METHODS TO ASSESS THE IMPACT OF POLLUTANTS DISCHARGED INTO THE ATMOSPHERE BY MANUFACTURERS OF REFRACTORY MATERIALS

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The refractories industry is cited as a polluting industry. The most important agents encountered in this area are dust, gases, waste resulting from the processes. In this paper we present current methods used to assess the impact of pollutants discharged into the atmosphere by the producers of refractory materials, highlighting the practical application of these methods by HELIOS Astileu, Romania

Keywords: pollutants, atmosphere, refractory materials

1. Introduction

Refractory industry differs significantly from other sectors of the ceramic industry. The field of silico-aluminous refractory studied in this project is related to some extent to the one of building bricks for the flow of mixture-compression, combustion, as well as the production of cement, in particular in the preparation of firebricks.

Silico-alumina refractory obtaining involves the use of raw materials with high content of free silica, extremely harmful to human health. In this paper we present current methods used to assess the impact of pollutants discharged into the atmosphere by the producers of refractory materials, highlighting the practical application of these methods by HELIOS Astileu.

The Gaussian air pollutant dispersion equation (discussed above) requires the input of H which is the pollutant plume's centerline height above ground level—and H is the sum of Hs (the actual physical height of the pollutant plume's emission source point) plus ΔH (the plume rise due the plume's buoyancy).[1][15]

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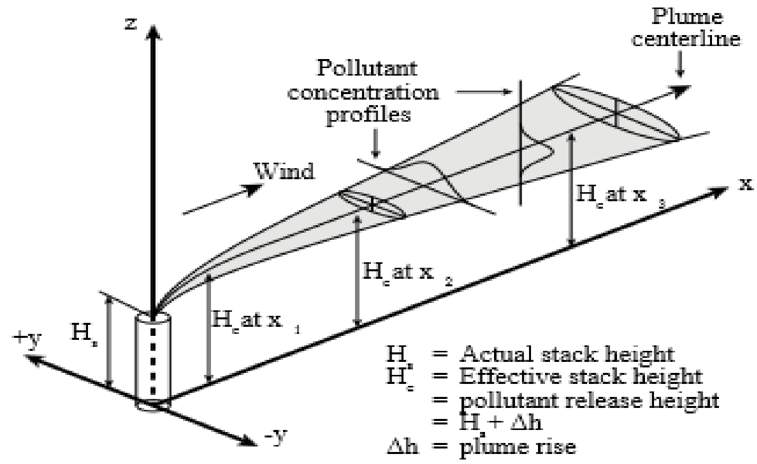

Fig. 1. Visualization of a buoyant Gaussian air pollutant dispersion plume, [1]

To determine ΔH, many if not most of the air dispersion models developed between the late 1960's and the early 2000's used what are known as "the Briggs equations." G.A. Briggs first published his plume rise observations and comparisons in 1965. In 1968, at a symposium sponsored by CONCAWE (a Dutch organization), he compared many of the plume rise models then available in the literature.[2] In that same year, Briggs also wrote the section of the publication edited by Slade dealing with the comparative analyses of plume rise models.[3] That was followed in 1969 by his classical critical review of the entire plume rise literature, in which he proposed a set of plume rise equations which have become widely known as "the Briggs equations". Subsequently, Briggs modified his 1969 plume rise equations in 1971 and in 1972.[4], [13]

2. Experimental work

2.1. Overview of pollutant emissions from

The most important component of pollution in this field is the dedusting one. Particulate emissions and immissions from technological processes for manufacturing refractory products is very important because they contain free crystalline silica and heavy metals.
The effects of HELIOS Astileu activity on the environment will be estimated according to the pollutants emitted and affecting environmental factors.

The recoverable products of this company are accompanied by gaseous, solid and liquid emissions.

Reduction or elimination of these emissions is imposed by environmental legislation and is the basic condition for further processes, the solution currently practiced is generally to discharge to the environment of pollutants and quantities of raw materials.

The company is located in the north-east of the country, in Bihor county, 35 km from the city of Oradea, in the east of the village Astileu, south-east of the town Alesd.

The dump of industrial wastes of the company is situated at a distance of 500 m from the boundary to the town Alesd, along Crisul Repede valley in the eastern part of the village Astileu.

The total area of the dump is 27.839 sqm. The dump has a length of 1,150 m and a height of 8.5 m with an average slope of 60 degrees. The large base of the dump is approximately 18 m, and small base is approximately 12 m. The volume of stored waste is approx. 150.000 m^3.

To assess the impact of pollutants discharged into the atmosphere two methods were used, namely:

- Climatological model of pollutants dispersion,
- Bosanquet-Peason mathematical model.

2.2. Presentation of the method of calculating the dispersion of pollutants using climatological dispersion model.

The matematical model used to evaluate the impact of evacuated pollutants in the atmosphere is the climatologic model SIMPG V3 for calculation of concentrations field.

Using this model was made taking into account that it allows the simultaneous intake of several sources to total concentration in a receiver; allows estimation of short term and long term; is applicable to continuous point and surface sources.

The fundamental physical basis of the model is the assumption that the spatial distribution of concentrations is given by the Gaussian plume pollutant. The model is therefore a Gaussian model combined with the mediation of the concentration on long intervals.[14], [17]

Gaussian solving of the diffusion equation has proved suitable for dispersion modeling. Complex experiments conducted by research groups in the world and in Romania showed a good degree of matching theoretical and experimental data: in addition it occurs advantage of facilities related to the development of computer programs, making the model an operational tool. Gaussian models are three-dimensional models that allow calculation of pollutant concentrations at a certain height (including the ground level) and at a certain distance from the source. The input data include information on computing grid, data broadcasting and meteorological parameters. The output data of the model is calculating every point grid covering the area of influence of the sources of the average concentration of seasonal or annual reports of each pollutant, the maximum concentration in 30 min. (The highest value involving all weather situations possible) and seasonal or annual average frequency of achieving and exceeding a threshold concentration per 30 min. (sanitary standards, the limit value for the protection of vegetation, etc.).

Based on these data we can trace on the area map the curves of iso-concentrations and iso-frequencies that emphasize spatial distribution of concentrations area and the level of atmospheric pollution and the long-term and short-term exposure. It is to be mentioned that if a group analysis of the impact of sources, measurements calculated in each grid point totals contributions of all sources. Using the presented climatological model the average short-term concentrations were calculated, daily and yearly for pollution sources within the company Helios Astileu. Data input into the program were taken from the previous tables that presented physical characteristics of sources, emission rate, flow and speed of the exhaust gases into the atmosphere. Dispersion calculations were made under the following conditions: simultaneous emission of all sources, disadvantageous conditions climatological, just to get the maximum concentrations that may be recorded.

There have been calculated dispersions for pollutants whose emissions have been assessed as the greatest (SO_2 and total dust). The area for wich the concentrations of discarded pollutants were calculated comprises the receptors in the area.[5]

2.3.Presentation of method of calculation for the dispersion of pollutants using the mathematical model Bosanquet-Pearson.

The dispersion of pollutants was compiled based on measurements from sources based on material balance and on the fixed measurements.

The factors that influence the dispersion of pollutants in the atmosphere are factors that characterize the source (stack height exhaust temperature, speed, quantity emitted), the relief and roughness of the zone in which the dispersion occurs, factors characterizing the air space in which the emission occurs (meteorological factors).

Pollutant dispersion process can be studied through mathematical modeling, allowing expression by calculating the spatial distribution in case of pollutants studied.

Starting from the equation of diffusion of pollutants in a system of interaction and introducing a number of simplifying assumptions, we reach to a solution as a Gaussian distribution.

Among the simplifying assumptions the most important are the emission source which is punctual, the emission source is located on relatively flat terrain, the turbulence is homogeneous and stationary throughout the air mass, the axis 0x is oriented downwind and the pollutants that are conservative (not undergoing physical or chemical changes).

Qm mass flow rates of pollutants (mg/s) entering the dispersion calculation are determined directly by measuring the concentrations of pollutants at the source in the exhaust gases into the atmosphere, or indirectly through assessments on the technological balance of materials.

$$Qm = Cc * Qv \quad (1)$$

, where: Cc - is the concentration of the pollutant and Qv - is the volumetric flow rate of the source.

The wind interferes into the dispersion through velocity and direction.

The calculation of wind speed at a certain level is usually based on ground wind velocity (standard height H_1 = 10 m) with a relation of the form:

$$V = Vo\,(H / H1) \quad (2)$$

, where: V = average wind speed at the height H, m/s
V_o = average wind speed at the reference level H_1 in m/s;
H_1 = effective height clearance in m;

$$\Delta h = h + h1 \quad (3)$$

, where h = geometric height of the source, m Δ h = heightening; N turbulence index.

Values of n depend upon atmospheric conditions.

Wind direction sets the travel of the mass of pollutants. The speed determines the direction of movement of the pollutant on heightening influence. This is defined as the distance that travels up from the exit from the chimney to the initial loss of momentum. This distance is inversely proportional to wind speed.

Heightening wedge pollutant was calculated using the following calculation equation:

$$\Delta h = 1{,}9\, D\, U/V \quad (2)$$

, where: V = average wind speed at the height H, m/s;D - represents the inner diameter of the exit at the chimney mouth, m; U – gas speed in the chimney section in m/s.

Based on the mathematical model an algorithm was developed that, in a certain meteorological situation, you can calculate the maximum concentration of the pollutant and distance from the source: you can also perform calculations of concentration on an axis with a step by choice for all stability classes and wind speeds compatible.

Dispersion calculations were made for pollutants for which recorded values of emissions were over the limits.

2.4. The results of dispersion calculations using climatological pollutant dispersion model

For hazards from directed and undirected sources, which concentrations exceed the allowable values maps of dispersion were drawn, considering the type of pollutant, ground conditions, the average air temperature, thermal inversions at the moment of measurements, sizing zone and permissible limit of the pollutant in g/m³.

The coordinate system was chosen so as to be within the entire affected area and the possible emission sources. With the help of the program used we made maps, diagrams of ground-level concentrations of pollutants, which presented the target, possibly affected neighborhoods and curves of iso-concentration for emitted pollutants. [18]

The results of dispersion calculations or maximum concentrations of pollutants at ground level (including distance from the source/site boundary) compared with the alert and intervention thresholds required by law are listed in Tables 1 and 2.

Table 1

Allowed concentrations for diferent types of pollutants

Pollutant	Maximum concentration		
	C_{max} µg/mc	Alert threshold, µg/mc	The limit value=intervention threshold µg/mc
Total dust	215	75	50
SO_2	260	500	350
Total dust	170	75	50
Total dust	109	60	40
SO_2	9	-	20

Table 2

Concentrations of pollutants at various distances from the emission source

Distance from the source/limit of perimeter of plaform and section (m-sector)	Concentration/span of concentrations, µg/mc	Limit value+intervention health threshold µg/mc	Observations
	Total dust	Total dust	
0-200	215-75	50	HOURLY
200-400	75-25		
400-600	25-5		
0-200	170-65	50	DAILY
200-400	65-15		
400-600	15-2		
0-200	109-60	50	YEARLY
200-400	60-11		
400-600	11-1		

2.5. Pollutant dispersion calculation using the mathematical model BOSANQUET PEARSON

As it was shown previously, at HELIOS Astileu the air pollution produced mainly consists of total dust resulting from production processes and particulate matter from combustion gases resulting from thermal aggregates [18].

Maximum concentration values for each source separately conducted calculation to which concentration exceeds allowable emission concentration at distances at which they were recorded, according to release calculations, are presented in Tables 3 and 4.

Table 3

Values of maximum allowed concentrations of pollution

Source	Name of pollutant	pollutant	Atmospheric state Wind speed 1 m/s	Maximum concentration mg/mc	Dist. for max. concentration m	Extreme values
P1	Chimney cyclone grinding clay	Total dust	Unstable Neutral Stable	0.78662 1.23028 2.13172	150 350 900	0.05
P2	Chimney cyclone trimming the old ward	Total dust	Unstable Neutral Stable	0.14143 0.22166 0.39577	250 500 1500	0.05
P3	Chimney cyclone trimming new department	Total dust	Unstable Neutral Stable	0.16839 0.26633 0.48094	300 600 1500	0.05
S1	Clay dryer chimney	SO_2	Unstable Neutral Stable	0.17632 0.27128 0.46194	150 250 700	0.35
		CO	Unstable Neutral Stable	0.26757 0.41168 0.70101	150 250 700	10
		Total dust	Unstable Neutral Stable	0.14319 0.22030 0.37513	150 250 700	0.05
S2	Chimney of rotating furnace	SO_2	Unstable Neutral Stable	0.09846 0.50412 0.92604	300 700 2000	0.35
		CO	Unstable Neutral Stable	0.07973 0.12709 0.23345	350 700 2000	10
		Total dust	Unstable Neutral Stable	0.08533 0.13600 0.24983	350 700 2000	0.05

S3	Chimney of tunnel furnace CT1	SO_2	Unstable Neutral Stable	0.09079 0.47466 0.87709	350 800 2000	0.35
		CO	Unstable Neutral Stable	0.11955 0.19182 0.34651	600 800 2500	10

Table 4

Values of concentrations of pollutants for different sources of emission

Source	Name of pollutant	Pollutant	Atmospheric status Wind speed=3.5 m/s	Conc. Max. mg/mc	Distance for max. concentration m	Limit values
N0	Section firebrick production Share+/- 0.00	Total dust	Unstable Neutral	6.48609 8.95967	20 40	0.05
N1	Grinding department Share granulation	Total dust	Unstable Neutral	2.37587 3.28194	20 40	0.05
N2	Grinding department Share vibrating sieve	Total dust	Unstable Neutral	0.25885 0.38689	80 200	0.05
N3	Section trimming Share silos	Total dust	Unstable Neutral	0.05694 0.08690	150 250	0.05
N4	Section insulation Share metering dose	Total dust	Unstable Neutral	0.48549 0.72214	60 100	0.05
N5	Section insulation Share mixers	Total dust	Unstable Neutral	0.94734 1.36262	20 60	0.05

Dispersion calculations were made for wind speed of 0-1 m/s, which is the worst in terms of pollutant dispersion (calm air) and wind speed of 3.5 m/s (the speed that characterized that period investigated and, according to statistics, is the most frequent in the studied area.) For the given situation in which we took into consideration a slow speed of the wind (<1m/s) the calculations of dispersion were made for the three characteristics atmospheric states, (unstable, neutral, and stable) and for the speed of 3.5 m/s the calculations of dispersion were made for the three characteristic atmospheric states (unstable, neutral, stable). Dispersion calculations were made for the pollutants with emissiond were the highest (over the allowed limits). [6]

3. Conclusions

From the comparison of the results obtained from the dispersion calculations fot total dust, with maximum allowed concentration according the current legislation, we find that:

- For P1 directed source, from the clay grinding section, there were recorded the highest overruns (cca.40 times the value limit of 0.05 mg/m allowed under Order 592/2002) under conditions of atmospheric stability, and about 24.6 times in neutral atmosphere conditions.
- For directed sources P1-P2 and S12-S2 it was observed overruns between 1.6 and 14 times.
- For unguided dust emission sources we recorded overruns especially in the firebrick department and in the birebricl grinding section.
- For toxic gas resulting from combustion ($S0_2$, CO) following dispersion calculations for directed sources, denoted by S1, S2 and S3 there resulted the following conclusions:
- For $S0_2$ it was observed exceedings of the permissible limit of 0.35 mg/cm especially in conditions of atmospheric stability.
- For CO we did not find exceedings of the permissible limits of 10 mg/m³.

Overall dedusting problem is presented as a necessity, firstly in terms of social harmfulness of dust emission, but also as a measure of economic growth in order to recover materials and rise technological operations efficiency.

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