Department of Technologies and Installations for Waste Management

Emission and Transport of Air Pollutants

Lecture 4

Calculation of emission and air pollution

1

Emission and concentration of pollution

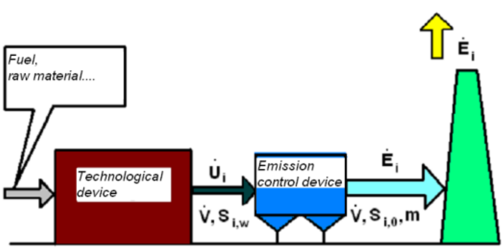
$\dot{U}_i$ - emission before control emission device – directly from source of emission, kg/h, kg/Mg of product

$\dot{E}_i$ - emission of pollution, kg/h

S_{iw}, S_{i0} - concentration of pollution in gas before and after control emission device, mg/m^3 , mg/m^3_u

2

Emission and concentration of pollution



3

Pollution concentration

Concentration before emission control device, mg/m^3

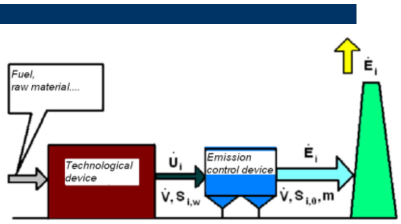
$$S_{iw} = \frac{\dot{U}_i}{\dot{V}}$$

Concentration after emission control device, mg/m^3

$$S_{i0} = \frac{\dot{E}_i}{\dot{V}}$$

4

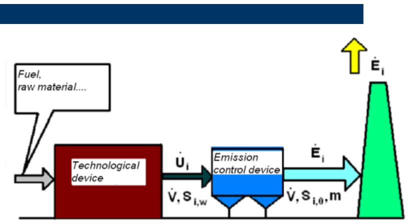
Emission



When $\dot{E}_i = \dot{U}_i$?

5

Emission



$$\dot{E}_i = \dot{V} \cdot S_i$$

6

Emission from installation
(Dz.U.nr 260, poz.2181 z zm.)

Emission standard from instalation relate to:

- **dry gas stream , m^3_u/h** $\dot{V}_{ss} = n''_{ss} \cdot \dot{P} \cdot 22{,}42$
- **standard conditions:** T = 273 K, p = 101,3 kPa
- **strict define oxigen content** in gas exhaust

7

Strict define oxigen content in gas exhaust

- **3%** - in case of combustion of liquid and gaseous fuels, as well as co-combustion of liquid fuels with waste,
- **6%** - in case of:
  - combustion of solid fuels: hard coal, brown coal, coke and biomass,
  - co-combustion of solid fuels with waste and biomass and co-combustion of waste with biomass,
  - estimation of concentration of heavy metals, dioxins and furans in exhaust gas form waste combustion process,
- **11%** - in case of waste combustion and co-combustion, when thermal power from combustion of hazardous waste is over 40% of nominal thermal power, with strictly precised exceptions,
- **15%** - in case of combustion of liquid and gaseous fuels in turbines.

8

Recalculation of substances' concentration in exhaust gas for standard oxygen amount

$$S_{iu}^{[O_2]=X\%} = S_{ipom} \frac{21-[O_2]_u}{21-[O_2]_{pom}}$$

where:

$S_{iu}^{[O_2]=X\%}$ – concentration of i substance in conventional conditions for standard oxygen concentration X%, mg/m^3_u

S_{ipom} – calculated, or measured concentration of i substance in conventional conditions, mg/m^3_u

$[O_2]_u$ – conventional (standard) oxygen concentration in dry exhaust gas, %

$[O_2]_{pom}$ – calculated, or measured oxygen concentration in dry exhaust gas, %.

9

Recalculation of substances' concentration in exhaust gas for standard oxygen amount

In case of combustion with oxidizer of defined oxygen concentration (different than in the air):

$$S_{iu}^{[O_2]=X\%} = S_{ipom} \frac{[O_2]_{utl}-[O_2]_u}{[O_2]_{utl}-[O_2]_{pom}}$$

where:

$[O_2]_{utl}$ – volumetric oxygen part in oxidizer

10

Recalculation of substances' concentration in exhaust gas for standard oxygen amount in polish regulations (Dz. U. nr 260, poz. 2181)

§ 4.2

2. Stężenie substancji w gazach odlotowych sprowadza się do standardowej zawartości tlenu w gazach odlotowych, obliczając według następującego wzoru:

$$E_1 = \frac{21 - 0_1}{21 - 0_2} \times E_2$$

gdzie:

E_1 — oznacza stężenie substancji w gazach odlotowych przy standardowej zawartości tlenu w gazach odlotowych,

E_2 — oznacza stężenie substancji w gazach odlotowych (zmierzone albo obliczone),

0_1 — oznacza standardową zawartość tlenu w gazach odlotowych, wyrażoną w procentach,

0_2 — oznacza zawartość tlenu w gazach odlotowych, wyrażoną w procentach (zmierzoną albo obliczoną).

11

Permissible emission – emission standards from installations (Dz. U. nr 260, poz. 2181)

Permissible emission of i substance introduced from installation to the atmosphere

- Permissible concentration at standard oxygen concentration: D_i, **mg/m^3_u**
- Permissible emission: $\dot{E}_{id}$, **kg/h, Mg/rok**

12

Minimal pollutant reduction ratio

Minimal pollutant reduction ratio of *i* substance introduced to the atmosphere in concentration above to the permissible one:

$$\eta_i = \frac{S_{iu}^{[O_2]=X\%} - D_i}{S_{iu}^{[O_2]=X\%}} \cdot 100\%$$

13

Permissible emission amount

Permissible emission amount of *i* pollutant introduced to the atmosphere, kg/h

$$\dot{E}_{id} = \frac{D_i}{S_{iu}^{[O_2]=X\%}} \cdot \dot{E}_i$$

14

Index method of emission calculation

Types of measurements:
- Continous – instalaltions of thermal power not less than 100 MW, where is realizezd process of combustion and co-combustion of waste and emission of VOC
- Periodical – transport, small boilers, etc.

Emission index is the mass of pollutant, expressed in **kg**, which is emitted from installation during combustion of **1 Mg of solid fuel, 1 m^3 of liquid fuel or 10^6 m^3 of gaseous fuel**

15

Index method of emission calculation

$$\dot{U}_i = \dot{P} \cdot w_i$$

where:

$\dot{U}_i$ - emission of *i* substance, kg/h

$\dot{P}$ - fuel stream, Mg/h

w_i - emission index: emission of *i* substance (kg) from combustion of fuel unit (1 Mg) in particular technology, kg/Mg

16

Index method of emission calculation for solid fuel

Emission of SO_2

$$\dot{E}_{SO_2} = \dot{P}\frac{w_{SO_2} \cdot s \cdot (100-\eta)}{100}$$

Emission of NO_2, CO, CO_2, benzo(a)piren

$$\dot{E}_i = \dot{P}\frac{w_i \cdot (100-\eta)}{100}$$

where
s- sulfer content in fuel
w_i – emission index, kg/Mg of fuel

17

Permissible air pollution

Permissible levels of substances in atmospheric air are defined for different **areas of country**, for different **time periods,** and for **standard condition (293 K, 101,3 kPa)**

- **Permissible one hour averaged concentration – D_1, µg/m^3**
- **Permissible annual averaged concentration – D_a, µg/m^3**
- **Permissible dust-fall on area – D_p, g/(m^{2}rok)**

18

Permissible air pollution

Permissible pollution of NO_x, as well as emission from installation is recalculated on amount of NO_2.

Recalculation of NO concentration to NO_2

$$S_{NO2} = 1{,}5332\ S_{NO} \quad mg/m^3_u$$

Total concentration of NO_2 in gas

$$S_{NO2} = S_{NO2} + 1{,}5332\ S_{NO} \quad mg/m^3_u$$

19

Permissible air pollution (Dz.U. nr 16 poz. 87)

Reference amount of pollutants concentration, or permissible levels are fulfilled when frequency of exceeding of reference amount by one-hour averaged concentration is no longer than **0,247%** of year in case of **SO_2**, and no longer than **0,2%** or the **rest of pollutants**.

20

Exam questions

1. Measurements in spa area showed, that concentration of NO and NO_2 is, respectively, 0,1 and 0,05 mg/m^3. Measurements were carried out in temperature 293 K and pressure 101,3 kPa. Does the permissible NO_x concentration (D_1 = 200 mg/m^3) is exceeded?
2. Recalculate 50 ppm$_v$ benzene concentration into mg/m^3.
3. Calculate SO_2 emission from combustion of 50 Mg/h of coal containing 1,25 mass % of sulphur. 80% of sulphur is combustible one, and desulphurization efficiency of exhaust gas is 90%.
4. What is index method of emission calculation?

Exam questions

5. Calculate conventional CO concnetration from waste combustion process. Measured CO concentration is 150 mg/m^3_u, and O_2 content in exhaust gas is 8%.
6. Calculate minimal efficiency of SO_2 puryfing installation in case where 30-minutes averaged permissible concentration is $D_{SO2/30}$=200 mg/m^3_u. Concentration of SO_2 is S_{SO2}=400 mg/m^3_u for 11% oxygen content.
7. Calculate permissible CO emission from waste combustion process, when day averaged concentration is D_{CO}=50 mg/m^3_u, measured concentration is S_{CO}=80 mg/m^3_u, and measured emission is E_{CO}=80 kg/h. What conclusion can be drawn from calculations?