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SELECTION OF A DEDUSTING SYSTEM FOR THE LIME STONE PREPARATION PLANT IN THE DEPOSIT "ZAGRADJE - 5"***

Abstract

This paper presents an example of a dedusting system in the deposit "Zagradje - 5" with the use of two different dedusting systems in order to more efficiently removal of harmful dust from the plant. The analysis is done by calculation and is a universal method of calculating the dedusting system, the results of which are necessary to verify the reliable operation of selected equipment. The technical characteristics of the filter and deduster as well as the technological scheme of dedusting are also given.

Keywords: central dedusting, single deduster, bag filter

1 INTRODUCTION

The problem of clean, unpolluted air in the industrial environments has become very acute today, and it must be solved very quickly. The air we breathe at workplaces in the factory halls is increasingly expressed in the number of concentrated dust particles. In fact, a large number of air pollutants in cities come from industry.

This paper is aimed at sizing and selection of technological and mechanical equipment that will ensure that the concentration of dust in the plant that occurs during operation is within the acceptable limits [7]. According to the standard SRPS Z.B0.001-1991 [8] entitled the "maximum permissible concentrations of harmful gases, vapors and aerosols in the atmosphere of working premises and construction sites" ("Official Gazette of SFRY", No. 54/91), the maximum permissible concentration of the total dust in the

working medium for mineral dust with less than 1% SiO₂ is 15 mg/m³.

The allowed concentration of dust in the air in the working environment is ensured by removal of dusty air from the source of dust by forced air circulation by means of a fan and its one-stage purification in the appropriate dedusting devices - bag filters so that the concentration of dust emitted into the atmosphere after purification is within the allowed limits.

According to the Decree on Limit Values for Emissions of Pollutants into the Air from the Stationary Pollution Sources, Except for the Combustion Plants (Official Gazette of RS, No. 111/2015) [9], the emission limit values for the total particulate matter in waste gas are 20 mg/m³ for the mass flow greater than or equal to 200 g/h or 150 mg/m³ for the mass flow of less than 200 g/h.

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2 DESCRIPTION OF A TECHNOLOGICAL SCHEME OF DEDUCTING

Figure 1 shows the Technological scheme of dedusting installation, which shows the positions that will be processed in this text.

Figure 1 *Technological scheme of dedusting installation*

The central dedusting system will be installed next to the open warehouses at positions 15.1, 15.2, 15.3, and after that, the individual dedusters will be used.

The central dedusting system will use two HVP bag filters with involute input 8HVP504, filter area: 453,274 m². Dimensions of the HVP filter are: Ø4267.2 × 12911 mm.

From the open pit "Zagradje -5", the excavated limestone is transported by trucks to the shaft pit, where there is a robust steel grid with square openings. Limestone passes through the grid and then falls into the shaft pit. It descends directly to a jaw crusher. A feeder with chains (Pos.6) is provided in front of the

jaw crusher. Through this feeder and one slider (Pos.8.1), limestone is dosed in a controlled manner into the hatch of the C130 jaw crusher. The "Jaw crusher C 130" performs the primary reduction of limestone size.

At the loading point above the primary crusher, a suction hood will be installed, pos. N01 on a section D01 which extracts the dusty air in an amount of 5000 m³/h, wherein the concentration of dust of 11.5 g/m³. Via the slide (Pos.8.1), the primarily crushed limestone is directed to a belt conveyor Pos. T-1 which transports the material to the conveyor at position T-2, which transports the limestone to the primary screen (Pos. 9.1).

A suction hood, pos. N02, is installed at the unloading point of the crusher, which sucks out dusty air in the amount of 14000 m³/h, where the dust concentration is 11.87 g/m³ on section D08.

A suction hood was installed at the pressure point pos. N03 between the belt conveyors T1 and T2, which sucks out dusty air in the amount of 3350 m³/h, where the dust concentration is 6.5 g/m³. The sieve has a sieving surface of 11.4 m² and circular openings of the sieving surface of the sieve of 88 mm (separation 80 mm). A suction hood, pos. N04, is installed above the sieve, which sucks out dusty air in the amount of 9800 m³/h.

The screening of the sieve at Pos.9.1 through one slide (Pos.8.3) is directed to the receiving hopper of small capacity (Pos.10) below when there is a belt feeder T3 (Pos.11). The mentioned feeder doses limestone into the hatch of the secondary Cone crusher HP300 in which the secondary reduction of the size of limestone is performed (Pos. 12). A suction hood, Pos. N05, will be installed in the recessed place above the crusher, as well as at the exit from the crusher Pos. N06. An exhaust hood N07 will be installed at the loading point of the T4 belt conveyor from the sieving of the CVB301P sieve.

The crushed material of the secondary crusher HP 300 is combined with the sieve of the primary screen CVB 301P where another hood Pos. N07 will be installed, where the air capacities are 4000 m³/h, 8500 m³/h and 5400 m³/h, respectively. The material is then transported with a T-4 conveyor to the sieving via a slide (Pos. 8.5), on a secondary sieve CVB 302P (Pos.9.2) manufactured by Metso minerals. The sieve has two sieving areas of 11.4 m². Above the sieve is placed the hood Pos.N08. The openings of sieving surfaces of wire panels are: 48 × 48 mm (separation 40 mm) and 23 × 23 mm (separation 20 mm). Screening of sieve I, sieving area on (Pos.9.2) size class - 80 + 40mm over one slide (Pos.8.7)

is directed to the conveyor Pos. T-5, which deposits this size class, which is the first finished product of the limestone preparation plant, to the first open warehouse (Pos.15.1). From there, this size class - 80 + 40 mm through concrete openings and 4 bars (Pos.8.19-4) and 4 vibrating feeders (Pos.17.1) is dosed to the conveyor with a rubber conveyor belt Pos.T-8, which this size class, i.e. the finished product of crushing and screening is transported to the conveyor on Pos.T9, more precisely it is connected to this conveyor. Via the conveyor T9, which will work in alternating mode with the conveyor T8, i.e. the alternating functioning and dosing of the material will be provided, via the reversible conveyor T11, to the receiving bunkers of the lime plant (Pos. 13 and 14).The sieving of the secondary sieve CVB 302P of the I sieving surface, size class - 40 + 0.0 mm, immediately falls on the II sieving surface of the sieve CVB 302P (Pos.9.2) on the third sieving. The screening of this sieve CVB302P (Pos.9.2) II sowing surface, size class - 40 + 20 mm, is the second finished product of the limestone preparation plant. This size class -40 + 20 mm, i.e. the screening of the sieve II of the sieving surface is directed via one slide (Pos.8.7) to the conveyor Pos.T-6, which deposits this class of size to another open stack (Pos.15.2). From there, this size class - 40 + 20 mm is dosed to the transporter with a rubber conveyor belt via concrete openings and 4 bars (Pos.8.10-4) and 4 vibrating feeders (Pos.17.2). T-9 which this class of size i.e. the finished product of crushing and sifting is transported to the receiving bunker of the lime plant (Pos 13). Therefore, the two main products, fractions -80 + 40 mm and -40 + 20 mm, will be transported to the receiving bunkers, Pos.13 and 14, via the reversible conveyor T-11. This further means that the T-8 conveyor, as already mentioned in the text, "connects" to the T-9 conveyor, which disposes of the mentioned fractions in the receiving bunkers via the T-11 reversing conveyor, each

intended for a specific fraction. While the conveyor T-8 is in operation mode, and delivers the size class - 80 + 40 mm, from the warehouse Pos.15.1, to the conveyor T-9, it is clear that the dosing of product -40 + 20 mm, through the warehouse 15.2, will be suspended and vice versa, when dosing, i.e. feeding the bunker pos.13, with the product - 40 + 20 mm, via the conveyor T-9 and T-11, feeding the bunker Pos.14 with the product - 80 + 40 mm, via the conveyor T-8, T-9 and T-11 will be suspended. The introduction of the T-11 reversible conveyor enables uninterrupted feeding of the provided bunkers for the appropriate required products, while the alternating operation of the T-8 and T-9 conveyors, more precisely the alternating dosing of materials from open warehouses to the mentioned conveyors, enables uninterrupted transport of defined products without mixing them.

Above the CVB302P vibrating screen, a NO8 extraction hood is provided for an air volume of 10200 m³/h at a dust concentration of 11 g/m³.

A closed hood will be installed at the loading point of screening sieves on the belt conveyor Pos. NO9, for the air capacity of 2650 m³/h, and at the unloading places Pos. NO10 and NO11 on belt conveyors T5 and T6 hoods for the air capacity 2300 m³/h and 1700 m³/h, respectively, where the dust concentration for all three suction points is 6.5 g/m³.

Furthermore, sieve of the screen CVB302P class size - 20 + 0.0 mm is a product that is transported by conveyor Pos.T-7 to the third open warehouse (Pos.15.3) and which will be through 4 concrete openings and 4 bars (Pos.8.11- 4) and 4 vibration feeders (Pos.17.3) for further treatment should be sent to a new conveyor with a rubber conveyor belt Pos. T-10, on micronization in the lime plant.

Individual dust collectors PO1-PO7 with compressor stations for production the compressed air for impulse blowing of

individual dust collectors, manufactured by KDK-EKO or similar, will be installed at the filling points pos. NO12-NO17.

All dust will be unloaded from the central dedusting system from these two HPV filters into two pyramidal steel dust collection bunkers, and from there via telescopic devices for unloading material into trucks.

2.1 Calculation of the Suction Air Quantities

The quantities of exhaust air for all exhaust points are given in Table 1.

The quantities of exhaust air for loading places NO1, NO2, NO5 and NO6 were adopted from the literature No11k [1]. For loading places NO7, NO9, NO10, NO11, NO12, NO13, NO14, NO15, NO16, NO17, NO18, the Molčanov [2] calculation method was used. And for loading places NO4 and NO8, the Volkov method was used.

The **Molčanov** calculation method is the following:

The quantity of suction air is calculated according to the following formula:

$$L_{NO} = L_E + L_N [m^3/h]$$

where:

L_E - quantity of air introduced by material

L_N - quantity of air entered through the openings

Quantity of air introduced by material is calculated by the following formula:

$$L_E = 0.12 * k_y * V_m * v_k^2 [m^3/h]$$

where:

k_y - coefficient (depending on construction and type of material) - in this case we adopt 1.4 for ordinary loading troughs

V_m - volume flow of material

v_k - final speed of material

The final speed of material is calculated by the following formula:

$$v_k = 4.43 * \sqrt{H * (1 - f_t * ctg \alpha)}$$

where:

H – height of material drops

f_t - coefficient of material friction against the walls (according to the document SN 155-61[3] it can be seen for lime 0.56)

α - inclination angle of a section

Volume flow of material is calculated:

$$V_m = \frac{Q}{\rho} [m^3/h]$$

where:

Q – mass flow of material

ρ - bulk density of material (according to OHTII-10-85[4] for lime is 1.5 $[t/m^3]$)

The quantity introduced through the openings is calculated by the formula:

$$L_N = A * C * B^2 * v_k * M_y$$

where:

A – coefficient for material loading from a belt conveyor

C – coefficient for a belt width 800 mm

M_y - coefficient for impassable loading place

B – width

By **Volkov**[5] the quantity of suction air for sieve is calculated by the formula:

$$L_{NO} = L_E + L_N [m^3/h]$$

where:

L_E – quantity of air introduced by material

L_N – quantity of air that enters through the openings

The amount of air introduced with the material is calculated according to the following formula:

$$L_E = 0.2 * V_m * v_k^2 [m^3/h]$$

where:

V_m – volumetric flow of material

v_k – final speed of material

Final speed of material is calculated by the following formula:

$$v_k = 4.43 * \sqrt{H * (1 - f_t * ctg \alpha)}$$

where:

H – height of material falls

f_t - coefficient of material friction against the walls (according to the document SN 155-61[3] it can be seen for lime 0.56)

α - inclination angle of a section

Volume flow of material is calculated:

$$V_m = \frac{Q}{\rho} [m^3/h]$$

where:

Q - mass flow of material

ρ - bulk density of material (according to OHTII -10-85[4] for lime is 1.5 $[t/m^3]$)

The quantity introduced through the openings is calculated by the formula:

$$L_N = 3600 * F * v$$

where:

F – surface of tightness

v - air speed through tightness (by Volkov [5] it can be adopted for sieves of 2)

$$F = 0.1 * P$$

where:

0.1 - coefficient of tightness (by Volkov it can be adopted for sieves of 0.1)

P – surface

Table 1 is formed on the basis of given calculations.

Table 1 Amount of suction air in the limestone preparation plant

Suction mark	Amount of air in m ³ /h	Dust concentration in g/m ³
NO1	5000	11,50
NO2	14000	12,00
NO3	3350	6,50
NO4	9800	11,00
NO5	4000	20,00
NO6	8500	20,00
NO7	5400	6,50
NO8	10200	11,00
NO9	2650	6,50
NO10	2300	6,50
NO11	1700	6,50
NO12	1260	6,50
NO13	1700	6,50
NO14	1260	6,50
NO15	1700	6,50
NO16	1260	6,50
NO17	1700	6,50
NO18	2520	6,50

2.2 Dust Concentration at Suction Points

For dust concentration at suction points, the recommendations for certain devices, given in the literature SN 155-61[3], were used.

Following the example of calculation the dust concentration on the following sections, Table 2 is given.

Figure 2 Section view

$$Q_{D02} = Q_{D01} + Q_{D08} = 5000 + 14000 = 19000 [m^3/h]$$

where:

Q_{D02} – air quantity in given section

$$C_{D02} = \frac{C_{D01} * Q_{D01} + C_{D08} * Q_{D08}}{Q_{D02}} = \frac{5000 * 11.5 + 14000 * 12}{19000} = 11.87 [g/m^3]$$

where:

C_{D02} – dust concentration in given section

Table 2 Air quantities and dust concentrations in given sections

Section mark	Amount of air in m ³ /h	Dust concentration in g/m ³
D01	5000	11,50
D02	19000	11,87
D03	22350	11,06
D04	50500	12,80
D05	66900	11,90
D05a	33450	11,90
D05b	33450	11,90
D06a	33450	0,0119
D06b	33450	0,0119
D06	66900	0,0119
D07	66900	0,0119
D08	14000	12,00
D09	3350	6,50
D010	8500	20,00
D011	12500	20,00
D012	22300	16,04
D013	27700	14,18
D014	4000	20,00
D015	9800	11,00
D016	5400	6,50
D017	2650	6,50
D018	4950	6,50
D019	15150	9,53
D020	16850	9,22
D021	2300	6,50
D022	1700	6,50
D023	10200	11,00

Based on the given parameters, the machine design and selection of dedusting system equipment in the limestone preparation plant is done.

3 TECHNICAL DESCRIPTION OF A DEDUSTING SYSTEM

The dedusting system of the limestone preparation plant comprises two units or phases. **Phase 1** includes a transport system from the primary crushing to the two-level sieve facility, and since it is a dependent system that is in operation at the same time, a central dedusting system is adopted where dust is suctioned from all dust sources that are in operation at the same time.

The central filter plant is located on a filter facility located on the existing road near the two-level sieve facility. It consists of two symmetrical lines that work in parallel. Each line consists of a bag filter with air blowing under which there is a pyramidal steel bunker for dust collecting with the associated equipment. Technical characteristics of the filter are as follows:

Type: HVP bag filter with involute inlet
 Producer: CAMCORP
 Designation: 8HVP504
 Filter area: 453,274 m²
 Filter capacity: 33450 m³/h
 Dimensions: Ø4267,2x12911 mm
 Total mass: 9915 kg

From the fan, the purified air is ejected into the atmosphere through the exhaust element with a protective net. On this section, a connection for measuring and sampling dimensions is provided, and in its vicinity, the same connection is also provided on the incoming pipeline of dusty air on the section. The choice of a fan with a frequency regulator enables a relaxed start when starting the fan, easier regulation of the plant as well as the possibility for more flexible operation of the plant. Dust separated in the filters is first collected in the conical lower part of the filter. A level measuring device for signaling the maximum level as protection against overfilling will be mounted on the wall of the

conical part of the filter. From the conical part of the filter, dust is discharged into bunkers via a star feeder on electric drive.

Phase 2 includes dedusting of the loading parts of conveyor, and since the transport system is independent, i.e. the conveyors work independently of each other, an individual dedusting system was adopted. The mentioned system is based on purification the dusty air in a deduster itself (which is installed at the suction point), and then returns it to the belt conveyor as purified. Depending on the required amount of air for suction, 3 dedusters, manufactured by KDK-EKO, with the following characteristics were selected:

- Designation: KFE-12-TV/2-R
- Filter area: 15 m²
- Capacity: 1260 m³/h
- Power: 4 kW
- Designation: KFE-16-TV/2-R
- Filter area: 20 m²
- Capacity: 1700 m³/h
- Power: 4 kW
- Designation: KFE-24-TV/2-R
- Filter area: 30 m²
- Capacity: 2520 m³/h
- Power: 5 kW

3.1 Calculation

The following calculation formulas were used in the aerodynamic [6] calculation of the pressure drop:

$$d = \sqrt{\frac{4 \cdot Q}{3600 \cdot \pi \cdot v}} [m] - \text{diameter of a pipe-line section (equivalent diameter)}$$

$$\lambda = 0.013 + \frac{0.001}{d} - \text{friction coefficient}$$

$$v_{kr} = 0.3 \cdot \sqrt{c \cdot g \cdot d \cdot \frac{\rho_c}{\rho_v} \left[\frac{m}{s} \right]} - \text{critical air speed}$$

$\Delta p_v = \left(l \cdot \frac{\lambda}{d} + \Sigma \zeta \right) \cdot \frac{\rho_v \cdot v^2}{2} [Pa]$ - pressure drop in clean air flow

$\Omega = 0.02 \cdot \frac{v^2}{g \cdot \frac{d}{2} \cos \beta}$ - pressure increase factor

$\Delta p_{\xi} = \Delta p_v \cdot (1 + k \cdot c) [Pa]$ - pressure drop during dusty air flow

Individual labels in formulas have the following meanings:

$v \left[\frac{m}{s} \right]$ - air speed

$Q \left[\frac{m^3}{h} \right]$ - volume air flow

$c \left[\frac{kg_{\xi}}{kg_v} \right]$ - concentration of solid particles in the air

$\rho_{\xi} = 2660 \left[\frac{kg}{m^3} \right]$ - density of solid particles

$\rho_v = 1.2 \left[\frac{kg}{m^3} \right]$ - air density

$g = 9.81 \left[\frac{m}{s^2} \right]$ - gravitational constant

$l [m]$ - length of a pipeline section

$\Sigma \zeta [-]$ - sum of the coefficients of local resistance of a pipeline section

$\beta [^\circ]$ - inclination angle of a pipeline section

$k = 1.4 [-]$ za $\Omega > 1$ - coefficient of pressure increase

$k = 0.4 \div 0.6 [-]$ za $\Omega < 1$ - coefficient of pressure increase

The total pressure drop includes the additional pressure drops in the appropriate sections, as follows:

1. $\Delta p_p = 50 [Pa]$ - underpressure in suction hoods

2. $\Delta p_f = 2000 [Pa]$ - pressure drop in a bag filter with pulse shaking

Calculation of the pressure drop in a pipeline for the most unfavorable circuit is given in the table.

AERODYNAMIC CALCULATION OF AIR PIPELINE FOR DEDUSTING OF THE LIMESTONE PREPARATION PLANT IN ZAGRAĐJE																		
Calculation of pressure drop for the circuit with sections D01, D02, D03, D04, D05, D05a, D06a, D06 and D07 for dedusting from the loading place above the primary crusher - suction point NO1																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
NO. OF SECTION	SECTION LENGTH	VOLUME FLOW	VOLUME FLOW	SPEED	CALCULATION DIAMETER	ADOPTED OUTER DIAMETER	ADOPTED INNER DIAMETER	ACTUAL SPEED	CONCENTRATION OF PARTICLES IN AIR	CRITICAL SPEED	FRICTION COEFFICIENT	SUM OF LOCAL RESISTANCE COEFFICIENTS	PRESSURE DROP IN AIR FLOW	PRESSURE INCREASE FACTOR	PRESSURE INCREASE COEFFICIENT	PRESSURE DROP IN FLOW DUSTY AIR	PRESSURE DROP DUE TO THE ADDITIONAL RESISTANCES	TOTAL PRESSURE DROP
	L	Q*	Q	v*	d*	d	d	v	c	v _{kr}	λ	Σζ	Δp _v	Ω	k	Δp _ξ	Δp _d	Δp
	m	m ³ /h	m ³ /s	m/s	m	mm	mm	m/s	kgξ/kgv	m/s	-	-	Pa	-	-	Pa	Pa	Pa
01	11.1	5000	1.389	20	0.297	300	294	20.46	0.00958	2.35	0.016	1.62	562.6	5.81	1.4	570.1	50	620.1
02	145.1	19000	5.278	20	0.580	560	554	21.90	0.00989	3.27	0.015	0.72	1322.9	3.53	1.4	1341.2	0	1341.2
03	15.5	22350	6.208	20	0.629	630	624	20.30	0.00922	3.35	0.015	0.30	163.9	2.69	1.4	166.1	0	166.1
04	65.0	50050	13.903	20	0.941	900	894	22.15	0.01067	4.32	0.014	0.51	452.4	2.24	1.4	459.2	0	459.2
05	35.1	66900	18.583	20	1.088	1120	1114	19.07	0.00992	4.65	0.014	0.39	180.6	1.33	1.4	183.1	0	183.1
5a	15.0	33450	9.292	20	0.769	800	794	18.77	0.00992	3.93	0.014	1.69	414.2	1.81	1.4	419.9	0	419.9
6a	34.9	33450	9.292	15	0.888	900	894	14.81	0.00001	0.13	0.014	1.92	325.0	1.00	1.4	325.0	2000	2325.0
06	16.1	66900	18.583	15	1.256	1250	1244	15.29	0.00001	0.16	0.014	0.53	99.4	0.77	0.5	99.4	0	99.4
07	17.0	66900	18.583	15	1.256	1250	1244	15.29	0.00001	0.16	0.014	1.43	227.1	0.77	0.5	227.1	0	227.1
																	Total pressure drop	5614.1

4 CONCLUSION

If the problem of spreading the air pollutants would be solved where it is regenerated, then it would be a significant contribution to the preservation of the human environment. The importance of clean, unpolluted air in the industrial zones is well known. Well-designed and executed ventilation offers a solution that will bring the air pollutants at least below the maximum allowable concentrations, and thus provide the necessary protection for workers in such conditions. This paper gives a practical solution to the problem related to the appearance of increased dust concentration at the suction points in the plant for limestone preparation Zagradje-5.

Figure 1 defines an optimal layout of air purification equipment. Air purification equipment can be installed in other ways depending on the specific conditions.

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