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Pneumatic moulding sand reclamation in the linear regenerator system

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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 (phenolic – formaldehyde and furan resins) as well as water glass (hardened with flodur and arconite hardener). Reclamation has been carried in the pneumatic conveying system in the linear regenerator in the technical scale. 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.

Keywords: Pneumatic conveying, diphase stream, 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 [1, 2, 3]. The possibility of the future reuse of the reclaim depends on how effectively the sand grain is cleaned ie. 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 depends on the type of binder and the requirements for the reclamation products. The most popular method is the dry method (mechanical, thermal and pneumatic) [8]. 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 [5, 6, 7]. 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 bay 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 in the linear regenerator system

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. The stand was equipped with the system of devices in the technical scale and the necessary measuring apparatus. The working personnel of Kooperacja POLKO from Mikołów was also actively involved in this research activities and provided the testing equipment as well as carried a part of these laboratory tests. Kooperacja POLKO provides technical solutions for the pneumatic transport conveying and is a leading partner in providing the solutions to its customers from Poland and abroad. The studies involved testing the reclamation of three different types of sand, where resin and water glass binder were applied.

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 devises:

- high - pressure chamber feeder for pneumatic conveying (1), usable capacity Vu = 0.25 m3,
- linear regenerator (3) collaborating with pipeline of the diameter of DN = 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),

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 [4]. The testing has been carried at two levels of narrowing of the linear regenerator. Sp = Amax/ Amin.

2.2. Testing methodology

The research works included the primary treatment of moulding sand through crushing and sieving 2.5 x 2.5. The crushing and sieving installation of Kooperacja POLKO was used to prepare the material. 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.

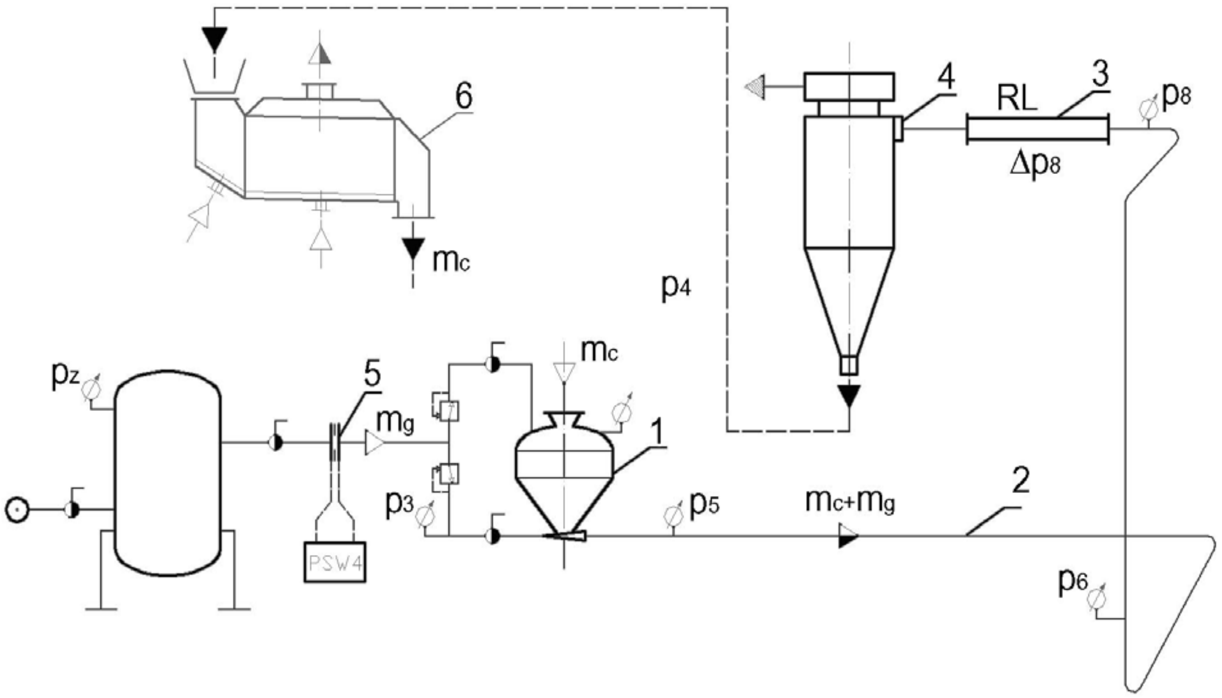

Fig. 1. Research stand scheme

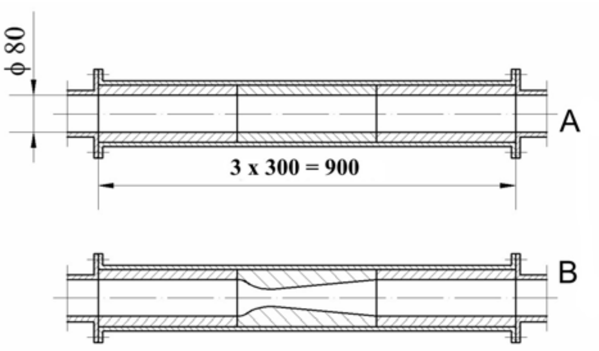

Fig. 2. Testing parts of linear regenerator

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:

p8 – value of overpressure of the compressed air measured before the linear regenerator
Δp8 – pressure drop caused by the stream flow before the linear regenerator
w8 – velocity of the conveying stream flow before the linear regenerator
mc – value of the mass rate of flow of the material during conveying
μc – mass mixture concentration (reclaimed sand and air) referred to as concentration
wf – velocity of the stream flow of the fluidisation in the classifier
UR – output of the reclaimed sand during testing
Δ p01 – number of fractions < 0.1 mm in the tested loose material (sieve analysis)
dh – harmonic mean of grain size (sieve analysis)
St – theoretical specific surface (sieve analysis)

The results determined by these parameters are shown as examples in tables 1 and 2 for two types of sand.
A, B, C, D symbols – types of tested reclaimed sand: A - sand with phenolic – formaldehyde resin binder, B – furan sand, C – flodur hardened water glass sand, D - arconite hardened water glass sand

Table 1a.
Results of calculation of the pneumatic moulding sand reclamation system, sand base B work parameters

It.	Pneumatic conveying					Classification		
	p8	Δp8	w8	mc	μm	mc	wf	UR
-	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 1b.
Laboratory research results of reclaimed moulding sand, sand base B - after reclamation

It.	Sieve analysis			Roasting losses		
	Δp01	dh	ST	0,315-0,400	0,160-0,200	<0,100
-	%	mm	m2/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 2a.
Results of calculation of the pneumatic moulding sand reclamation system, sand base C work parameters

It.	Pneumatic conveying					Classification		
	p8	Δp8	w8	mc	μm	mc	wf	UR
-	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 2b.
Laboratory research results of reclaimed moulding sand, sand base C – before and after reclamation

It.	Sieve analysis – before regeneration			Sieve analysis – after regeneration		
	Δp01	dh	ST	Δp01	dh	ST
-	%	mm	m2/kg	%	mm	m2/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

In the Fig. 3 and 4 the influence of velocity on roasting looses of B mass and number of fractions after reclamation process for C mass are presented.

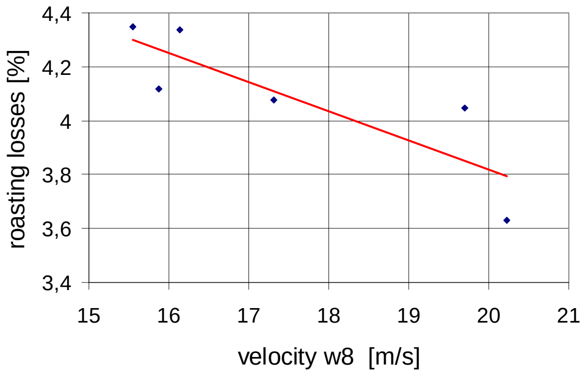

Fig. 3. The influence of velocity on the roasting looses after reclamation process for B mass.

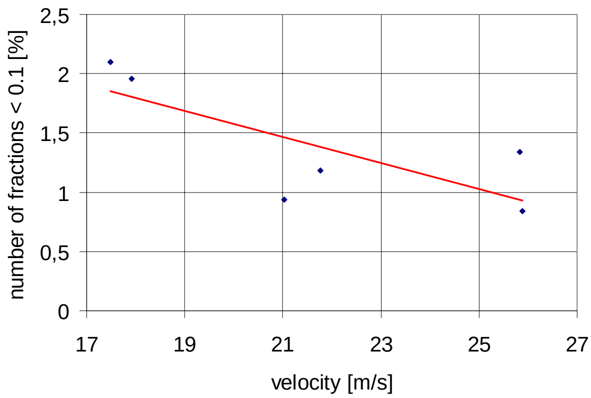

Fig. 4. The influence of velocity on the number of fractions after reclamation process for C mass

3. Conclusions

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. As it is seen in the graphs (Fig. 3 and 4) the velocity increase causes the decrease of analyzed parameters (roasting looses and number of fractions). 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 Sp = 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 regenerator can be obtained for the stream flow velocity of w8 = 15 – 28 m/s and mass mixture concentration of μc = 12 - 25 kg/kg. These conditions with the narrowing level of Sp = 3.6 facilitate the achievement of good results in the moulding sand reclamation

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