RECYCLING OF FINES GENERATED IN THE FERROALLOY PRODUCTION THROUGH COLD-BONDED AGGLOMERATION PROCESS: PRELIMINARY TESTS.

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ABSTRACT

This work deals with the main technical difficulties which originated when we tried to make cold-bonded pellets of slimes from the production of Ferro Alloy utilizing cement as a binder. The hydration reaction of cement was not compatible to the Ferro Alloy fines and therefore, it was not possible to obtain pellets with the necessary compressive strength, without very special curing procedure, such as autoclaving the fines beforehand.

INTRODUCTION

The production of Ferro Alloy usually generate a very fine material, which is disposed as a slime and which is considered for all purpose a waste material.

Although the amount of fines is not so considerable, it is for the majority of industries, troublesome to handle this material.

As a matter of fact, this particular fine material, due to its chemical composition could be reused as part of the charge of an eletric furnace. It has an average carbon content of 11,5% and MnO_2 higher than 35,0%.

The main difficulties presented by the recycling of the slimes would be the drying operation and the subsequent agglomeration.

Factors such as: low investiment, low operational cost, technical simplicity, and small scale, indicate that the best alternative for the agglomeration of this fines would be through the cold bonded pelletization using inorganic binders (cement and lime).

This work deals with the main problems which appeared when we tried to obtain pellets with good physical properties. The fines presented good balling properties, but hydation reaction of the binder (cement) did not develop due probably to some deleterious component of the fines.

MATERIAL AND METHODS

The material was received in a pre-dried condition, with a moisture content of 33%. In order to make the handling and the homogeneization operation easier, the material was thoroughly dried in an oven at a 100^0C. Despite the care taken in the drying procedure, some lump were formed.

The chemical composition of the fine material is shown in Table 1. The material has a specific gravity of 2,02 and its size analysis shows it is 66,7% minus 325 mesh.

Two kinds of cement have been used: one was an ordinary Portland cement and the other was a cement ground to a more fine size distribution (high surface area). The chemical and physical analysis of both are shown in Table 2.

The aditive used was a quartizite ground to 100% minus 100 mesh.

The material was mixed in a high intensity mixer device and pelletized in a small drum. As the binder used was a cement, the physical properties of the pellets were measured over the period of two weeks.

Table 1 - Chemical composition of ferro alloy fines

CaO	MgO	K_2O	Al_2O_3	Fe_2O_3	Na_2O	SiO_2	MnO_2 total	C	P.P.C
6,66	7,93	1,13	4,43	2,53	0,14	15,09	40,20	11,45	24,10

Obs.: oxides + P.P.C = 100%
carbono included in P.P.C

Table 2 - Physical and Chemical analysis of cements

	special	ordinary
P. 200	0,8	3,8
Blaine	3860	2786
Set - Begin (minutes)	115	130
- End (minutes)	200	240
- $\%H_2O$	28,3	26,3
Expansion mm	0,5	0,5
Strength - 01 day	257	-
kg/cm^2 - 03 days	364	234
- 07 days	419	272
- 28 days	485	355

	PF	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	R.I	Cal
special	2,74	19,50	5,10	2,54	64,10	0,97	3,15	0,03	0,80	0,37	1,09
ordinary	3,77	20,66	5,95	2,72	62,72	0,89	1,47	0,03	0,75	0,42	1,22

RESULTS AND DISCUSSION

The pelletizing tests where programmed in a way that we could carry out a factorial statistical study of the main variables which usually affect the development of the compressive strength of the cold-bonded pellets.

Those variables were:

a) type of cement (ordinary and special) - 2 levels

b) amount of cement (2, 4, 6 and 10%) - 4 levels

c) additives (with silica and without it) 2 levels

Tables 3 and 4 show the results obtained for the compressive strength of pellets. Those results represent the average strength of 10 pellets, with a diamenter of 22,0 mm each. The pellets had very good plasticity and good green compressive strength.

As the preliminary results, were far below our expectation, some other tests were carried out using an excessively high amount of binder, that is; 30%, in order to investigate the possibility of increasing the compressive strength of the pellets(Table 5). The mixing time was also increased (besides the recommended one) in order to make the mixing operation as perfect as possible. Yet, the pellets had a very low compressive strength.

Some hyphotesis were raised, in order to explain the poor performance of the pellets in terms of physical properties. Among them were: excess or lack of moisture pH of the slimes, mixing procedure and so on. None of them proved to be the true cause of the low strength obtained.

Finally, it was considered that the low strength could be caused by some components of the slimes which reacting with cement produce some expansion, hindering the development of the compressive strength. Lea (1) mentioned that one way of neutralizing those harmful components would be to hydrate them in autoclave before mixing with cement. So, the slimes were put in autoclave at 352 PSI (250^{0}C) for a curing period of 2 hours. After that the slimes were pre-dried, mixed with cement and pelletized. Table 6 shows the results obtained when the slimes were autoclaved before the pelletization.

The results obtained in Table 6 show very clearly that the pellets made with autoclaved slimes have much higher compressive strength than the one without autoclaving. A comparison between tests 3 and 4 shows that the compressive strength on the 7º day of curing, change from 3,5 kg/pellet to 9,3 kg/pellet, that is,an increase of 165%. A comparison between Table 3 and 6 are still bether.

It must be pointed out that the size of pellets shown in Table 6 was 16,0mm, whereas in Table 3 it was 22,0 mm. Despite the improvement obtained in the compressive strength of autoclaved slimes, it should be borne in mind, that the compressive strength obtained was rather low for pellets of that size and with the high amount of binder used.

Difratometric analysis has shown no significant difference betweem the autoclaved and non-auto claved slimes. On the other hand, Differential Thermo Analysis (DTA) (Figures 1 and 2) shows inequivocally the difference between the two slimes. There is an endothermic peak at 210^{0}C.

Table 3 - Compressive strength of dried pellets made with ordinary Portland cement

% \ Day	whith sílica			without sílica		
	1º	3º	7º	1º	3º	7º
2	$\bar{x}$ = 8,10 d = 0,74	7,25 1,01	7,15 0,63	7,70 0,89	8,50 1,20	10,00 1,35
4	$\bar{x}$ = 8,15 d = 0,58	7,75 0,63	7,75 0,92	7,45 0,50	7,35 0,58	9,00 0,82
6	$\bar{x}$ = 6,30 d = 0,98	6,20 1,27	7,00 1,08	7,60 0,88	7,30 1,00	6,06 0,60
10	$\bar{x}$ = 5,20 d = 0,82	6,50 0,94	7,50 0,75	5,30 0,59	6,90 0,79	7,35 0,88

Table 4 - Compressive strength of dried pellets (22,0 mm diameter), made with special cement

% \ Day	with sílica			without sílica		
	1º	3º	7º	1º	3º	7º
2	$\bar{x}$ = 6,75 d = 0,92	6,25 0,98	6,95 0,83	7,40 0,61	7,20 0,92	7,50 1,07
4	$\bar{x}$ = 5,55 d = 0,96	4,70 0,59	5,72 1,00	10,30 1,78	11,70 1,38	10,40 1,05
6	$\bar{x}$ = 7,35 d = 0,75	6,20 0,82	5,60 1,01	7,10 0,46	7,20 0,67	6,50 0,53
10	$\bar{x}$ = 5,00 d = 0,53	7,80 0,95	6,50 1,04	6,00 1,05	8,50 0,76	6,90 1,08

Table 5 - Compressive strength of pellets made with special cement without additive and changing de mixing time. Amount of binder: 30% cement

mixing time (minutes) \ day	moisten compressive strength		dried compressive strength			
	1º	3º	1º	3º	1º*	3º*
5	$\bar{x}$ = 12,15 s = 1,36	17,75 2,28	14,00 3,16	14,30 1,77	14,60 0,96	14,60 2,53
8	$\bar{x}$ = 15,70 s = 1,44	18,90 2,29	16,30 2,59	15,45 2,07	13,60 1,98	18,10 1,52
10	$\bar{x}$ = 15,35 s = 1,68	19,20 1,99	15,05 2,10	14,00 1,91	13,80 1,10	16,50 1,32

Table 6 - Compressive strength of pellets (16,0 mm) made with ordinary cement

cement \ day	test	After Pelletizing	time		
			1º day	3º day	7º day
2*	1	3,00 0,24	2,90 0,20	2,70 0,19	2,90 0,25
4*	2	5,50 0,42	4,05 0,41	3,78 0,50	4,25 0,58
6*	3	4,00 0,36	6,30 0,40	7,40 0,27	9,30 0,76
6**	4	4,60 0,17	3,10 0,37	3,70 0,19	3,50 0,33
6***	5	4,17 0,47	3,80 0,38	3,90 0,32	4,01 0,33

* Autoclaved fines ** Non-autoclaved fines *** Non-autoclaved fines and "ground" before hand.

Figure 1 - Thermo Differential Analysis of Non-autoclaved Fines

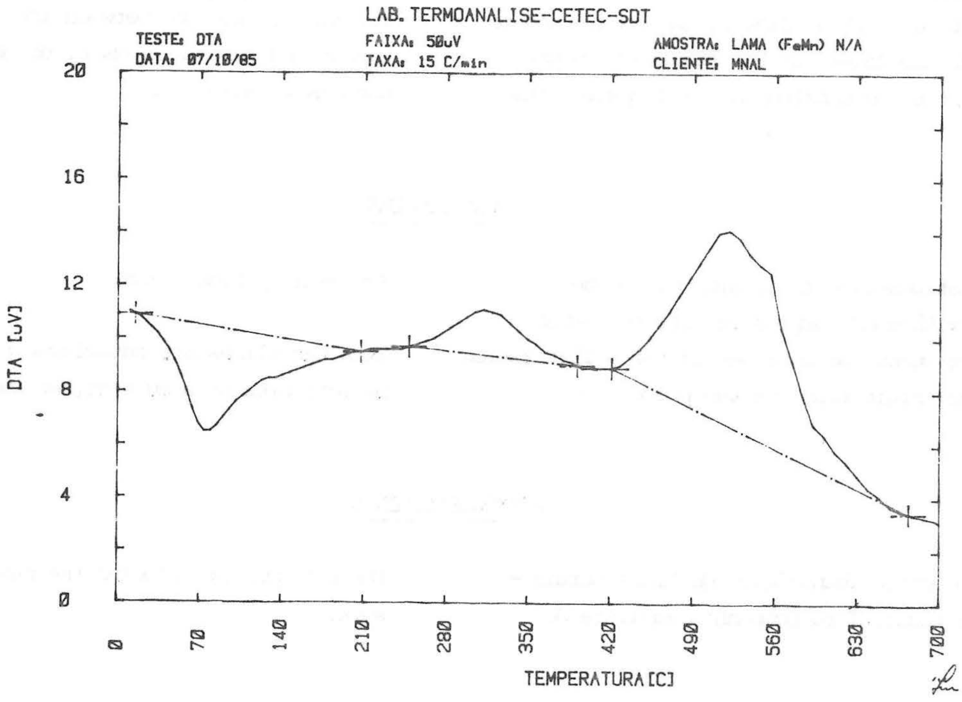
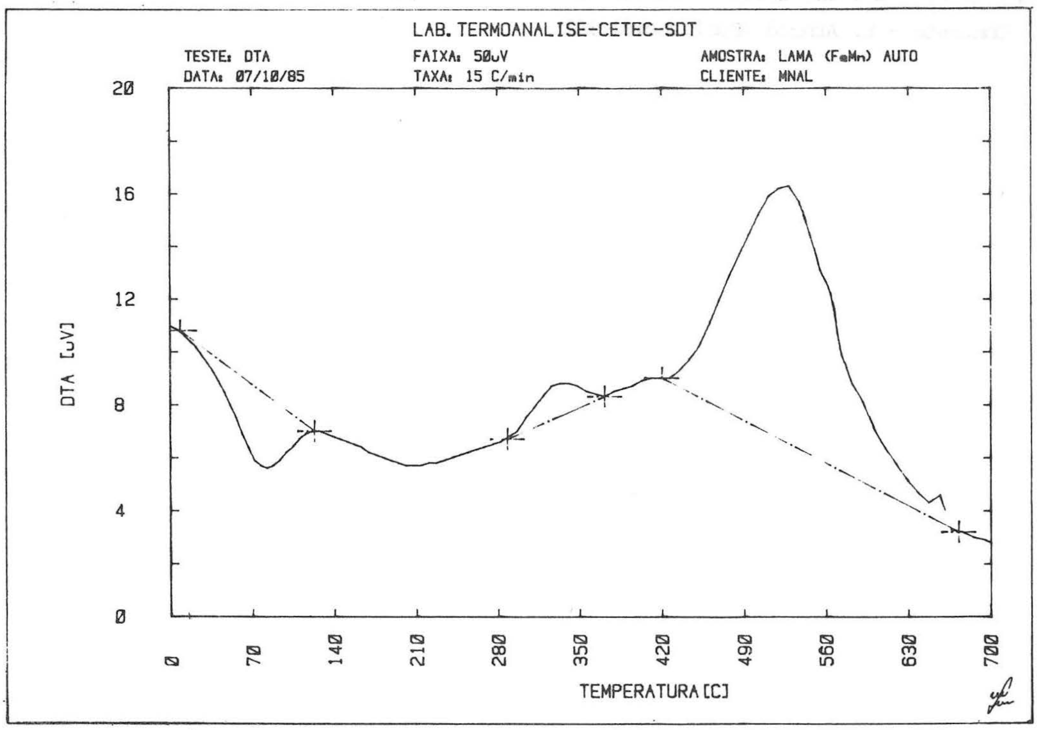


Figure 2 - Thermo Diferential Analysis of Autoclaved Fines



Lea pointed out that the presence of crystals of MgO, periclase, in a clinker, has been found to long-term usoundness in the resultant cement because of the expansion that accompanies its slow hydration. Another type of expansive reaction is the one between the alkalis of cement and certain kinds of dolomitic limestone, used as an aggregate.

CONCLUSIONS

It was not possible to obtain cold bonded pellets with good compressive strength when utilizing cement as a binder in the pelletization of slimes originated from the process of Ferro-Alloy Production.

When the slimes are autoclaved beforehand, the pellets present a much higher compressive strength.

ACKNOWLEDGEMENTS

Fundação Centro Tecnológico de Minas Gerais - CETEC is thankful to Companhia Paulista de Ferro Ligas for allowing the publication of this work.

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