CLEEN MMEA- WP 4.2.2 Scrubber emissions from a mine process

Agnico-Eagle Finland
Emission study of gold mine in Kiistala year 2010

Authors: Harri Puustinen, Olli Antson

Confidentiality: Confidential

Agnico-Eagle Finland
Emission study of gold mine in Kiistala year 2010

Customer, contact person, address	Order reference
Agnico-Eagle Finland Anita Alajoutsijärvi	
Project name	**Project number/Short name**
CLEEN MMEA- WP 4.2.2 Scrubber emissions from a mine process	
Author(s)	**Pages**
Harri Puustinen, Olli Antson	8/
Keywords	**Report identification code**
Srubber emissions, gold mine	VTT-R-

Summary

This study summarizes the results from a scrubber´s gas and particle emission measurements at the enrichment unit´s autoclave at Agnico-Eagle Finland Oy´s Kiistala gold mine.

Confidentiality	Confidential

Written by	Reviewed by	Accepted by
Espoo 24.3.2011		
Harri Puustinen, Research Engineer Olli Antson Senior Research Scientist	Tuula Pellikka Team Leader	Jukka Lehtomäki Technology Manager

VTT's contact address
PL 1000, 02044 VTT

Agnico-Eagle Finland
VTT registry

Contents

1 Introduction

At Agnico-Eagle Finland Oy´s gold mine in Kiistala the exhaust gases from the enrichment unit´s autoclave are conducted to outer air through a scrubber. The emission measurements of this study were carried out on the 2nd and on the 5th of November 2010 by technician Hannu Vesala and research engineer Harri Puustinen.

The results of the previous emission measurements on particulate matters (VTT report VTT -R-08323-09) led to the conclusion that the particle emission from the scrubber, as determined by the standard EN 13284-1, consists of solid particles and also of gaseous components condensed to the sampling line. This is why the observed concentration of particles can be expected to be larger than what is meant by the standard. Thus the emission measurement results of the particles from the autoclave´s scrubber are not relevant when compared to the limit values given in the environmental permit.

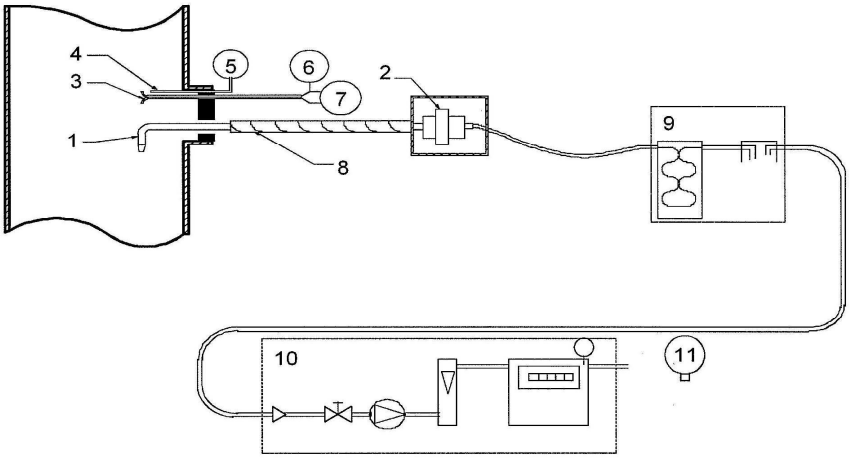
2 Goal

The goal of this study is to determine the effect of the entry nozzle´s initial temperature to the particle concentration (or the temperature of the nozzle before it is put into the stack), and the effect of the suction tube´s and filter´s (in filter holder) temperatures during the sampling period to the particle concentration.

The entry nozzle is not equipped with a separate heating unit but it was heated with a separate heat jacket. The heating of the suction tube and the filter holder is done by integrated heat jackets.

3 Measurement methods

The particle concentration was determined by the standard EN 13284-1 (Determination of low range mass concentration of dust. Part 1: Manual gravimetric method). The measurement principle is shown in Fig. 1.



Key

1 Entry nozzle
2 Filter holder
3 Pitot tube
4 Temperature sensor
5 Temperature indicator
6 Static pressure measurement
7 Dynamic pressure measurement
8 Suction tube („out-stack" device)
9 Cooling and drying system
10 Suction unit and gas metering device (see Figure 5)
11 Pressure gauge

Figure 1. Out-Stack-method, standard EN 13284-1

SO_2 and CO concentration of the scrubber´s exhaust gas was determined by a FTIR analyzer, and O_2 concentration was determined by a paramagnetic analyzer. The gas sample taken from the stack was diluted by N_2.

4 Measurement results

Table 1 shows the results of the particle measurements.

Table 1. The concentration of particles from the autoclave´s scrubber at Agnico-Eagle Finland´s Kiistala gold mine in 2010.

Sample		1a	1b	2a	2b	3a	3b
Date		3.11	3.11	5.11	5.11	5.11	5.11
Time		15:35-15:42	17:50-18:00	12:15-12:35	14:20-14:30	16:20-16:30	17:50-18:00
Autoclave process data -enrichment - O_2 – feed - sulphur in enrichment	t/h Nm^3/h %	3,6 – 3,7 5500-5700 16 - 17	3,6 – 3,7 5500-5700 16 - 17	3,7 – 4,0 5000-5500 16 - 17	3,7 – 4,0 5000-5500 16 - 17	3,7 – 4,0 5000-5500 16 - 17	3,7 – 4,0 5000-5500 16 - 17
Temperature of sampling line: -entry nozzle (preheating) -suction tube (in sampling) -filter holder (in sampling)	 ºC ºC ºC	 160 207 184	 160 194 203	 160 169 167	 160 160 158	 gold 162 153-170	 gold 163 157-162
Particles: -dry gas, NTP -wet gas, NTP	 mg/m^3 mg/m^3	 337 33	 273 25	 234 22	 255 23	 147 13	 186 17
Particle deposits: - entry nozzle - suction tube - filter holder Total mass	 % % % %	 22,0 70,5 7,5 100	 20,0 73,9 6,1 100	 38,8 46,3 14,9 100	 32,2 52,5 15,3 100	 31,9 50,4 17,8 100	 31,0 42,1 26,9 100
Scrubber out gas: -temperature -moisture	 ºC v- %	 96,5 90,3	 - 90,9	 - 90,8	 - 90,9	 - 91,0[1)]	 - 90,8[1)]
Gas flow rate, NTP: -dry -wet	 m^3/s m^3/s	 0,6 6,4					
Field zero, NTP, dry gas (6.11.2010) Test 1 Test 2	 mg/m^3 mg/m^3	 21 23					

1) Water content is estimated based on tests 1 and 2

The preliminary gas concentration results at 3.11.2010 are shown in Table 2, and the corresponding results at 5.11.2010 are shown in Table 3.

Table 2. SO_2 , CO_2 and O_2 concentrations, exhaust gases of the autoclave, Agnico-Eagle Finland, Kiistala gold mine, 3.11.2010 at 16:33 – 16:45.

Component	Unit	wet gas	dry gas
SO_2	ppm	400	4440
CO_2	%	3,6	40
O_2	%	3,3	37

Table 3. SO_2 , CO_2 and O_2 concentrations, exhaust gases of the autoclave, Agnico-Eagle Finland, Kiistala gold mine, 5.11.2010 at 12:50 – 13:24.

Component	Unit	wet gas	dry gas
SO_2	ppm	356	3952
CO_2	%	4,1	45
O_2	%	2,7	30

4.1 Particle concentrations

In the experiments 1 and 2 the entry nozzle was preheated to 160 ºC before it was inserted to the stack, and in the experiment 3 the entry nozzle was not preheated. The purpose of the experiment was to clarify if particles are generated from the gas phase eg. due to thermophoresis when the entry nozzle is not preheated. There are no considerations of this issue in the standard used in these measurements (EN 13281 – 1).

In the experiment 1 the temperature of the suction tube was set to 194 ºC – 207 ºC, and in the experiments 2 and 3 its temperature was decreased to 169 ºC - 160 ºC.

In the experiment 1 the temperature of the filter holder was set to 184 ºC - 203 ºC, and in the experiments 2 and 3 the temperature was decreased to 170 ºC - 153 ºC.

The purpose of changing the suction tube´s and filter holder´s temperatures was to clarify the effects of temperature to the generation of particles.

The results of the experiments 1 and 3 indicate that the temperature of the entry nozzle has an effect. In the experiment 1 the particle deposition in the preheated entry nozzle is 20.0 % - 22.0 %, and in the experiment 3 the particle deposition is 31 % - 31.9 % of the collected total particle mass. However, there is no such difference between the experiments 2 and 3. In the experiment 2 the particle depositition was 31.9 % - 32.2 %.

The decrease of the temperature of the suction tube was shown to decrease the particle deposition in the suction tube. In the experiment 1 the particle deposition was 70.5 % - 73.9 %, and in the experiments 2 and 3 the particle deposition was 52.5 % - 42.1 %,

Concerning the results of the filter holder it was shown that when the deposition in the suction tube decreases the particle mass in the filter increases. In the experiment 1 the particle mass in the filter was 7.5 % - 6.1 %, and in the experiments 2 and 3 it increased to 14.9 % - 26.9 %.

4.2 Gas concentrations

The concentrations of SO_2, CO and O_2 gases changed in different days (during the experiment period) but the decrease of SO_2 concentration at 5.11.2010 could explain the decrease of the total particle concentration in the experiments 2 and 3 in the same day.

4.3 Gas matrix

These emission measurements were complicated by the exceptionally high water contents of the exhaust gases or 90.3 % - 91.0 % (vol.). Typically the water contents in a scrubber´s exhaust gas is less than 40.0 % (vol.).

5 Conclusions

According to the experimental results the effect of the sampling temperature to the particle concentration could not uniquely be determined when the sampling is done according to the standard EN 13284 -1. It was expected that into a cold entry nozzle more particles could be deposited than into a preheated entry nozzle. As the results indicate, this did not happen.

In these experiments most of the particle mass or 73.1 % - 92.5 % was deposited into the entry nozzle and into the suction tube before the filter holder. Typically in particle sampling the depositions into entry nozzle and into suction tube are only a minor part of the total particle mass. This result may indicate that the generation of particles from the gas phase is significant in this process case.

The Out-Stack measurement method based to the standard EN 13284-1, as used here in the particle measurements of an autoclave´s scrubber, is dedicated to the measurement of particle concentrations in exhaust gases of combustion processes. It is typically used eg. to the measurement of particle concentration after a scrubber when the gases are wet and saturated. The sampled gas is conducted through an entry nozzle and a heated suction tube to a heated filter. The purpose of the heating of the sampling line is to prevent the possible condensation of gas components to the sampling line.

Typically the term particle means solid material in gas phase. In the sampling the total particle mass includes the mass collected to the filter, and all the particle depositions which stay on the inner surfaces of the entry nozzle and the suction tube before the filter. Generally the particle depositions in entry nozzle and suction tube are less than 10 % of the total particle mass.

In these measurements a large particle deposition may be caused by the condensation of gaseous sulphur compounds into the water droplets in the stack or in the particle sampling line (entry nozzle and suction tube).

This observation was confirmed also by the results of the field zero tests (only entry nozzle) which were 21 mg/m^3 ja 23 mg/m^3 (NTP, dry gas). In a field zero test the entry nozzle was inserted into the stack but the sampling suck was not started.

References

Research report VTT-R-08328-09