Commissioning a Ventilation Expansion in a Saskatchewan Potash Mine

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The Rocanville potash mine has historically been accessed through two shafts; a production and ventilation exhaust shaft, and a service and ventilation fresh air shaft. The mine is completing an expansion to increase nameplate capacity from 3.0 million metric tonnes per annum (MMtpa) to 5.7 MMtpa of finished potash products. The historical service shaft has been converted to a second production shaft. Construction of a new service shaft 15 km from the existing site is completed; three shafts are now available for mine ventilation. To facilitate safe production, the existing ventilation system capacity was increased from 142 m^3/s to 283 m^3/s. This paper summarizes the design, construction, and implementation of the expanded mine ventilation system.

Introduction

The Rocanville potash mine is located in Saskatchewan, and has been in continuous production from its inception in 1971. Potash is mined at approximately 1000 m depth below surface at Rocanville, and after 45 years of mining, existing underground mining rooms are extensive. Until June 2015, the mine was historically accessed through two shafts: a production and ventilation exhaust shaft, and a service and ventilation fresh air shaft. The mine is completing an expansion to increase production from 3.0 MMtpa to 5.7 MMtpa finished potash products, by expansion of the mining fleet and accessing new potash reserves. The expansion also required new ore processing facilities and increased hoisting capacity. The historical service shaft was converted to a second production shaft. Construction of a new service shaft to access the workings 15 km from the existing site was in completed 2015: three shafts are now available for mine ventilation.

To facilitate safe production the existing mine ventilation system capacity needed to be increased from 142 m^3/s to 283 m^3/s. This was required for the increase in the number of underground mining faces, and for the increased distances of underground workings as mining continues. This paper summarizes the implementation of the expanded mine ventilation system. Computer modelling was used to assist in fan selection, location, and analyze shaft conveyance performance. Simulations were done integrating production scheduling and ventilation requirements. Commissioning of the new ventilation system was implemented in phases to permit a controlled ramp up to full ventilation capacity with minimal disruption to mine operations, and these phases were modelled prior to implementation and compared to actual surveys throughout to verify the design and then forecast the results of changes to the network.

Design

An engineering assessment and design of the Rocanville mine ventilation system upgrade was completed. A total of six main surface fans were sized and selected with an installed brake power of 895 kW and a total of eight underground booster fans were sized with an installed brake power of 1194 kW. Overall, fourteen fans were sized and selected, with an installed brake power of 2089 kW, to achieve an overall flow underground of of 254 m^3/s (283 m^3/s at surface, reduced by accounting for auto-compression going underground) [1]. Installation details are available in Figure 1. The design was then verified using a ventilation computer modelling program.

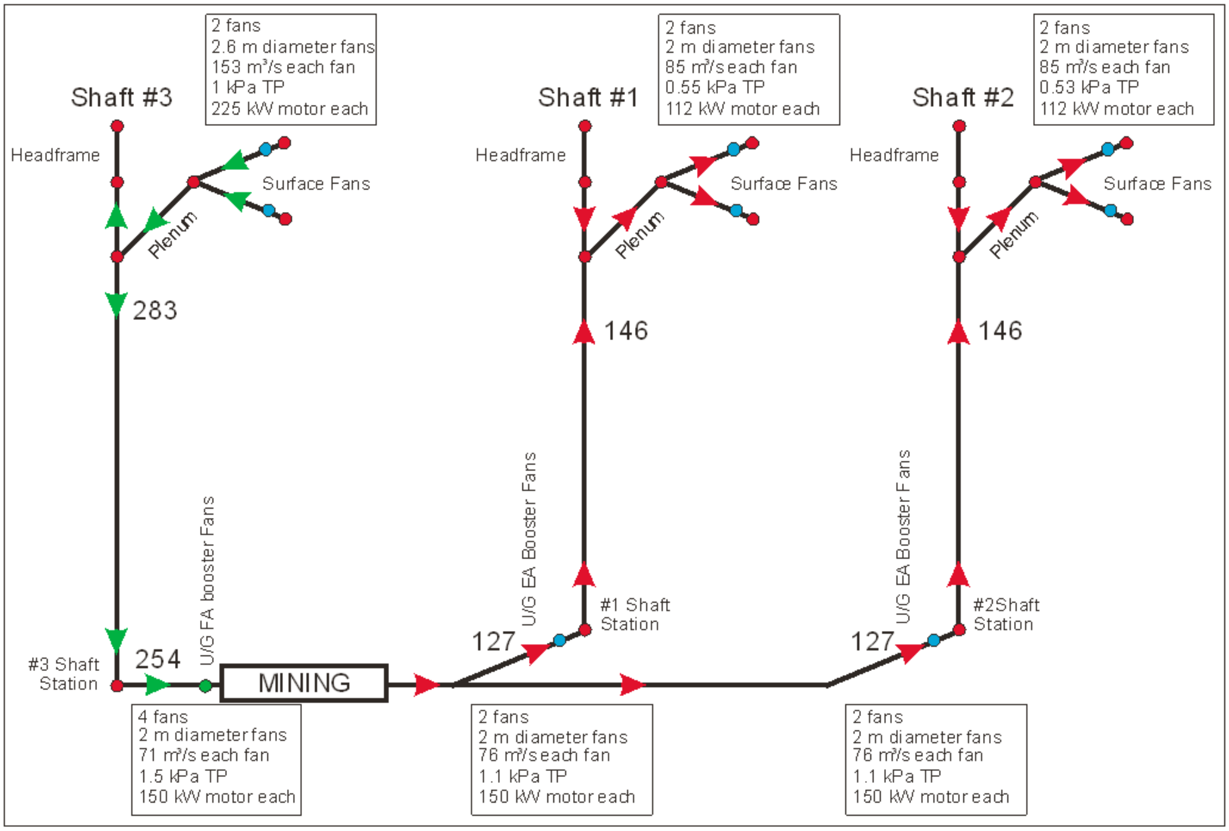

Figure 1: Mine primary and main booster fan requirements [1]

Phased Implementation

Throughout the entire expansion, Rocanville mine had to maintain a consistent supply of potash production. To facilitate production and meet regulatory requirements for ventilation, a phased implementation was planned and executed for the various systems.

Phase I consisted of preparing the mine for the transition from the historical two-shaft system to a three-shaft system. The overall ventilation design was completed prior to any execution inside of Phase I in the implementation plan. The computer model used to verify the design was then used as a predictive tool to step through and analyze changes in the mine ventilation circuit as the phases were executed. New exhaust fans were installed, commissioned, and put into service underground at the #1 Shaft. New exhaust fans were installed and commissioned underground at the #2 Shaft. New fresh air fans were installed and commissioned both underground and on surface at the #3 Shaft. Finally, circuit adjustments were made in the mine workings to better adapt the mine to the post-expansion ventilation design. In this phase, the #2 Shaft remained downcasting 142 m^3/s, the #1 Shaft remained upcasting 142 m^3/s, and the #3 Shaft did not provide airflow to the mine.

Phase II consisted of the breakthrough of the new shaft into the mine, and the beginning of the transfer of fresh air to the new shaft. Upon immediate breakthrough of the #3 Shaft into the mine, the shaft bottom area was air-locked from the rest of the mine. The underground fans were then utilized to draw air down the #3 Shaft. The volume of fresh air downcast in the #2 Shaft was lowered to offset the air in the #3 Shaft, retaining 142 m^3/s exhausting in the #1 Shaft. At the end of Phase II, the #2 and the #3 Shafts were both downcasting 71 m^3/s.

Data collected during the transition from Phase I (pre-shaft breakthrough) to Phase II was used to do a preliminary validation of the computer-based ventilation model, and therefore the design calculations. In mine surveys were performed as work was completed on the ventilation transition and compared to the model-predicted results. The first case study was completed at the time of shaft breakthrough. Volume surveys taken in the mine at all three shafts were compared to the volumes predicted in the model. The results can be seen in Table 1, the variance between the model and field surveys is quite low.

CASE I - SHAFT BREAKTHROUGH ANALYSIS						
	PRE-BREAKTHROUGH			POST-BREAKTHROUGH		
	Field (m^3/s)	Model (m^3/s)	% Difference	Field (m^3/s)	Model (m^3/s)	% Difference
#1 Shaft (Upcast)	112	110	-2%	102	103	0%
#2 Shaft (Downcast)	106	110	4%	127	129	1%
#3 Shaft (Upcast)	-	-	-	24	26	6%

Table 1: Case Study I – Shaft Breakthrough Analysis

A second case study was completed at an additional point of the transition to Phase II, once a downcast air volume was established in the #3 Shaft. A single fresh air fan was turned on and the speed was adjusted by way of the variable frequency drive (VFD) to provide volume to suit the mine operations needs. Due to operational constraints at the #1 Shaft (a risk of skip instability due to over-volume in the shaft) and at the #2 Shaft (personnel working in the shops at shaft bottom, as well as it still acting as the mine service shaft), a full stop of ventilation down casting at the #2 Shaft could not be done, and so only partial system capacity could be tested versus the model [2], which was adjusted to suit the mine (fan settings, resistance adjustments to shafts and drifts based on construction status', etc…) at the time of the surveys. Figure 2 is a presentation of a portion of the circuit analyzed in the mine to provide context to the results displayed in Table 2, which is a presentation of the case study results. The model again correlated well with the field measurements, with the exception of the #2 Shaft downcast air volume which continually measured higher in the field versus what the model predicted. Given the location at which these readings are taken in the mine, some skew may have existed in the data due to vehicle traffic, altered controls (nearby control doors opening and closing, significantly changing mine resistance at the time of the survey), and leakage and recirculation across several old sets of doors and bulkheads in the higher pressure areas adjacent to the fans (these locations were not operationally worth repairing at this point in time, as the move to the new surface site and abandonment of the area was impending). Given the repeatability of the small deviations between the model and the field surveys, it was at this point inferred that the initial design calculations were correct to a sufficient degree of accuracy for the system to operate as designed when the mine expansion and full system implementation was completed.

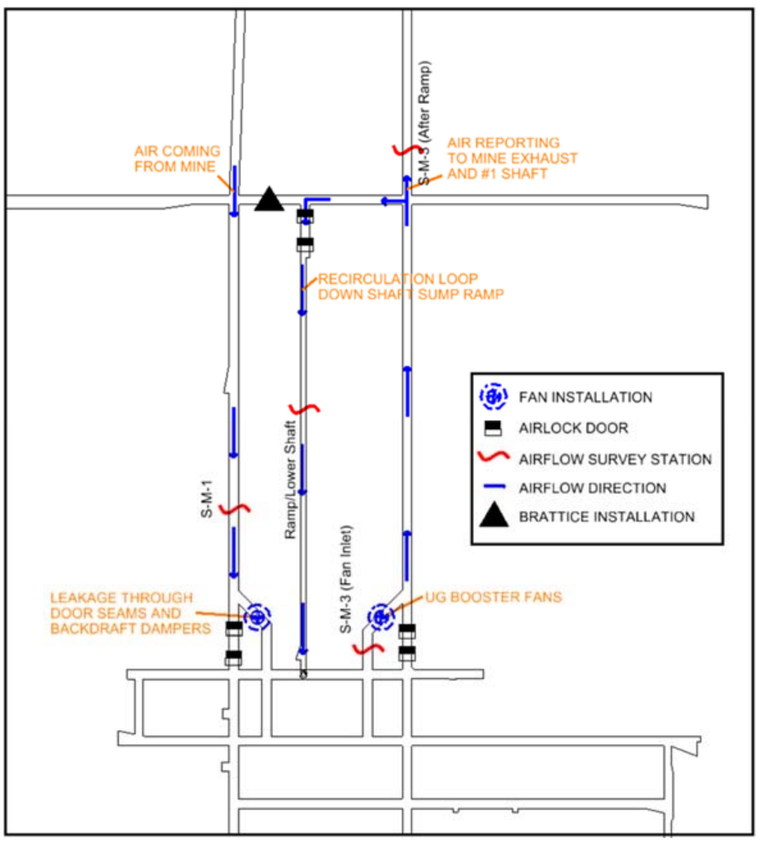

Figure 2: Case Study II - The #3 Shaft Circuit

CASE II - SCISSORS CREEK UG FAN ANALYSIS						
	Field Survey Average		VentSim Model Average		% Difference	
	Flow Rate (m^3/s)	Pressure (Pa)	Flow Rate (m^3/s)	Pressure (Pa)	Flow Rate (m^3/s)	Pressure (Pa)
S-M-1	14.8	-	14.9	-	1%	-
S-M-3 (After Ramp)	29.6	-	29.2	-	-1%	-
Ramp/Lower Shaft	22.6	-	22.7	-	0%	-
S-M-3 (Fan Inlet)	51.5	864.8	54.5	880.1	5%	2%
#3 Shaft Downcast	15.1	-	16.7	-	9%	-
#2 Shaft Downcast	128.3	-	109.0	-	-18%	-
Main Exhaust	110.7	-	114.2	-	3%	-

Table 2: Case Study II – The #3 Shaft Primary Downcast Analysis

Phase III consisted of the cut-over to the #3 Shaft as the single source of fresh air for the mine. Circuit adjustments were made in the mine to reflect the cut-over, downcast fans were shut off and locked out at the #2 Shaft (top and bottom), and fan capacity was used in the #3 Shaft to retain 142 m^3/s exhausting in the #1 Shaft. Minor (off-plan) adjustments were then made to transfer a portion of the mine exhaust to the #2 Shaft to retain a moderate temperature in the shaft and prevent negatively affecting the cast-iron shaft liner. At the end of Phase III 156 m^3/s were downcast in the #3 Shaft, 47 m^3/s were upcast the #2 Shaft, and 109 m^3/s were upcast in the #1 Shaft. With this phase complete, the final fan system (new #2 Shaft surface exhaust fans) were then able to be installed and commissioned.

Phase IV was initiated once the #2 Surface exhaust fans were available and construction activities allowed for a ramp-up of total volume to near design criteria. The ramp-up was completed in two stages: In the first stage, downcast in the #3 Shaft was increased to 207 m^3/s and the #2 Shaft was ‘officially’ converted to an exhaust shaft with the commissioning of the new surface fans. The ventilation model was used to determine/predict main fan VFD set points for each set of fans to establish the desired volume quantities and expected operating points. In mine surveys were completed to verify predictions on volume and fan pressure and to verify resistance inputs to the design at higher quantities. The results are presented in Table 3.

	Model (m^3/s)	Field (m^3/s)	Difference (%)
#3 Shaft	435	455	4.6%
#1 Shaft	220	240	9.1%
#2 Shaft	217	210	3.2%

Table 3: Case Study III – Ramp Up to 207 m^3/s Downcast

Case Study III was completed with the #3 Shaft surface fans set at 57% on their VFD drives (405 rpm), Two fans of the four fans at the #3 Shaft bottom were run and set at 100% on their VFD drives (1200 rpm), all four underground fans at the #1 and the #2 Shafts were run and set at 70% each (840 rpm), and the surface fans at the #1 Shaft at 70% (630 rpm) and 100% (900 rpm) and both fans at the #2 Shaft were set at 75% (675 rpm) on their VFD drives. Comparing the volumes in each shaft, the model and the values collected in the mine are very near to each other. The larger discrepancy in the #1 Shaft reading (9%) is allocated to some circuit adjustments for operational needs at the time of the survey, making a ‘true’ in-mine reading difficult. Despite this, the results further validated the model (and therefore the design and assumptions within) as correct.

The second stage consisted of increasing downcast air volumes in the #3 Shaft to approximately 260 m^3/s, and splitting the #1 and the #2 Shafts evenly, exhausting approximately 130 m^3/s each. The ventilation model was again used to predict main fan VFD set points for each set of fans to establish the desired volume quantities and expected operating points. In mine surveys were completed to verify predictions on volume and fan pressure and to further verify resistance inputs to the design at higher quantities. The results are presented in Table 4.

	Model (m^3/s)	Field (m^3/s)	Difference (%)
#3 Shaft	249	260	4.2%
#1 Shaft	123	127	3.8%
#2 Shaft	127	132	3.7%

Table 4: Case Study IV – Ramp Up to 249 m^3/s Downcast

Case Study IV was completed with the #3 Shaft surface fans set at 71% on their VFD drives (500 rpm), all eight underground fans (at all three shafts) set at 85% on their VFD drives (1020 rpm), and the surface fans at the #1 Shaft at 40% (360 rpm) and 100% (900 rpm) and both fans at the #2 Shaft were set at 85% (765 rpm) on their VFD drives. Comparing the volumes in each shaft, the model and the values collected in the mine are very near to each other. This further validated the model (and therefore the design and assumptions within) as correct.

Phase V has yet to occur, but will consist of a final ramp-up to 283 m^3/s downcast in the #3 Shaft, splitting exhaust evenly between the #1 and the #2 Shafts at 142 m^3/s each. This final phase will comprise of a small increase in fresh air volume of only 18 m^3/s. Several safety devices on the cage conveyance require testing and commissioning prior to this push (drifting avoidance at the higher airflows). As well, once the system has some run-time, the fan rotors will be adjusted to operate as effectively and efficiently as possible in their steady state condition.

Conclusion

This paper has presented the successful implementation a new ventilation system to facilitate safe production in the Rocanville potash mine. The existing mine ventilation capacity has been successfully increased from 142 m^3/s to 260 m^3/s with a final push to 283 m^3/s still pending. Mine production was not affected during this change-over. Computer modelling was used to assist in design and fan selection. Commissioning of the new ventilation system was implemented in phases to permit a controlled ramp up to full ventilation capacity with minimal disruption to mine operations, and these phases were modelled prior to implementation and compared to actual surveys throughout to verify the design and then forecast the results of changes to the network.

References

[1] K. Penner, E. De Souza, "Reconciliation of ventilation and production expansion in a potash mine", Proceedings of the 15th North American Mine Ventilation Symposium, June 2015

[2] K. Penner, "Ventilation Design Strategy to meet Future Production Requirements for a Saskatchewan Potash Mine", A thesis submitted to Queen's University (Masters of Applied Science), Kingston, ON, October 2015