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Analysis of the processes in pneumatic moulding sand reclamation

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Abstract

This article covers the analysis of the pneumatic moulding sand reclamation, made of different types of binders. The research has been carried out for the sand with resin binder (furan resins) as well as water glass hardened with flodur. Reclamation has been carried in the pneumatic conveying system in the linear regenerator in the technical scale and equipped with an abrasion impact disc. Evaluation of the effectiveness of the reclamation has been made on the basis of tests determining the contents of binder's components before and after the process and on the basis of the sieve analysis. The subject of this publication is the comparison of the effectiveness of these two types of solutions.

Keywords: Diphase stream flow; Linear regenerator.

1. Introduction

The energy of the stream flow in pneumatic conveying of loose material can be used for the moulding sand reclamation. Moulding sand reclamation enables the recovery of sand base (most frequently it is the silicon sand) of technological parameters that guarantee its reuse in new moulding processes. The reclamation process involves crushing the waste sand, cleaning the sand grain surface from the residuals of the used binder and removing side products (fine dust fractions) of the reclamation process. The possibility of the future reuse of the reclaim depends on how effectively the sand grain is cleaned i.e. on the degree of the removal of the residuals of the used binder and the classification of the reclamation products. The essential part of the reclamation process is the removal of binder for example through the abrasive sand grain interaction. The parameters of the operation of the appropriate system of devices depend on the type of binder and the quality requirements for the reclamation products. The most popular is the dry method (mechanical and pneumatic). The pneumatic regeneration provides solutions involving elements responsible for the abrasive cleaning process of the sand grain surface from the binder. One of the solutions in pneumatic moulding sand reclamation is the use of stream flow to help convey the loose material through the linear regenerator system.

Thanks to the possibility to control the disturbances of the pneumatic air flow in the conveyer pipeline, the abrasive cleaning process of the sand grain surface from the residuals becomes intensified. The pneumatic conveying of the particles is determined be the resisting force that occurs as the result of the gas and material friction against the walls of the pipeline, friction between the particles as well as the gravity force and absolute force of the flowing particles. The resistance of the diphase stream flow may be overcome by the differential pressure that causes its motion in the determined conditions of conveying.

2. Research works

The research works of the relevant reclamation process have been carried out at the testing stand in the Department of Foundry at the Institute of Engineering Materials and Biomaterials at the The Silesian University of Technology equipped with the system of devices in the technical scale and the necessary measuring apparatus. The studies involved the reclamation of two different types of moulding sand where resin and water glass binders were used.

2.1. Research and testing stand

Figure 1 shows the system of devices for the pneumatic moulding sand reclamation tests. It is equipped with the following essential components and control devices:

- high - pressure chamber feeder for pneumatic conveying (1), usable capacity V_u=0.25 m^3 ,
- linear regenerator (3) collaborating with pipeline of the diameter of D_N=0.08 m,
- receiving device (4) connected to the de-dusting system,
- fluid classifier (6) as a separate device,
- ISA orifice (measuring reducer) with the measuring option (5),
- abrasion impact disc as a receiving device (7)

Moreover the testing system is equipped with the monitoring and measuring apparatus as well as the control apparatus.

The elements of the linear regenerator in the testing process are shown in Fig. 2. They have been made of the abrasion resistant material. Their inner structure is similar to the Witoszyński nozzle at the inlet and Laval nozzle at the exhaust, which is the result of model testing. The testing has been carried at two levels of narrowing of the linear regenerator ($S_p=A_{max}/A_{min}$ amounting to 1.8 and 3.6).

The influence of the receiving device (abrasion impact disc) on the correct process of cleaning (removal) of the binders may depend on the maximum value of air flow. This process has been illustrated in Fig. 3.

In accordance with the stream technique and own research we can assume that at the distance of l_1 = to 0,3 m spanning between the exhaust end of the pipeline and the abrasion impact disc, the velocity of particles of the size of ds. > 0.3 mm is constant.

For working purposes the shape of the disc internal surface was assumed to be part of a cylinder with the radius of R_1. The requirement for the maximum velocity at the exhaust end of the pipeline may be described through the relations in Fig. 3.

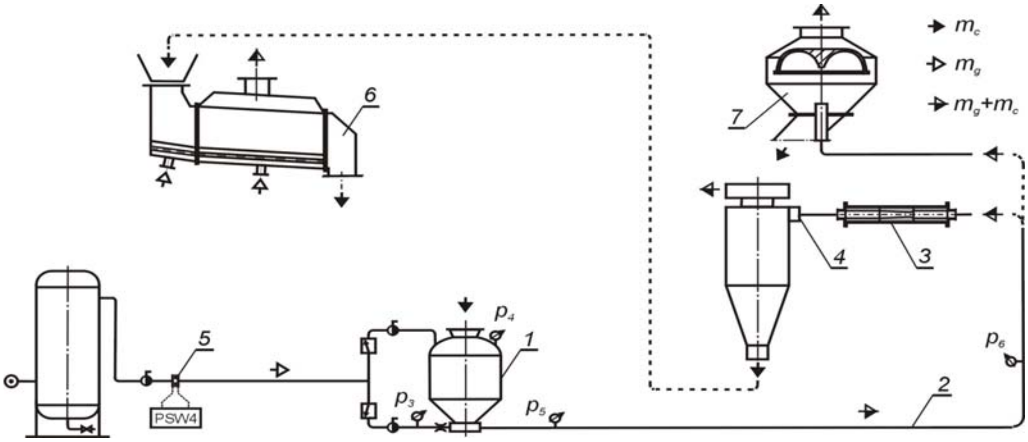

Fig. 1. Research stand scheme

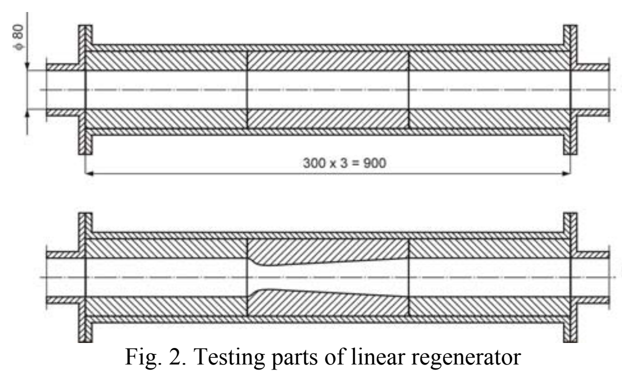

Fig. 2. Testing parts of linear regenerator

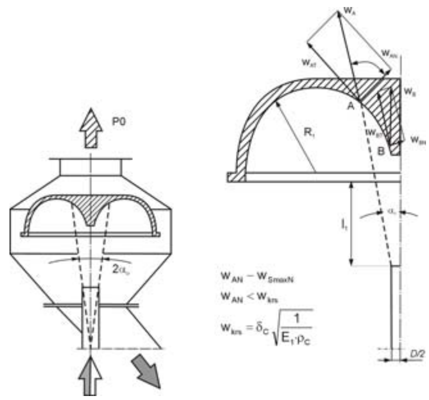

Fig. 3. The model of the process of influence of the stream flow on the surface of the abrasion impact disc

2.2. Testing Methodology

The research works included the primary treatment of moulding sand through crushing and screening through 2.5 x 2.5 mm sieves. So prepared material, after a precise weighing, was loaded into the chamber feeder and conveyed in the testing unit to the receiving device through the linear regenerator in the specified conditions of compressed air supply. The conveying involved the measurements of parameters necessary to determine the characteristic indicators of the process. The reclaimed sand, after the conveying in the testing unit, was subject to classification in the fluid classifier. The testing samples have been prepared before the reclamation (after sieving) and the completion of the classification and conveying process.

2.3. Preparation of results and applied characteristics

Parameters describing the pneumatic conveying process for the moulding sand reclamation have been calculated on the basis of the prepared algorithm according to the current standards. The parameters included in the tables of results should be read as follows:

p_8- value of overpressure of the compressed air measured before the linear regenerator

Δp_8-pressure drop caused by the stream flow before the linear regenerator

w_8- velocity of the conveying stream flow before the linear regenerator

m_c- value of the mass rate of flow of the material during conveying

μ_m- mass mixture concentration (reclaimed sand and air) referred to as concentration

w_f- velocity of the stream flow of the fluidisation in the classifier

U_R- output of the reclaimed sand during testing

Δp_{01}- number of fractions < 0.1 mm in the tested loose material (sieve analysis)

d_h- harmonic mean of grain size (sieve analysis)

S_T- theoretical specific surface (sieve analysis)

The results determined by these parameters are shown as examples in the tables.

Table 1a.
Results of calculation of the pneumatic furan resin moulding sand reclamation system where abrasion impact disc is used.

It.	Pneumatic conveying					Classification		
	p_8	Δp_8	w_8	m_c	μ_m	m_c	w_f	U_R
-	kPa	kPa	m/s	kg/s	kg/kg	kg/s	m/s	%
1	6,02	2,97	11,99	2,735	22,06	1,48	0,18	92,1
2	5,12	0,92	10,30	3,147	29,14	2,02	0,16	90,6
3	9,81	4,40	12,48	4,641	26,42	2,14	0,16	90,2
4	13,15	5,92	13,21	3,918	27,59	2,34	0,12	94,5
5	14,52	6,21	12,08	4,244	32,40	1,98	0,15	93,1
6	15,55	6,20	13,27	4,798	32,42	2,06	0,22	87,4

Table 1b.
Results of laboratory testing of the reclaimed pneumatic furan resin moulding sand - after reclamation, where abrasion impact disc is used.

It.	Sieve analysis			Roasting losses		
	Δp_{01}	d_h	S_T	0,315-0,400	0,160-0,200	<0,100
-	%	mm	m^2/kg	%	%	%
1	1,16	0,247	9,157	0,834	1,457	10,934
2	0,06	0,303	7,464	1,295	2,146	16,325
3	0,66	0,255	8,901	0,985	1,630	12,890
4	0,90	0,240	9,433	0,837	1,514	11,186
5	1,15	0,236	9,609	0,697	1,301	10,167
6	0,70	0,244	9,286	0,644	1,371	12,727

Table 2a.
Results of the calculation of the parameters of the work of the pneumatic moulding sand reclamation system where linear regenerator is used.

It.	Pneumatic conveying					Classification		
	p_8	Δp_8	w_8	m_c	μ_m	m_c	w_f	U_R
-	kPa	kPa	m/s	kg/s	kg/kg	kg/s	m/s	%
1	38,1	36,8	15,55	3,301	25,37	1,64	0,21	89,6
2	40,3	38,2	17,31	2,945	20,05	1,89	0,20	88,9
3	26,5	25,0	16,14	2,287	18,54	1,47	0,18	90,3
4	24,4	22,6	15,88	2,404	20,13	1,36	0,17	91,2
5	25,2	24,3	19,70	1,780	11,88	1,42	0,19	91,4
6	25,0	23,8	20,22	1,777	11,60	1,35	0,20	92,3

Table 2b.
Results of laboratory testing of the reclaimed pneumatic furan resin moulding sand - after reclamation, where linear regenerator is used.

It.	Sieve analysis			Roasting losses		
	Δp_{01}	d_h	S_T	0,315-0,400	0,160-0,200	<0,100
-	%	mm	m^2/kg	%	%	%
1	0,30	0,286	7,934	1,116	4,347	17,124
2	0,45	0,278	8,144	0,998	4,075	16,372
3	0,11	0,290	7,813	1,000	4,336	17,008
4	0,28	0,286	7,913	1,432	4,117	18,416
5	0,39	0,292	7,751	1,086	4,045	16,812
6	0,60	0,281	8,086	1,024	3,631	16,215

Table 3a.
Results of the calculation of the parameters of the work of the pneumatic floster type moulding sand reclamation system where linear regenerator is used.

It.	Pneumatic conveying					Classification		
	p_8	Δp_8	w_8	m_c	μ_m	m_c	w_f	U_R
-	kPa	kPa	m/s	kg/s	kg/kg	kg/s	m/s	%
1	36,1	34,2	25,89	1,547	7,35	1,27	0,18	89,4
2	38,0	36,7	25,83	1,503	7,05	1,32	0,16	90,8
3	32,4	30,8	21,02	2,136	12,88	1,83	0,21	91,3
4	30,0	29,1	21,77	2,087	12,33	1,94	0,16	92,4
5	27,4	26,2	17,49	2,857	21,52	1,68	0,17	90,5
6	28,3	27,1	17,91	2,769	20,20	1,48	0,18	92,6

Table 3b.
Results of laboratory testing of the reclaimed pneumatic floster type moulding sand - before and after reclamation, where linear regenerator is used.

It.	Sieve analysis – before regeneration			Sieve analysis – after regeneration		
	Δp_{01}	d_h	S_T	Δp_{01}	d_h	S_T
-	%	mm	m^2/kg	%	mm	m^2/kg
1	1,28	0,346	6,638	0,84	0,301	7,523
2	2,07	0,353	6,368	1,34	0,287	7,842
3	2,34	0,318	7,121	0,94	0,294	7,699
4	2,17	0,337	6,919	1,18	0,297	7,548
5	3,14	0,324	7,032	2,10	0,309	7,313
6	2,86	0,317	7,045	1,96	0,302	7,518

Table 4a.
Results of calculation of the parameters of work of the pneumatic floster type moulding sand reclamation system where abrasion impact disc is used.

It.	Pneumatic conveying					Classification		
	p_8	Δp_8	w_8	m_c	μ_m	m_c	w_f	U_R
-	kPa	kPa	m/s	kg/s	kg/kg	kg/s	m/s	%
1	44,1	42,4	20,69	2,169	12,83	1,24	0,17	89,9
2	41,5	40,8	19,93	2,118	12,72	1,16	0,16	89,0
3	22,4	21,4	22,60	1,112	6,88	0,96	0,16	87,4
4	22,4	21,2	22,60	1,070	6,62	0,95	0,14	88,6
5	37,5	35,8	24,28	1,655	8,31	1,10	0,20	89,2
6	35,8	34,2	27,80	1,387	6,91	1,08	0,20	88,6

Table 4b.
Results of laboratory testing of the reclaimed pneumatic floster type moulding sand - before and after reclamation, where linear regenerator is used.

It.	Sieve analysis – before regeneration			Sieve analysis – after regeneration		
	Δp_{01}	d_h	S_T	Δp_{01}	d_h	S_T
-	%	mm	m^2/kg	%	mm	m^2/kg
1	3,26	0,271	8,297	1,54	0,241	9,097
2	3,31	0,254	8,526	1,75	0,237	9,142
3	2,97	0,262	8,059	1,09	0,254	8,451
4	3,04	0,258	7,786	1,49	0,246	8,357
5	2,83	0,268	8,155	1,76	0,265	8,295
6	3,25	0,249	8,631	1,92	0,243	8,742

3. Summary

The analysis of the laboratory research results (mainly sieve analyses) shows the usability of the pneumatic moulding sand reclamation system for the tested types of sand. The effectiveness of the operation of the linear regenerator depends on the system supply parameters that enable to obtain the required parameters of the diphase stream flow. These parameters include flow velocity and mass mixture concentration. The important factor for the correctness of the process is the construction of the elements of narrowing. It has a substantial impact on the flow resistance. Too small levels of narrowing can cause the drop of effectiveness of work, whereas with too large levels (exceeding S_p= 4) we can observe resistance which will prevent higher efficiency and repeated use of narrowing elements during conveying the reclaimed sand stream. This research shows that the most desirable effects of the linear generator can be obtained for the stream flow velocity of w_8= 15 - 28 m/s and mass mixture concentration of μ_m= 12 – 25 kg/kg. These conditions with the narrowing level of S_p= 3.6 facilitate the achievement of good results in the moulding sand reclamation.
The use of abrasion impact disc requires the adjustment of the diphase stream flow from the exhaust end of the pipeline to the disc. This velocity should not exceed the critical value, which could cause the destruction of the sand grain (cracking and exfoliation). The admissible value of the diphase stream flow velocity on the disc is w_{AN} = 35 m/s.
Having analysed the technological solutions for both types of pneumatic moulding sand reclamation systems, it should be admitted that they are more beneficial than other solutions for dry reclamation. Also the test results confirm that they can be useful for their purposes.

References

[1] H. Szlumczyk, Analiza ruchu strumienia dwufazowego w regeneratorze liniowym, Archiwum Odlewnictwa Nr 15, Rocznik 5 , Wyd. PAN Katowice 2005.
[2] H. Szlumczyk, Badania procesu ścierania zużytego spoiwa z powierzchni ziaren osnowy w regeneratorze liniowym, Transport Pneumatyczny 2005, IX Międzynarodowa Konferencja, Sielpia – Kielce 2005.
[3] H. Szlumczyk, J. Gawroński, Regenerator liniowy-nowoczesna technologia pneumatycznej regeneracji mas formierskich, Archiwum Odlewnictwa Nr 8, Wyd. PAN Katowice 2003.
[4] J. A. Goliński, A. T. Troskolański: Strumienice, WNT Warszawa 1979.
[5] J. Dańko, R. Dańko, Reclaimability of used seft setting Sand with selected type of resin, Archives of Foundry vol.4, No 13 (2004),45-50 (in Polish).