An investigation into the physical constraints of the current sub-decline at Turffontein Shaft

by M.C. Bhulose*

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Synopsis

The purpose of this project was to identify constraints that could occur in the current sub-decline shaft at Turffontein Shaft should an increase in production take place. Particular attention was to be paid to the transportation of men and materials and to the broken rock and ventilation capacity of the shaft.

This project is an in-depth evaluation of the logistic capacity of the sub-decline system at Turffontein Shaft in order to determine by how much production can be increased in this area to replace tonnages from the vertical shaft area, where ore reserves are rapidly becoming depleted.

Introduction

Mine background and general information

The Bushveld Complex in South Africa, which hosts the Merensky and the UG2 Reefs, is the largest known layered igneous intrusion in the world and it contains the largest known deposits of chrome, vanadium and platinum group metals. This complex covers an area of 66 000 km^2, with a north-south axis of 350 km from Pretoria to the Brits district, and a 480 km east-west axis from Zeerust to the Lydenburg districts.

In June 1925, the Merensky Reef was located some 45 km to the east from the present lease area of Rustenburg Platinum mines. Rustenburg Section is the oldest platinum producing area in the western Bushveld. The reef was later discovered on Turffontein and Waterval farms near the town of Rustenburg. The Merensky reef has since been traced on the eastern limb of the Bushveld Complex for a distance of 150 km and on the western limb for a distance of 200 km, making it the largest platinum deposit in the world. Systematic prospecting of the lower portion of the Bushveld Complex led to the discovery of the UG2 chromitite layer, some 30–370 m below the Merensky Reef. The platinum bearing ore bodies, i.e. Merensky and UG 2 reefs, are found in the upper part of the critical zone. The UG2 reef is consistently about 70 cm–1.2 m thick. The reefs being mined have an average dip of about 10°.

Turffontein Shaft had been part of Rustenburg Platinum Mines Limited, which was formed in early 1931. The shaft is now part of the Anglo Platinum Corporation. This mine has a call of 120 000 tons per month (tpm). The mine produced 1 401 018 tons of ore and 153 596 ounces of platinum during the past year.

At present South Africa and Russia are the major sources of the world's platinum group metals, with South Africa being the number one producer. The Bushveld Complex is the source of 79% of the world's platinum production and hosts 70% of the world's economic platinum resources.

Platinum uses fall into three main categories, namely the automobile industry for catalytic converters, the jewellery industry, and industrial applications.

Project background

Turffontein Shaft has been in production for many years. The current production from the Merensky horizon is about 120 000 tons per month (tpm). To maintain these production levels, it has become necessary to deepen the mine with new incline clusters from 29 level to 36 level. The major Merensky production areas will be from 33 level to 36 level and these will account for virtually all the shaft's Merensky output by the year 2009[1]. The mine is developing towards the UG2 horizon, which has never been mined in this mine before.

All the workings in these areas are accessed by an inclined shaft system. The system comprises of men, materials and rock transportation decline shafts. For optimum efficiency and smooth operation of the inclined shaft complex, a critical analysis of current shaft practices is needed to ensure that the

* *School of Mining Engineering, Faculty of Engineering and Built Environment, University of the Witwatersrand.*

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required tonnage/ounce output is maintained. An increase in production in this area implies more rock, materials and men up and down this shaft system, thus it has become necessary to investigate and find any constraints of the inclined shafts in this regard.

Problem statement

A critical investigation into the physical constraints for the current sub-decline at Turffontein Shaft.

Objectives

This project is an in-depth evaluation of the logistic capacity of the sub-decline system at Turffontein Shaft in order to determine by how much production can be increased in this area to replace tonnages from the vertical shaft area, where the ore reserves are rapidly becoming depleted.

- ➤ Background investigation
- ➤ Identification of the critical constraints of the decline shaft system, which includes broken rock handling, materials handling, and transportation of workers
- ➤ A critical analysis of the current vertical shaft schedule and production profiles, material handling, and workers' transport
- ➤ Ventilation capabilities of the shaft system
- ➤ Identification of critical areas if an increase in production of the sub-decline must take place
- ➤ Conclusion and possible recommendations.

Scope of the study

During this study the following aspects have been covered and investigated: transportation of men from the vertical shaft to the decline shaft system, transportation of materials down the vertical shaft, ventilation capabilities of the decline shaft, transportation of broken rock through the decline shaft, and identification of critical areas if an increase in production takes place.

The transportation of materials through the inclined shaft is one important aspect of the decline shaft operation that has not been covered thoroughly in this study.

Methodology

In order to satisfy the objectives, the investigation was conducted in the following manner;

- ➤ *Literature search*—reports were obtained and read to gain insight into the project and background and to obtain some information about mines that have a similar setup; people were also consulted[1]. Books were also read for more insight into some of the project elements[2].
- ➤ *Observations*—the observations were made at all the incline shaft sites in order to view all critical areas and areas that could possibly be affected by an increase in production.
- ➤ *Measurements*—measurements were taken of hopper cycle times at the materials decline, timing of instances when the conveyor runs empty or when stopped, amount of time taken when walking from the station to the chair lift decline, measuring the amount of time it takes to lower and raise the shift by the vertical hoisting system for all three shifts of the day, time allocated for transportation of materials down the vertical hoist, and capacities of the conveyor belt and chair lift.
- ➤ *Data collection*—data about ventilation layouts from the ventilation department, a copy of the shaft schedule, mine background, and project background reports were collected.
- ➤ *Computations*—computations were done in order to accurately analyse results obtained from observations and measurements.

Results from literature study

During this study, the practice at the Townlands Shaft for transporting people from the underground stations to close proximity of their work areas has shown great reduction in travel times, thus increasing the time people spend at the work face. The use of transport carts that match the cages being used has shown to be of vital importance since this ensures that no people arriving from the surface wait for this transportation system because of lack of space.

The same system can be used at the Turffontein Shaft, since an increase in the number of people that will be using 29 level as their base station is expected. The distance that people have to travel to the decline shaft is approximately 2 km. Most of the mine's production in future will be handled by the levels in the inclined section, which depends on 29 level for all transportation purposes.

Observations, measurements, data collection

Decline shaft

The decline shaft system comprises three shafts, namely the conveyor belt decline, the materials decline, and the chair lift decline. The decline has a dip of approximately 13° and it will service all seven levels from 30 level to 36 level. Currently production in the decline clusters is at 31 level and the decline development ends are at 33 level.

In total there will be seven decline levels mining both the Merensky and the UG2 reefs.

Broken rock transportation

Currently broken rock is transported using two systems in the decline shaft: the conveyor belt and hauling through the materials decline.

The materials decline is being used to transport materials required for the mining operation and waste rock broken from the development ends that are progressing to 36 level. This waste rock transportation is achieved by hauling hoppers up the decline to tip at 28 level silos during afternoon and night shifts. Currently 20 hoppers per shift are hauled and tipped. The afternoon shift is being utilized for pulling out empty material cars and waste rock hauling, while the night shift is utilized only for waste rock hauling. These hoppers are loaded using load haul dumpers (LHD). Of the three available LHDs one is used to load the hoppers (Figures 2 and 3c) and the other two are used to clean the development ends. At times only one LHD is available for both cleaning and loading hoppers; this results in longer hopper cycle times (Figure 1). The LHDs that clean the development ends after blasting tip the waste rock in one large designated area. When the face has been cleaned, one of these LHDs moves this broken rock to a smaller rock pile close to the rails were the third LHD is used to load the rock into the hoppers. The waste rock is then tipped at 28 level waste silos.

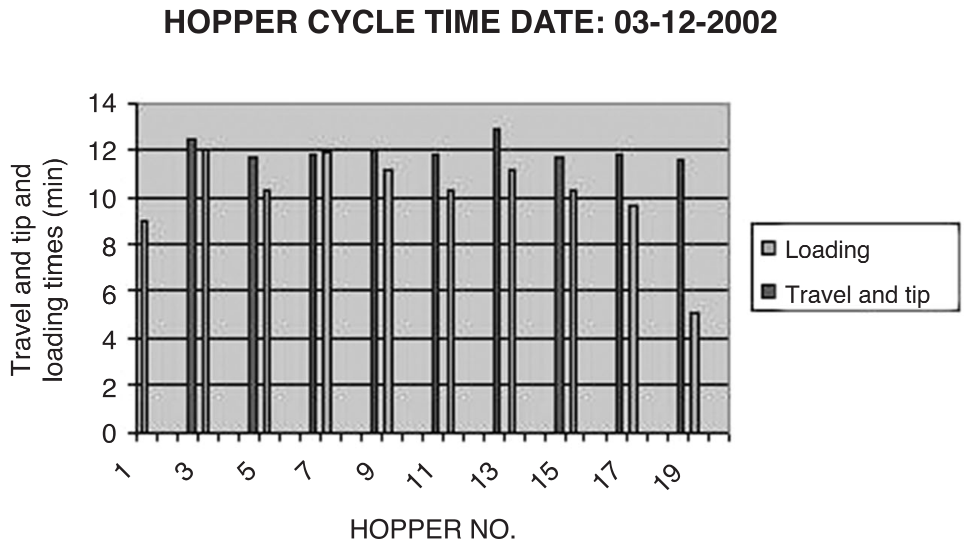

Figure 1a—Hopper cycle time with 1 LHD being used to clean and load

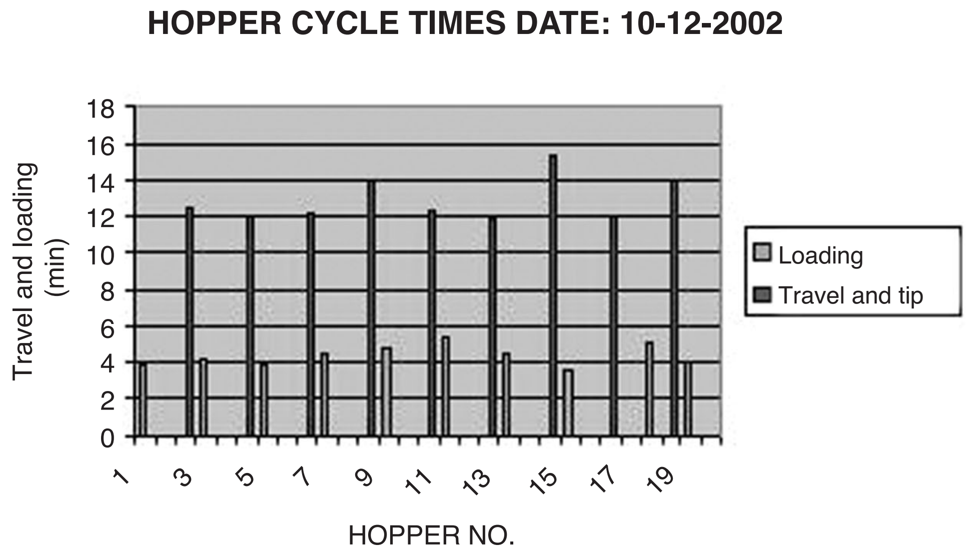

Figure 2—Hopper cycle time with 2 LHDs, one being used for loading and one for cleaning

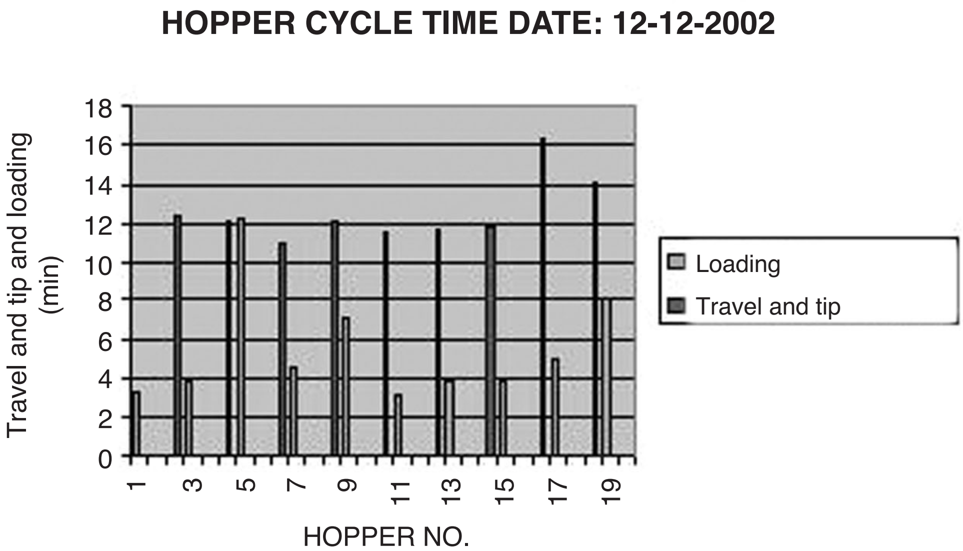

Figure 3—Hopper cycle time with 2 LHDs, one being used for loading and one for cleaning

Table I

Number of hoppers loaded per shift

Date	Shift	Duration (actual shift time—hours: minutes)	Number of hoppers
03/12/2002	Afternoon shift	3:35	10
09/12/2002	Afternoon shift	No loading—no power	–
10/12/2002	Afternoon shift	2L59	12
11/12/2002	Afternoon shift	No loading—LHDs down	–
12/12/2002	Afternoon shift	3:11	12

Figure 4—Main conveyor belt

Figure 5—Tripper conveyor

The conveyor belt is used to move broken rock (both reef and waste) from 28 level down to 31 level. The conveyor has a capacity of 400 tons per hour. This conveyor belt used is differentiated into two sections; the main conveyor (Figure 4) and the tripper conveyor (Figure 5). The tripper conveyor is situated at the top end of the belt decline and is used to tip the broken rock into different silos. The belt is operated over three shifts. The night shift loads and tips mainly reef, but waste is sometimes tipped when reef chutes are empty.

The conveyor is kept running most of the time and is only stopped when silos are being changed at the tripper conveyor section.

There are three silos at the tripper conveyor section. The waste silo is used to tip waste rock from all levels serviced by the conveyor; the other two silos are used to tip reef, but 28 level has its own designated silo because all the cleaning is carried out by contactors. This ensures that contractors are properly paid, based on the tonnages cleaned. From 29 level down to 31 level the remaining silo is used.

Loading on the belt from a single ore chute is not continuous; this is done in order to prevent possible belt overloading. There is no clear ore loading sequence from 29 level to 31 level chutes on to the conveyor.

The efficiencies of the conveyor belt, as calculated from the shifts observed, have shown to be very low (Table III).

This, however, is not a downside of the belt utilization since the belt still has to service four more levels still to be developed (both reef and waste).

Transportation of men

Transportation of men in the decline is done using a chair-lift system (Figures 6a and b) with a capacity of 450 men per hour with a chair spacing of 6 m. The final length of the chair-lift will be approximately 1394.063 m, and will service 7 levels i.e. from 30 to 36 level. The decline has an inclination of 13°. Accumulation of people at boarding points during the beginning and end of shifts is a norm and this is not outweighed by the amount of reduced travel time to the working areas.

The chair-lift system currently services two levels (30 and 31 levels). Extension to 33 level will be complete towards mid-February 2003.

The chair-lift system can have an increased velocity of 1 m/s, which will result in an increased capacity of 600 men per hour. This increase would still be within the allowable safety limits. With an increased velocity, the chair spacing should be kept the same for comfortable boarding.

There will be approximately 900 people expected to work in the decline from 30 level to 33 level at full production of these levels, while the rest of the development proceeds. This number of people will take 1 hour, 54 minutes to transport on the production shift. Lowering the shift at different times down to 29 level in the vertical shaft area could be one solution to minimizing the waiting times at 29 level boarding station.

Transportation of materials

The materials decline is used for two purposes, namely transportation of materials and the transportation of waste rock from development ends. This has meant that there is little time for transportation of materials. Materials are transported during the morning shift (Figures 7a and b) and the afternoon shift is used for the removal of empty material cars and transportation of broken rock; the night shift is used for transportation of broken rock only.

Currently overtime is also being used for transportation of materials to meet the demand. Materials are transported to four levels (30, 31, 32 and 33 level) and the broken waste rock is transported from the development ends only at 33 level.

However, the utilization of this decline for rock transportation will be stopped towards the end of February 2003, thus allowing for enough time to transport materials. This will be due to the extension of the conveyor belt to close proximity to the face.

Ventilation

Development of any kind into virgin rock will result in higher ambient temperatures. This virgin rock temperature causes a temperature increase of the ventilating air being passed through the area. In ventilating the new mining areas, a planned velocity of no more than 2.5 m/s in the belt decline is planned. This is to ensure that the ventilating air does not cause dust from the rock being conveyed on the belt. However, higher velocities in the chair-lift and material decline can be achieved if needed.

The decline tunnels will serve as intake airways. The decline cluster's intake levels will be levels 30, 32, 34 and 36, while the return air levels will be levels 29, 31, 33 and 35. The return air levels will be linked to the existing mine return airways.

Air entering the decline shafts is approximately 17°C wet bulb (wb) and the return air reject temperature is expected to be 32°C wb. The existing downcast and upcast shafts will be used for the additional air quantities needed in these new working areas.

These declines are currently ventilating three working levels, and the three decline development ends at 33 level.

The declines are developed at 3.5 × 3.5 m, resulting in a cross-sectional area of 12.25 m^2. An air velocity of 2.5 m/s in a decline results in: 2.5 m/s × 12.25 m^2
= 30.6 m^3/s of air per decline.

The three declines can thus provide 92 m^3/s of air at 2.5 m/s, but the materials decline and the chair-lift decline can have increased velocity in excess of 5 m/s. This increase can be achieved by the installation of booster fans in these two declines. This shows that the declines will have more than sufficient air for all the workings since the air requirement for this area is 90 m^3/s.

Two fridge plants exist on the mine and, due to an increase in depth and thus an increase in rock virgin temperature, another plant with a power rating of 9 600 KW will be erected in order to help with air cooling.

Vertical shaft

Broken rock hoisting

The broken rock from the conveyor belt silos is transported by hoppers to the vertical shaft tipping area where it is then hoisted to the surface. Hoisting of broken rock in the vertical shaft occurs 24 hours a day. This continuous hoisting system is automated. Hoisting is normally done for reef, and waste is hoisted only as it accumulates. The hoisting is done using 11-ton skips at a rate of 22.5 skips an hour.

Production profiles obtained show that 1 245 210 tons of rock (both reef and waste) were hoisted to surface over 11 months (Table IV).

Table III

Efficiency - (actual tonnage/theoretical tonnage) x 100%

Date	Shift	Efficiency
13/12/2002	Evening	22.90%
16/12/2002	Evening	26.00%
18/12/2002	Morning	39.22%

Figure 6—Chair-lift system

Table II

Conveyor belt utilization shift

Date	Shift	Total delays (h:m:s)	Actual shift time (h:m:s)	Actual running time (h:m:s)	Availability (h:m)	Theoretical tonnage values	Actual tonnages achieved
13/12/2002	Evening	1:57:57	6:49	4:51:03	6:33	2358	540
16/12/2002	Evening	3:20:05	7:12	3:51:55	6:40	2400	624
18/12/2002	Morning	2:35:34	7:21	4:45:26	5:48	2088	819

Delays include the total time the belt is stopped, power cuts, etc. Actual shift time is the time from when the belt is started until its final stop
Theoretical tonnage values calculated from belt capacity and running time at 90% efficiency

Figure 7—Materials decline (materials and safety device)

Man transportation

The observations made show that the current shaft schedule for transportation of men is not in accordance with actual practice for the number of people designated at various levels (Table V). More discrepancies occur in the afternoon when the shift from 29 level has to be raised. Employees working in 29 level and sub-decline levels are raised to surface first, then the above levels follow, but people from upper levels come down to 29 level for earlier transportation, resulting in prolonged hoisting time at 29 level. This is beyond mine personnel control.

Material transportation

Transportation of materials occurs daily after the completion of man hoisting. The same cage that is used to transport men is used to transport materials. Materials transported range from explosives to timber supports. Large materials that do not fit into the cage, such as rails and rail junctions, are transported (slinging) on Sundays when there is more free shaft time.

Analysis and evaluation of research/ investigation results

Decline shaft

Broken rock transportation

Hoppers

The graphs obtained (Figures 1, 2, and 3) for the transportation of broken rock using the materials decline show that at least 2 LHDs must be available per shift in order to minimize hopper cycle times. This availability also ensures that two duties are performed efficiently at the same time, i.e. hopper loading and face cleaning.

Table I shows that on average 3 hours, 16 minutes are taken to load and haul 11 hoppers.

Average = (3:40 + 2:59 + 3:11)/3
= 3:16

However, mine shift duration = 9:20 (ie. from clock-in time.)

Travelling time from surface to working site
= 2* Σ (hoisting times + loading & offloading + travelling time underground to site)
= 2* Σ (2 min + 2 min + 37 min)
= 82 min

Thus working time available = 9:20–0:82
= 7:58

Therefore 22 hoppers can be achieved in 5 h 32 min; the remaining 1 h 26 min is more than enough time to be used for starting up, refuelling and lowering the first 2 empty hoppers.

In total 44 hoppers can be achieved per day: 20 during the afternoon shift (since the shift is also being used to remove empty material cars) and 24 during the night shift. Any shift should not have any problems in hoisting the designated number of hoppers per shift time allocated.

However, the mine target of 40 hoppers per day is not always met, suggesting better supervision is necessary for this cycle.

Conveyor

The amounts of broken rock tipped by the conveyor into the silos (Table II) show that at the moment the conveyor is still being underutilized.

Efficiency = actual amount conveyed/ theoretical amount × 100%

The efficiency of the conveyor system ranges from 22.90% to 39.22% for the days investigated.

The mine call is 120 000 tons per month. This will result in an operating efficiency of:

(120 000/211 200)×100% = 56.82%

Thus the conveyor must operate at an efficiency of 57% if the mine call is to be achieved when the decline is fully operational, and all the mine's production comes from this area.

The resultant underutilization of the conveyor belt shows that the belt should be able to handle the broken rock tonnages when the whole decline is operational.

With an assumed efficiency of 80%(taking into account maintenance and other unforeseen delays) the conveyor has a capability of 168 960 tons per month. If production in the mine takes place only in areas serviced by the conveyor belt in the future with the same mine call of 120 000 tons per month, the conveyor will be more than capable of handling the mine's production rates.

Table IV

Production profile for 2002

Rock (tons)	Period (month)											
	01	02	03	04	05	06	07	08	09	10	11	Total
Dev. Waste(t)	11390	13113	12858	16411	17644	18482	27977	28237	25608	25420	24972	222112
Dev. Reef(t)	5910	6493	9352	8661	10007	9117	10184	8832	8171	9996	8910	95633
Stoping Waste(t)	5104	4024	5277	5291	5938	5756	6063	5892	5765	7240	5937	62287
Stoping Reef(t)	67607	65095	72624	78083	82739	76852	93330	81856	83693	93093	70206	865178

Table V

Summary of shaft schedule for the morning shift 06/01/03 and 09/01/03

Shift	Level	Hoisting time average/min	Allocated time shaft/min
Morning shift	29	57	30
	26	49	30
	24	9	25
	22	5	15
	20	3	10
	18	3	10

Transportation of men

Accumulation of men at chair-lift climbing points is not a problem as yet; however, this could become a serious problem when all decline levels are operational because people that work in the decline levels all arrive at chair-lift climbing points at the same time in the morning and leave their working area almost simultaneously.

This problem could be overcome by modifying the current shaft schedule so that people that work in 36 level (which will be the bottom-most level) are lowered first in the morning then the above levels follow consecutively, with each level having its own designated time of going down, as it is currently being done for the vertical levels. This practice will ensure that long queues do not form in the mornings and afternoons and thus employees will get to work faster.

Vertical shaft

Broken rock hoisting

The automated skip system ensures constant rock hoisting so that shortages of ore on surface are not experienced.

The number of skips per day = 22.5 skips/hour × 24 hours
= 540 skips/day

Assuming an 85% utilization factor (accounting for maintenance, power cuts, service etc.), then:

Number of skips per day = 540 skips/day × 0.85
= 459 skips/day

Assuming a 90% skip fill factor, then: 11 tons/skip × 0.9
= 9.9 tons/skip

Therefore tonnes in one day = 9.9 tons/skip × 459 skips/day
= 4 544.1 tons/day

Thus tonnes that can be hoisted in 12 months
= 4 544.1 tons/day × 336 days
= 1 526 817.6 ton

Actual tons hoisted in 11 months = 1 245 210 tons (Table IV), thus estimated tonnes in 12 months 1 358 410 tons (estimated, since the data for the month of December was not available at the time)

Therefore hoisting efficiency = 1 358 410 tons/ 1 526 758.7 tons × 100%
= 88.97%

Figure 8—Man transportation: (a) surface (b) underground

This hoisting efficiency shows that the vertical hoisting system will not be able to handle much increase in production since a 100% efficiency cannot be achieved. Assuming that a maximum efficiency of 95% can be obtained, then:

Tonnes that can be hoisted = 1 526 758.7 tons × 95%/100%
= 1 450 420.7 tons

Therefore the current hoisting system can handle only a 92 010.77 ton increase over 12 months.

This is = 92 010.77/1 450 420.77 × 100 = 6.43% production increase.

If production increases more than this value over the same period, then the hoisting system must be changed.

Man transportation

It is evident that time allocated to transport employees to deeper levels is not enough (Table V). More time is needed to transport men working in shallower levels i.e. levels above

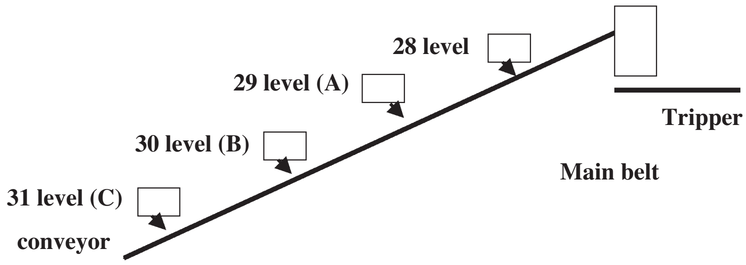

Figure 9—Part of the conveyor belt cross-section

26 level. An increase in the number of people using 29 level as their base station has resulted in more time being needed for hoisting to this level. Thus the shaft schedule must be modified accordingly to accommodate such increases.

As more decline based levels open for operation, an increase in the number of people using 29 level as a base station is imminent and thus modification of the shaft schedule must result.

Critical areas if production increases

The mine should thoroughly investigate the following areas if an increase in production is to occur.

- Skips
- Shaft schedule
- Chair-lift
- Conveyor belt
- Logistical systems.

Conclusions

The installed chair-lift system should be able to cope with an increase in the number of people still to be transported when the development of the decline shaft system is complete. However, the congestion of people at boarding points could cause delays in getting people to their working areas. This congestion could be countered by modifying the shaft schedule. This can be done by lowering people that work in the deepest points of the decline first to 29 level.

The installed conveyor belt should be more than capable of handling the expected tonnages from all the decline clusters at full production. This is also observed when looking at current operating efficiencies for the operating levels.

The materials decline will be able to handle all the required materials to all levels when the hauling of waste rock is stopped. Overtime will not be necessary in meeting the demand for materials.

All these three declines put together will be capable of handling the ventilation requirements of the decline areas.

The vertical shaft schedule must be modified in order to prevent any constraints arising from the vertical shaft area, thus hindering production in the decline production areas.

Recommendations

- The mine must look into doing a feasibility study on the use of carriages for man transportation in 29 level
- In minimizing broken ore hoisting in the materials decline, the conveyor belt decline must be the leading decline and belt extensions must not be delayed so that the LHDs can tip directly onto the conveyor belt. This will allow for enough time in transporting needed materials to production sites without delay as more production levels open up
- The mine must review and optimize the current shaft schedule
- Changing of skips could be necessary if production increases are expected
- Possible increase in chair-lift speed can still be done within safety limits and regulations
- Sequential loading on the conveyor belt.

Currently the conveyor efficiency can be increased by sequential loading of loading boxes as illustrated in Figure 9.

A common reef silo is used for tipping from 29 level down. Instead of just loading the belt using any box at the beginning of the shift, sequential loading should be practised. Box (A) should be loaded first, then (B), then (C) and so on. When the bottom box has finished loading, e.g., (C) the following box to be loaded must be (B), then (A). This practice will limit the times that the belt runs empty.

Acknowledgement

I wish to express my appreciation to the following organizations and persons who made this project report possible:

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- Professor H. Phillips, my supervisor, and Mr T. Mugodi, my co-supervisor, for their guidance and support.
- My family for their encouragement and support during the study.

References

1. Read, Swatman and Voigt (Pty) Ltd. ‘Logistics Evaluation on Incline Level and Below at Turffontein Shaft’ and ‘Scope of Work for Decline Clusters at Turffontein Shaft’.
2. Engineering Conference of the Conveyor Equipment Manufacturers Association. *Belt Conveyors for Bulk Materials*, Second edition. ◆

Appendix A

Detailed LHD Hopper loading times

Date: O3/12/02 No. of hoppers	Travel and tip (minutes)	Loading (minutes)
1		7.416667
2		1.616667
	12.5	
3		10.05
4		1.916667
	11.75	
5		7.383333
6		2.933333
	11.8333333	
7		9.166667
8		2.7
	12	
9		8.15
10		3.05
	11.85	
11		8.116667
12		2.216667
	12.8333333	
13		7.666667
14		3.45
	11.7	
15		8.05
16		2.25
	11.85	
17		6.85
18		2.733333
	11.6333333	
19		2.716667
20		2.366667

Date: 10/12/02 No. of hoppers	Travel and tip (minutes)	Loading (minutes)
1		1.15
2		2.733333
	12.5333333	
3		0.983333
4		3.233333
	12.0666667	
5		0.866667
6		3.033333
	12.1333333	
7		1.283333
8		3.216667
	13.9833333	
9		1.683333
10		3.133333
	12.3333333	
11		2.383333
12		2.966667
	11.8333333	
13		1.216667
14		3.283333
	15.2833333	
15		1.016667
16		2.6
	12.05	
17		1.05
18		5.033333
	13.9166667	
19		1.116667
20		2.933333

Date: 12/12/02 No. of hoppers	Travel and tip (minutes)	Loading (minutes)
1		0.716667
2		2.6
	12.3666667	
3		1.05
4		2.883333
	12.0833333	
5		8.1
6		4.033333
	11.04	
7		1.283333
8		3.233333
	12.0666667	
9		2.85
10		4.216667
	11.5833333	
11		1.15
12		2.066667
	11.6333333	
13		1.25
14		2.65
	11.8666667	
15		18.05
16		2.816667
	16.35	
17		1.45
18		3.516667
	14.05	
19		4.566667
20		3.6

Appendix B

Detailed conveyor belt running times

Date: 13/12/02 Start time	Night shift run—empty (minutes)	Stopped (minutes)	Reason
20:44	12.15		Beginning of shift
		21:08	Changing silos
21:11			
	3.3		Changing loading boxes
	3.18		Changing loading boxes
	9.31		Changing loading boxes
	2		Changing loading boxes
	6.3		Changing loading boxes
	5.5		Changing loading boxes
	2.26		Changing loading boxes
	4		Changing loading boxes
		23:59	Changing silos
0:03			
	10.13		Changing loading boxes
	11.85		
		0:23	Changing silos
0:25			
	11.1		Changing loading boxes
	5.2		Changing loading boxes
	2.5		Changing loading boxes
		2:04	Changing silos
2:08			
	8.05		Changing loading boxes
		2:34	Changing silos
2:37			
	10.59		Changing loading boxes
	4		
		3:35	End of shift

Appendix B **(continued)**

Detailed conveyor belt running times

Date: 16/12/02 Start time	Night shift run—empty	Stopped	Reason
20:29			
	13.1		Changing loading boxes
	3.13		Changing loading boxes
		21:01	Changing silos
21:03			
	2.08		Changing loading boxes
	2		Changing loading boxes
	5.26		Changing loading boxes
		22:02	Changing solis
22:04			
	8.2		Changing loading boxes
		22:21	Changing silos
22:24			
	12.13		Changing loading boxes
	4.1		Changing loading boxes
	7.4	0:23	Changing loading boxes
	3.48		Changing loading boxes
	4.3		Changing loading boxes
	2.2		Changing loading boxes
		0:06	Changing silos
0:09			
	5.3		Changing loading boxes
		0:14	Changing silos
0:18			
	11:15		Changing loading boxes
	2		Changing loading boxes
	6.5		Changing loading boxes
	3.25		Changing loading boxes
		1:03	Changing silos
1:05			
	12.5		Changing loading boxes
	10.1		Changing loading boxes
		2:00	Changing silos
2:03			
	9.4		Changing loading boxes
	3.3		Changing loading boxes
	4		Changing loading boxes
		2:46	Changing silos
249			
	6		Changing loading boxes
		2:55	Changing silos
2:58			
	10.4		Changing loading boxes
	13		Changing loading boxes
		3:43	End of shift

Appendix B **(continued)**

Detailed conveyor belt running times

Date: 18/12/02 Start time	Morning shift run—empty	Stopped	Reason
5:27			
	4.52		
		5:32	Changing silos
5:35			
	9.15		Changing loading boxes
	12.23		Changing loading boxes
	5.2		Changing loading boxes
	2		Changing loading boxes
	54		Changing loading boxes
	15.5		Changing loading boxes
		7:52	Power cut
		8:54	Power cut
		9:04	Power cut
		9:10	Power cut
9:13			
	2.35		Changing loading boxes
	1.5		Changing loading boxes
	4.38		Changing loading boxes
	4.35		Changing loading boxes
		10:52	Changing silos
10:56			
	3.3		Changing loading boxes
		11:10	Changing silos
11:12			
	8.46		Changing loading boxes
	3		Changing loading boxes
	2.16		Changing loading boxes
	4.58		Changing loading boxes
	3.44		Changing loading boxes
		12:34	Changing silos
12:37			
		12:48	End of shift