

Royal Oak Mines Inc.  
Yellowknife Division

\$ 200,000 savings /yr.  
Cap + Oper = Exp. NonEconomic

TO: M. Werner, G. Halverson, G. Wolfe  
FROM: C. J. Hall  
DATE: August 29, 1991  
RE: Provisional Roaster Heat Analysis

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### Purpose

The purpose of this report is to give a brief analysis of the value of heat recovery from the roaster flue gases, and the problems that such a system might cause. Some attention is paid to possible legislation to reduce SO<sub>2</sub> and arsenic emissions, and increased pollutant dispersal. No attempt is made to evaluate the capital or operating costs of the systems.

### Conclusions

1. A coil system operating in the flue gases after the bag house would save about \$175,000 propane costs annually, but propane costs would still be about \$300,000 per year.
2. It is probable that in the next ten years there will be legislation regarding stack gas concentrations of SO<sub>2</sub> and arsenic, and possibly stack gas dispersal. This could lead to the replacement of any heat recovery system installed by a system designed mainly to reduce contaminants.

### Recommendations

1. It is recommended that at least for the next two years no action be taken. Should it become apparent that stack gas cleaning be required, the system designed should include a heat recovery system.
2. If, after two years, it is thought that no legislation is likely within five or ten years regarding stack gas contaminants, an engineering design firm should be engaged to assess capital and operating costs and benefits of a heat recovery system. It is probable that the system would handle the low temperature gases, and it would most likely utilize coils.

## Discussion

1. Air from the roaster leaves the cottrell electrostatic precipitators at 725 F. It is mixed with atmospheric air before going to the bag house at about 250 F, and enters the stack at 200-210 F. The amount of air at this point is about 40,000 cfm. The stack diameter is 9 feet, so the air velocity is about 600 feet/minute.
2. The stack gases contain about 1% SO<sub>2</sub> and a small amount of arsenic. There is a distinct possibility that lower values of SO<sub>2</sub> emissions might be legislated, and this might be expanded to include arsenic. In addition, a greater dispersion of the present contaminants might be required. The legislation could be enacted in the next two or three years.
3. Heat could be taken from the flue gases before the bag house, at 725 F, or after the bag house, at say 200 F. At low temperatures, sprays or coils could be used. At high temperatures, it is likely that a steam generator followed by sprays or coils would have to be used in order to handle the arsenic.
4. The high temperature heat recovery system would seem to be complex and capital intensive, and only worthwhile if considerable extra heat recovery is generated. The system would have to recover most of the arsenic in a solid form, as at present. The appendix shows that the heat recovery could be boosted from 1750 HP to 2630 HP by using the high temperature source, and at best, the extra heat would be worth \$100,000 per year.
5. From the point of view of this analysis, the savings have been calculated for low temperature coils to save heat from propane used for mine ventilation. It is possible that greater savings could be made if the heat was used for a year-long process, such as the hot water supply for the dry. However, even this is cyclic for the day, so it would be difficult and probably capital intensive to utilize all the heat that could be saved.
6. The calculations in the appendix use a flue gas exit temperature of 70 F. It is likely that at this temperature there would be condensation on the coils, which would lead to coil fouling and scrubbing of arsenic from the system. Very little SO<sub>2</sub> would be scrubbed at coils, but the atmosphere would be highly corrosive. Thus special materials would have to be used for the coils and all supporting structure. In addition, the toxic atmosphere would make a double coil system desirable, with one unit in operation whilst the other was being cleaned. Mechanically, robust coils, without the usual fins and less efficient heat

exchanging characteristics are available and probably desirable. Automatic high pressure water sprays could be used to clean the coils, with the effluent going to tailings, at little extra tailings handling costs. Should arsenic limits legislation be enacted, this system might be sufficient for compliance. On the other hand, the system installed ahead of legislation could lead to lower values being required.

7. A spray system would lead to scrubbing of the arsenic and much of the  $\text{SO}_2$ . This system would require a water to glycol heat exchanger, with the water being discharged to tailings. This would entail heavy operating costs for limestone neutralization, but as discussed for arsenic, might be beneficial or detrimental regarding  $\text{SO}_2$  legislation. Most  $\text{SO}_2$  scrubbing at present is high temperature gas to solid processes, sometimes with gypsum sales to offset costs. It is unlikely that Giant could produce a saleable gypsum product because of arsenic contamination. The extra limestone costs could be enforced by legislation. The water in the glycol heat exchanger would be highly toxic and corrosive.
8. With any system of heat exchange, except a high temperature system operating from 725 to 250 F, the stack dispersal will be reduced. The effect would probably be quite significant if little  $\text{SO}_2$  is scrubbed from the gases. The dispersal characteristics could be restored by increasing the flue gas discharge velocity. A 10 HP fan could boost the flue gas velocity to 4000 feet per minute, at a power cost of \$5,000 per year. This fan would be operating in a highly corrosive atmosphere unless placed ahead of the coils. This position, however, could lead to leakage of toxic flue gas into the local atmosphere, and should probably be avoided. The velocity of 4000 feet per minute would require some stack alterations so that the discharge diameter was 3.5 feet, and most of the gases would end up at least 100 feet above the top of the stack. It is not known if the increased velocity is equivalent to the higher discharge temperature presently existing. With the relatively short guaranteed life, heavy capital expenditure on a new higher stack should be closely scrutinized.

## APPENDIX 1

### Roaster Heat Economics

#### 1. Assumptions:

Mean winter air temperatures, -20 F  
Mean winter water temperatures, 40 F  
Air entering stack, 40,000 cfm at 200 F  
Air leaving roaster at 725 F  
Air leaving heat exchanger at 70 F

#### 2. Air Quantities

40,000 cfm @ 200 F = 2400 lbm/minute  
Mix 710 lbm/minute at 725 F with 1690 lbm/minute at -20 F to  
give 2400 lbm/minute at 200 F.

#### 3. Available Heat

A) Heat Exchanger at - 200 F (coils)  
 $2400 * (200-70) * 0.24 = 75,000 \text{ BTU/minute}$   
 $= 1750 \text{ HP}$

B) Sprays at 200 F, water in at 40 F

(i) Water out at 200 F  
Water flow rate = 469 lbm/minute  
Heat =  $469 * 130 = 60,900 \text{ BTU/minute}$   
 $= 1420 \text{ HP}$

(ii) Water out at 180 F  
Water flow rate = 536 lbm/minute  
Heat =  $536 * 110 = 58,900 \text{ BTU/minute}$   
 $= 1390 \text{ HP}$

C) Heat Exchangers at 725 F  
 $710 * (725-70) * 0.24 = 111,600 \text{ BTU/minute}$   
 $= 2630 \text{ HP}$

D) Sprays at 725 F, water in at 40 F

(i) Water out at 200 F, air out at 70 F  
Water flow rate = 698 lbm/minute  
Heat =  $698 * 130 = 90,700 \text{ BTU/minute}$   
 $= 2140 \text{ HP}$

(ii) Water out at 180 F  
Water flow rate = 797 lbm/minute  
Heat =  $797 * 110 = 87,700 \text{ BTU/minute}$   
 $= 2070 \text{ HP}$

4. Average atmospheric temperatures, by month ( F)

<u>OCT</u>	<u>NOV</u>	<u>DEC</u>	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>
26	-5	-20	-19	-19	8	24

5. Average Mine Airflow, 200,000 cfm at say -20 F is 18,000 lbm/min, to be heated to 40 F.

6. Heat available from compressors 815 HP  
 Heat available from fans 180 HP  
 Heat available from coils at 200 F 1750 HP

Total Heat Available 2745 HP  
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Temperature rise from 2745 HP

$$= \frac{2745 * 33,000}{778 * 18,000 * 0.24} = 27 \text{ F}$$

7. Propane must raise air temperature to 13 F

Monthly air mass flow rate

$$= 18,000 * 60 * 24 * 30 = 780 \text{ M lbm/month}$$

Heat required from propane (minimum)

$$= 780 \text{ M} * 0.24 (18 + 33 + 32 + 32 + 5) \\ = 22,500 \text{ M BTU}$$

Propane cost at 19,460 BTU/lbm and \$0.184/lbm

$$= 22,500 \text{ M} * 0.184 / 19,460 = \$210,000 \text{ per year}$$

Present cost = \$475,000

This includes savings from compressors and fans,  
 estimated at \$120,000 per year

Savings from roaster heat = \$200,000 annually.

Note: 1) Based on 1750 HP required for 7 months, the annual savings would be \$212,000. Thus the actual savings, considering the fan and compressor heat is already being used, is probably closer to \$175,000, and annual propane costs would still be \$300,000.

2) Based on \$500/HP year, savings of \$175,000 per year on 1750 HP of heat shows a heat recovery value of about 20%.