THE SOURCES OF AIR POLLUTION IN THE EXPLOITATION OF SOLID MINERAL RAW MATERIALS

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ABSTRACT

In the paper are discussed the particular phases in the processing of solid mineral raw materials by which dust and waste gases are produced. The quantities and kinds of pollutants are presented with respect to their generating sites, and cleaning methods and equipments are demonstrated. At last, measures that have to be taken for protecting the air quality are recommended.

1. INTRODUCTION

In the exploitation course of solid mineral raw materials, beginning with mining proper through ore dressing to extraction processes and coal combustion, waste is generated, what causes environmental pollution. Depending on the technology applied at particular steps, waste appears as mine or concentration waste, dust, ash, dross, slag and various gases usually combined with oxygen. Besides solid and gaseous waste, waste water of various pollution grades is generated, too. The influence of the mentioned waste materials on the environment, above all on the quality of air, primarily depends on their physical and chemical properties and on the total mass of mineral raw materials at the particular exploiting steps. Thus, for instance, most of mine and concentration waste and dust is generated at mining and processing iron, copper, coal and raw materials for cement manufacturing, while most of waste gases are emitted during the metallurgical processing of sulfide ores and iron, and during coal combustion. The fine dust particles of sulfide ores and coal are far more harmful than solid waste or dust of non-metallic ores. Most harmful of all are sulphurous gases. Depending on the intensity and frequency of the air streaming, dust and gases remain suspended in the air nearer or farther from the source before being settled to the ground or to the sea.
surface in their primary shape or as a new compound most often combined with water.

Although in this paper air pollution is discussed primarily from the aspect of the mining of mineral raw materials, some examples are given concerning their metallurgical processing and coal combustion.

2. MINING AND TRANSPORT

A great part of mineral raw materials are mined from open pit quarries by using explosives. Drilling dry boreholes causes generation of dust, which can be successfully abated by using standard dust collectors, such as are cyclones and bag filters. After blasting the dust cloud can be very large, depending on the physico-mechanical properties of the raw materials and on the quantity of the applied explosive. The dust spreading can hardly be prevented by wetting the rock surface, because the surface area prior to blasting is much smaller than that after blasting. Dust creation may be reduced by proper choice of blasting parameters, so as by using the explosive force for fragmenting the rock rather than for blowing up. In mechanical coal mining and overburden removal great quantities of dust are created as well; that may be relatively easily abated by spraying water or, less often, bitumen or synthetic emulsions.

The dust emitted during loading and transporting by trucks is especially annoying in summer months. In deep open-pit mining, where the air circulation is weaker, dust reduces visibility which hinders safe transportation. Although there is no efficient solution for the abatement of such a dust, it is useful to wet the traffic routes with water, often with addition of chemicals (CaCl₂) to create a relatively solid wet crust. If the transport is by conveyers, the loading points are to be tightened in connection with a dust collector, usually a bag filter.

3. CRUSHING AND SCREENING

At a great number of concentration plants the first processing step is crushing and screening. Secondary and tertiary crushing are the greatest dust sources, especially if crushers with rotating crushing elements are used; screening can be treated as equal in dust production. All these points as well as loading stations (conveyers,
silos) have to be well tightened and included into centralized dust collecting system. Aerocyclones and bag filters, and sometimes wet scrubbers, are used for dedusting. Depending on the raw material the separated dust is either subject to subsequent treatment or rejected as waste.

4. TAILING DISPOSALS AND RAW MATERIAL STOCK PILES

Large tailing disposals and stock piles, particularly if they contain greater quantities of fine particles (iron, coal), often pollute the environmental atmosphere. If they are close to populated areas they have to be regularly sprayed with water and separated by vegetation plants. The inactive tailing parts have to be sowed with grass or planted with other appropriate plants.

Coal tailing disposals and stock piles are a particular nuisance because, besides dust, they may emit noxious gases, such as \( \text{SO}_2, \text{NO}_x, \text{CO}, \text{CO}_2, \text{ammonia} \) and others, if they catch fire. Their burning is most often caused by air streaming through the pile and so causing coal and pyrite oxidation, and in consequence, a rise of temperature over 230 °C, where wood first starts burning and then coal, too. Fire extinguishing is rather difficult and long lasting. The air quality around tailing disposals may be improved by using more reliable methods of mining and concentration, what may reduce the coal content in the waste. By a stronger ramming of the material its permeability as well as the air flow intensity may be reduced, and consequently the danger of a spontaneous coal ignition may be lessened.

5. CEMENT MANUFACTURING

The most considerable mass-production of non-metallic ores, besides alluvial aggregates and crushed aggregates, is the production of materials for manufacturing cement, above all of limestone, marl and clay. In 1986 the world production of cement was 989 Mt (SFRY, 8.21 Mt). If this quantity is multiplied by 1.6, since 1.6 ton of raw material is necessary to produce 1 ton of cement, it is evident that there are enormous quantities in question.

Cement can be manufactured by wet and dry process, usually in four steps, each of them causing air pollution, mainly due to dust. The first step (mining, transport, crushing) is operated as already described in previous
chapter. The second step depends on whether the grinding and blending are performed by dry or wet process/1/. In dry grinding the quantity of dust ranges from 2 to 3 $m^3/kg$ of clinker. For dust control aerocyclones, electrostatic precipitators or bag filters are used. The third step (production of clinker) generates the greatest quantity of dust. Depending on whether the operating process is wet or dry, the quantities range from 70 to 140 kg/t of clinker for the wet process and 6 to 100 kg/t for the dry process. Electrostatic precipitators or bag filters are used for dedusting. In the fourth step, where clinker is ground in ball mills, the quantity of dust filled air ranges from 0.5 to 1.5 $m^3/kg$ clinker. Bag filters are most often used for dust control. The efficiency of electrostatic precipitators and bag filters ranges from 95 to 99 %. The maximum permitted dust concentration at the exit of the clinker kiln filter ranges from 150 to 250 mg/$m^3$n.

6. IRON AND STEEL PRODUCTION

The production of iron ore, as concerns its volume, is on top of all metal ores. The world production in 1986 was about 907 Mt pig iron (in SFRY, 6.6 Mt). Due to the great production volume and to various manufacturing steps (mining, transport, processing, sintering, production of pig iron and steel) it has a great influence on the environment, above all on the air quality. The greatest quantities of dust and waste gases are emitted during sintering and metal manufacture, but dust generation during mining, transport and homogenization is not to be neglected either. During mining air pollution is controlled as already described, most often by water spraying (transport routes, stock piles, etc.) or by aerocyclones and bag filters during crushing and screening.

Sintering is the process of agglomeration of ore before its processing in the blast furnace. A blend of ore and coke is subject to combustion at a temperature of about 1350 °C, which causes surface melting and fusing the ore grains. Thereby various waste gases are generated, such as NOx, SO2, CO2, CO and dust/2/. The dust contains more than 50 % Fe2O3, more than 10 % CaO as well as oxydes of silicon, magensuim and heavy metals. After separation in elektrostatic precipitator it is recycled in the sintering process. At the outlet of the precipitator about 150 to 200 g dust, about 2400 g SO2 and 10 g F per 1 t of produced sinter are emitted into the atmosphere.

The waste gas from the blast furnace contains 50 to 55 % N2, 23 to 24 % CO, 20 to 22 % CO2 and 2 to 4 % H2, while
sulphur mainly remains in the slag. For 1 t of produced steel, for example in a open hearth furnace, about 6800 g NO and 2000 g SO₂ are generated. Before it is let out into the atmosphere the gas is dedusted and the dust is recycled in the sintering process. For dedusting are used wet scrubbers, electrostatic precipitators and bag filters. Approximately 100 to 300 g dust per 1 t of produced iron and 400 to 550 g dust per 1 t steel are emitted into the atmosphere.

7. COAL COMBUSTION

The coal fired thermal power plants share in the total waste gas and dust pollution of the atmosphere with 60 % SO₂, 27 % NO and 22 % dust. Thus for instance the coal fired thermal power plants in the FRG annually emit into the atmosphere 1.86 Mt SO₂, 0.86 Mt NO, 0.033 Mt CO, 0.011 Mt CH and 0.156 Mt dust. The quantity of pollutant depends primarily on the quality of coal and on the applied combustion technology. The non-combustibles in coal are produced in the furnace as slag and dust, respectively fly ash. In grate-type furnaces the content of particles in flue gas is about 0.5 to 10 g/m³ and the size of particles ranges from 0.01 to 0.1 mm. For dedusting aerocyclones are used reaching an efficiency of about 85 to 95 %. In case of greater quantities of fine particles (> 20 % -0.02 mm) the air from aerocyclones is cleaned in electrostatic precipitators or in bag filters. If pulverized coal is combusted in the furnace the particle content ranges from 10 to 50 g/m³ flue gas, whereby the size of more than 50 % of the particles ranges from 0.005 to 0.025 mm, and about 10 % particles are <0.005 mm. For dedusting usually electrostatic precipitators are used or a combination of aerocyclones and precipitators achieving efficiency up to 99 %.

For the removal of SO₂ from flue gas two methods are generally applied, either directly in the furnace or only after a dedusting. In the first method finely pulverized calcite or dolomite is fed to the furnace together with coal. The reaction with SO₂ gives gypsum and ash. By this method an efficiency of about 50 % is achieved in grate-type furnaces and up to 90 % in fluidized bed furnaces. The other method comprises several processes, whereof the most common are a wet process with a suspension of lime or calcite, ammonia and sodium sulfite, and the so called regenerative process. The wet process with the suspension of lime or calcite is applied in 80 % cases. In this process the flue gas after dedusting is fed to a scrubber, and its reaction with lime or calcite produces gypsum. The
gypsum from the scrubber is dewatered and either settled into ponds or used in industry. This method may be illustrated by the example of a thermal power plant of 700 MW using coal with 8% ash and 1% S. The annual production of gypsum is 63500 t besides 102000 t of ash. 25000 t of limestone and 320000 m³ of water are consumed. The regenerative method uses magnesite suspension, which reacts with SO₂ in the scrubber. The obtained mixture (MgSO₃+MgSO₄) after calcination generates MgO, which is recycled into the process, and concentrated SO₂ used for the production of H₂SO₄.

8. CONCLUSION

The given examples show that waste is generated during the exploitation of solid mineral raw materials, what badly deteriorates the quality of the environment. With the production increase of raw materials, metals and energy more and more dust and waste gases are generated. The costs for environmental protection are increasing while the air becomes more and more polluted. It is evident that the necessary quality of air can not be achieved merely by using purifying equipment, but the intensity of exploitation of mineral raw materials and the consumption of metals and energy should be lowered as well. At the same time the recovery of the valuable mineral component by mining and concentration should be increased. The exploitation of old tailings should be initiated and the metal recovery during metallurgical processing respectively the share of metals produced by waste recycling should be increased. For the production of energy superior qualities of fuel, generated from coal, should be used, and the share of alternative energy sources should be increased to the greatest possible extent.

By adopting these measures and sticking at the same time to set standards and regulations it should be possible to prevent further air pollution increase and preserve a clean and healthy environment.
REFERENCES:


drilling machine

EXPLORATION

power shovel

hard material

soft material

transport

blocks of a few cm to a few dm

railway conveyor belt dumper

storage

blocks less than 1m³

giratory crusher

double cylinder crusher

primary size reduction

ball mill

secondary size reduction

cement

flotation

screening

metallurgy

tailing disposal

dust

SOx

NOx
ELECTROSTATIC PRECIPITATOR

- Electrodes
- Waste gas
- Cleaned gas
- Dust

FLOW POCKET FILTER

- Clean gas exit
- Moveable clean air feed
- Pocket in filtering position
- Filter pocket in cleaning position
- Flue gas entry
- Dust collector hopper
Wet Scrubber

Wash liquid

Waste gas

Cleaned gas

Liquid outlet

Porous adsorbent

Cyclone

Waste gas inlet

Cleaned gas

Exit to the dust-collecting box
ANNUAL EMISSION

SO₂  dust

MINING AND INDUSTRY  25.2  59.7

POWER PLANTS  62.1  21.7

HOUSEHOLDS AND TRAFFIC  12.7  18.6

COAL DESULPHURISATION

COAL

3% S  8% ash

95% efficiency

flue gas desulphurisation
aqueous scrubbing

CaCO₃ + SO₂ + H₂O → gypsum

230000 t/year

limestone

121000 m³/year

water

310000 t gypsum CaSO₄