

If the teams that execute the future expansions, which are promising to be larger than the first phase, take cognizance of how the first phase was executed and are aware of lessons learnt, then there should be no reason why they too, cannot be as successful.

AUTHOR'S CV

JOSE CARLOS DE SOUSA ANDRADE

Jose Carlos De Sousa Andrade joined the bulk materials industry with Nepean Conveyors (Pty) Ltd after obtaining his BEng Mechanical degree from the Rand Afrikaans University. He was employed by Nepean for four years project engineering and managing many conveying projects before moving to DRA Mineral Projects as a material handling engineer on the Khumani Iron Ore Mine. The Khumani project is one of the largest conveying projects undertaken with a total of 84 conveyors conveying iron ore over a distance of 26 km's. He is actively involved with the CMA and is part of the Beltcon 15 committee.