Optimization of Main Exhaust Fan Systems at Battle Mountain Canada Ltd., Golden Giant Mine

László Götz[1] and Euler De Souza[2]
[1]Battle Mountain Canada Ltd.,Golden Giant Mine, Marathon, Ontario;
[2]Queens University, Kingston, Ontario

ABSTRACT

In 1997, production needs required that the exhaust conditions at the Golden Giant Mine be maximized. One of the principal exhaust raises, the West Return Air Raise #1, designed to handle some 189 m^3/s (400,000 cfm) but operating at 102 m^3/s (216,000 cfm), was a primary candidate for optimization. This paper describes the major design changes and installation modifications carried out at this surface fan installation. The new installation not only outperformed the design expectations but also achieved the new mine exhaust requirements.

KEYWORDS

Ventilation, Mine-Ventilation, Surface-Fans, Main Fans, and Optimization.

HISTORY OF WEST RETURN AIR RAISE #1 FANS

One of the principal return air raises at Golden Giant Mine, the West Return Air Raise #1 (WRAR #1) is a complex underground airway system designed to handle some 189 m^3/s (400,000 cfm) of air.

In the original configuration, four Joy Series 2000 Axivane surface fans were installed in two parallel stacks. The Joy fans were models 78-30-1170, fitted with 186.5 kW (250 hp) motors [total installed capacity 746 kW (1000 hp)] with the blade pitch set at 1¼. These fans were installed horizontally, following a 90° vane-less elbow. The elbow continued in two 1.98 m (78 inch) diameter and 5.23 m (17 ft) long ventilation ducts that were connected to the elbow by two inlet bells (see Figure 1).

By operating both stacks, several fan blade failures were experienced. It was concluded that strong vortexes created in front of the fans were responsible for the numerous blade failures. To remedy this situation, two "eggcrate" flow-straighteners were installed, one in each stack, between the elbow and the fans (see Figure 2). Following the flow-straightener installation, attempts to operate both stacks resulted in fans being "kicked-out" due to high amperage. After the failed attempts, a decision was made to run only one stack at any given time.

To pick up the slack due to decreased airflow, an old backfill raise was furbished with fans and turned into a return air raise. At this time, with only one stack operating an air volume of 108 m^3/s (230,000 cfm) was exhausted.

After several years of operating only one stack at the WRAR #1, it was decided to remove the "eggcrate" flow-straightener. Also one of the fans from the West stack was removed, and only the West stack was operated. The West stack with one fan was moving 7 m^3/s (15,000 cfm) less air than the two fans with the "eggcrate" configuration.

Finally, in 1997 continuing mine expansion required that exhaust conditions at WRAR #1 be maximized. The

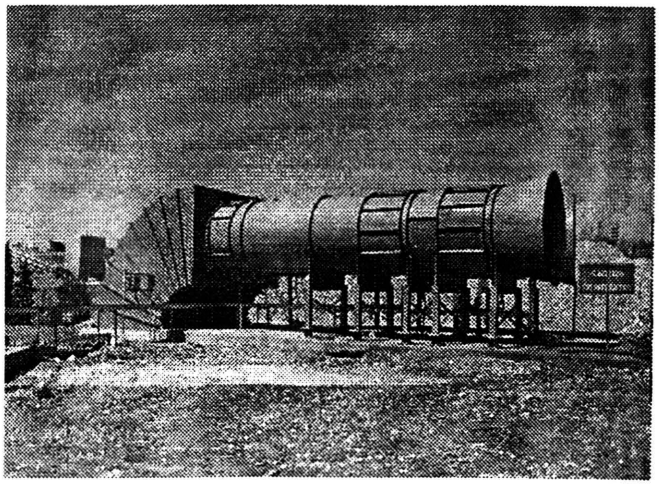

Figure 1. WRAR #1 before modifications.

problem remained that only one stack could be operated at a time and that the two stacks had different configurations. For this reason, major modifications to the exhaust fan surface installations were carried out as described in the following sections.

DESCRIPTION OF WEST RETURN AIR RAISE #1

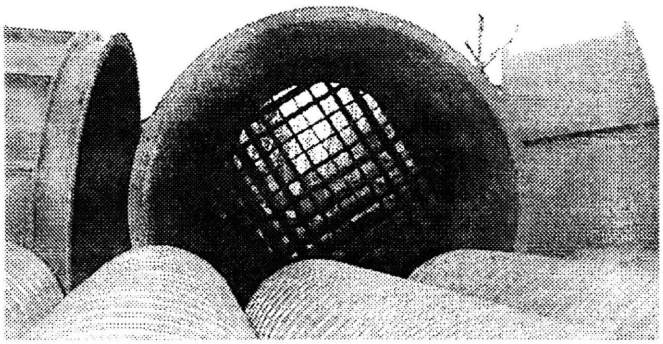

Figure 2. Eggcrate flow-straightener.

The West Return Air Raise #1 (WRAR #1Figure 3) is a square airway of section 3.66 m x 3.66 m (12 ft x 12 ft) extending from surface elevation to the underground 5000 level [hydraulic radius = 0.91 m (3 ft)]. Between 5000 and 4900 levels it splits into two parallel raises of 1.52 m and 2.43 m (5 ft and 8 ft) diameter [hydraulic radius = 0.38 m and 0.61 m, respectively (1.25 ft and 2 ft)], then rejoining into a single 3.66 m x 3.66 m (12 ft x12 ft) square airway [hydraulic radius = 0.91 m (3 ft)] which extends between 4900 and 4775 levels. Between 4775 and 4400 levels, the raise changes to a circular section of diameter 3 m (10 ft) [hydraulic radius = 0.76 m (2.5 ft)].

The upper section of the WRAR #1, running from 5000 level to surface, also serves the West Return Air Raise #2 (WRAR #2). Three surface fans were installed, with only one fan operating, with the following configuration:

Type: Joy Series 2000 Axivane – Number of Fans: 3
Configuration: one fan running in West stack, two idle fans in series in East stack, two stacks in parallel
Fan Model: 78-30-1170
Motor: 186.5 kW (250 hp) per fan [total installed capacity: 560 kW (750 hp)]
Blade Pitch: 1 ¼ setting
Estimated Total Flow: ~ 104 m^3/s (220,000 cfm)
Measured Static Pressure: 0.72 kPa (2.90" w.g.)

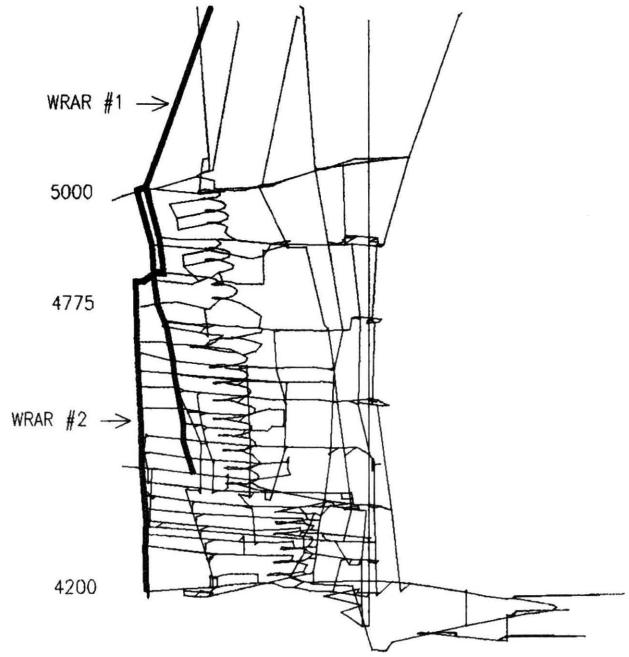

Figure 3. Wire-Frame diagram of Golden Giant Mine' ventilation model. The West Return Air raises are shown with bold lines.

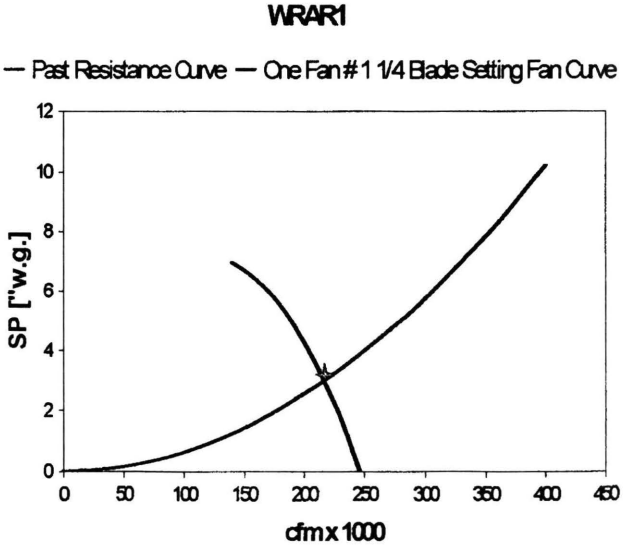

Figure 4. Fan curve of WRAR #1 fan before modifications, blade angle at # 1 1/4 setting.

According to the fan curve (Figure 4) the following operating conditions were verified:

Past System

Flow	102 m^3/s (216,000cfm)
Total Head	1.08 kPa (4.35" w.g.)
Static Head	0.74 kPa (2.98" w.g.)
Output force	107 kW (144 hp)
Input force	149 kW (200 hp)
Total Efficiency	72%

PROPOSED MODIFICATIONS TO WRAR #1 MAIN FAN INSTALLATION

In the light of increased exhaust requirements, the following changes were proposed:

1. Remove the third fan and run two fans in parallel.
2. Remove current elbow to pipe reducer from both stacks, remove the long pipe section, and replace them by smooth cones (see Figure 5). The 7.62 m (25 ft) long cone, running from the elbow to the fan, will have a wall angle of approximating 2.9°.
3. Remove the air straightener that is installed in the East stack.
4. Run the fans at a blade setting between 1 ¼ and 3, depending on head and flow requirements.

The volume and pressure gains associated with the proposed parallel configuration for different blade pitch settings are (see Figure 6 and Figure 7):

Proposed System
Blade Setting: # 1¼

Flow	149 m^3/s (315,000 cfm)
Total Head	1.78 kPa (7.15" w.g.)
Static Head	1.60 kPa (6.45" w.g.)
Output force	257 kW (345 hp)
Input force	358 kW (480 hp)
Total Efficiency	72%

Proposed System
Blade Setting: # 3

Flow	125 m^3/s (264,000 cfm)
Total Head	1.12 kPa (4.5" w.g.)
Static Head	0.99 kPa (4.0" w.g.)
Output force	142 kW (190 hp)
Input force	187 kW (250 hp)
Total Efficiency	76%

From the proposed changes the following conditions were expected:

- Increased flow capacity between 125 and 149 m^3/s (264,000 and 315,000 cfm) from a current flow of 102 m^3/s (216,000 cfm).
- Increased suction head to between 1.12 and 1.78 kPa (4.50 and 7.15" w.g.) that should minimize re-circulation problems currently existing in the ramp system.

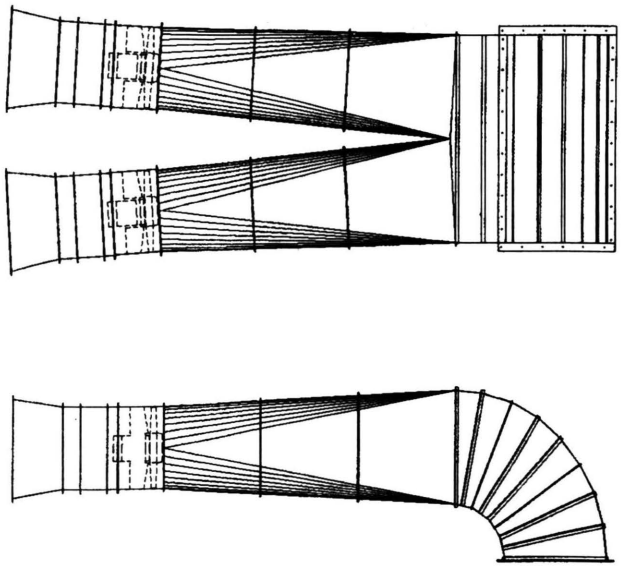

Figure 5. Proposed WRAR #1 elbow assembly. The connection between the elbow and fans is made through smooth transition cones.

- Although an increase in power requirements to between 186 and 358 kW (250 and 480 hp), from 149 kW (200 hp), would be realized, the associated increase in suction head would permit substantial power savings by reconfiguring booster fans underground in both WRAR #1 and WRAR #2.
- Increased fan efficiency.

The proposed modifications were carried out; the fan settings were set to 1 ½.

The changeover of the new elbow to fan cone, with the removal of the third fan, was accomplished in eight hours (see Figure 8). At start-up of the fans, high energy consumption and excessive vibration was measured. Pressure

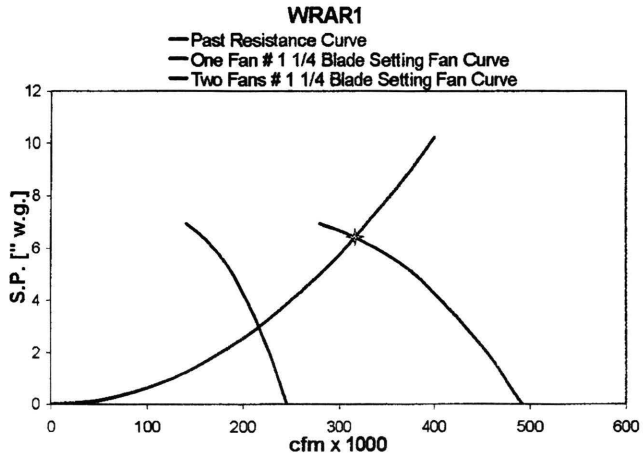

Figure 6. Proposed WRAR #1 fan curve with #1 1/4 blade setting.

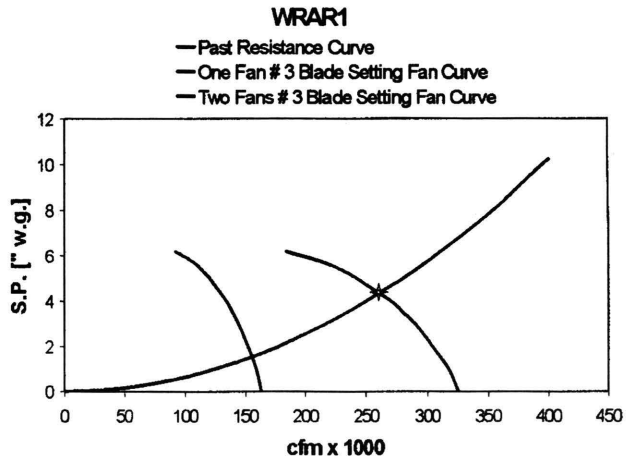

Figure 7. Proposed WRAR #1 fan curve with #3 blade setting.

measurements indicated that the fans were installed with different blade settings. Vibration measurements indicated that the fan supports were structurally weak.

Finally the fans were again removed, their blade angles re-set, and the fan supports re-inforced.

CONCLUSIONS

The final results (see Figure 9) outperformed the expectations. The comparison between expected and obtained results is as follows:

	Expected System Blade Setting: # 1¼
Flow	149 m^3/s (315,000 cfm)
Total Head	1.78 kPa (7.15" w.g.)
Static Head	1.60 kPa (6.45" w.g.)
Output force	257 kW (345.0 hp)
Input force	358 kW (480.0 hp)
Total Efficiency	72%

	Final System Blade Setting: # 1½
Flow	172 m^3/s (364,000 cfm)
Total Head	1.44 kPa (5.80" w.g.)
Static Head	1.12 kPa (4.50" w.g.)
Output Force	244 kW (327.0 hp)
Input Force	321 kW (430.0 hp)
Total Efficiency	76%

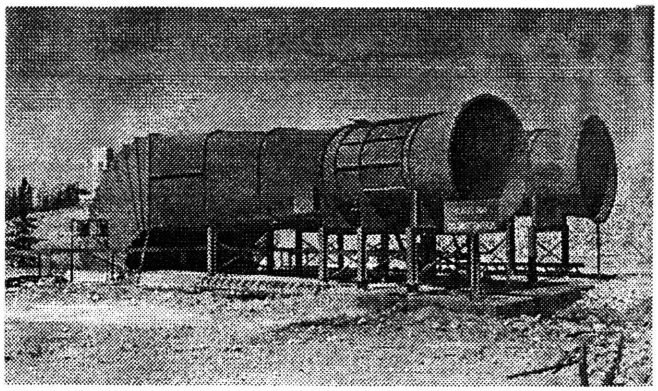

Figure 8. WRAR #1 after modifications.

Originally, the system was operating at 108 m^3/s (216,000 cfm) and proved to be insufficient for the exhaust needs of the mine. By using the same system curve as a worst case scenario, the system was redesigned to achieve at least 149 m^3/s (315,000 cfm). Since the newly installed cones reduced the system resistance, an airflow of 172 m^3/s (364,000 cfm) was achieved, 68 m^3/s (144,000 cfm) more than the starting point.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the support given by David Sprott, the Golden Giant Mine's Engineering Superintendent, and to the Golden Giant Mine's Plant Department for their work in the changeover.

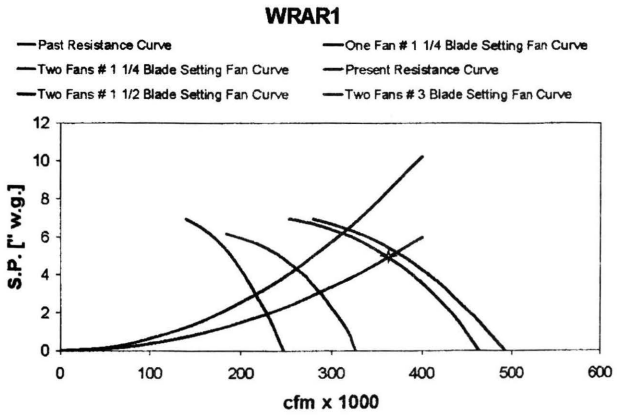

Figure 9. WRAR #1 fan curve after modifications, blade angle set to #1 1/2 setting.

REFERENCES

De Souza, E., 1997, "Mine Ventilation Design and Control," Department of Mining Engineering, Queen's University, Kingston, pp. 5.14–5.15, 5.23–5.29, 7.16.

Hartman, H.L., Mutmansky, J.M. and Wang, Y.J., 1991, "Mine Ventilation and Air Conditioning," Krieger Publishing Company, Malabar, Florida, pp. 291 – 331.

Jorgensen, R., 1983, "Fan Engineering," R. Jorgensen, ed. Buffalo Forge Company, Buffalo, pp. 2-35 – 2-63.