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TECHNICAL FACULTY BOR

52nd International October Conference on Mining and Metallurgy

PROCEEDINGS

Edited by

Saša Stojadinović

and

Dejan Petrović

November 29th – 30th 2021

Bor, Serbia

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CHARACTERIZATION OF PELLET SAMPLES OBTAINED BY PELETIZATION OF LIMESTONE AND SEAWEED

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Abstract

This paper presents the results of physico-chemical characterization of both the initial samples of lithotamnian limestone and seaweed (Ascophyllum Nodosum), and the products of aggregation of their mixtures in different ratios by the pelletization process. The initial samples were waste limestone from filter plants and dried seaweed. The final product of the pelletization process should serve the needs of agriculture as a means of biostimulation and can also be used in raising the pH levels of acidic soils. Several different pellet formulations were obtained by the process of discontinuous pelletization, and also by using a simulation of the continuous pelletization process on a pelletization plate.Tests of the mechanical properties of the pellets showed that the best results are shown by the pellets of the 4K sample, which were obtained by a continuous pelletization process with a mutual ratio of seaweed and limestone of 70:30%.

***Keywords**:litotamnian, limestone, seaweed, pelletization.*

1. INTRODUCTION

One of the most important parameters of soil fertility is substitution acidity. Over 60% of arable land worldwide can be classified as acidic. This is a consequence of the geological substrate and other natural factors, but also of industrial development and irresponsible attitude towards the environment[1].In Serbia, 13% of the soil is extremely acidic (pH ‹4), 17% very acidic (pH = 4-4.5), 30% medium (pH = 4.5-5.5), and 22% slightly acidic (pH = 5.5-6.5), while only 18% with a neutral and alkaline reaction [2].Acidic or alkaline properties of the soil have a decisive influence on the dynamics of nutrients and heavy metals in the soil. In an acidic environment, larger amounts of heavy metals are released into the soil solution.The use of limestone is very wide, on all acidic soils. The goal is to achieve the optimal pH value of the soil [3]. As powdered limestone from various filter plants is mainly used, the biggest problem in its application is scattering during transport and handling. This dust is also dispersed from the ground by the wind. On the other hand, limestone should be small enough to dissolve and evenly distribute in the soil under the influence of the weather.In order to reconcile these two demands, it is necessary to consolidate small classes of limestone. This is most often achieved by pelletization processes. Thus, a material of appropriate size is obtained, suitable for transport, manipulation and application, and at the same time small enough to dissolve under the action of weathering and moisture from the soil [4].The advantage of using pelleted or briquetted limestone versus the crushed limestone dust is related to easier application and lower consumption of pellets (ratio is 1:10) [5].Seaweed has recently been proven to be an excellent biostimulant and its use in various areas of agriculture is on the rise. It can be used in various fields of agronomy and horticulure, fruit and vegetable growing, production of certain types of organic fertilizers and also in the production of animal feed.The seaweed is obtained from the sea, using the so-called mowing proccess and can be used in various forms. They can be used dried and micronized to various sizes, they can also be used in the form of an extract or be used as sludge residue – which is a by-product. Having in mind the individual properties of limestone and seaweed, the idea came to make pellets by mixing these two raw materials in different proportions. As both starting samples are fine-grained (<100 microns), they represent an excellent input for the pelletization aggregation process, and as seaweed in contact with water release their sticky ingredients (alginates) during homogenization, it is not necessary to add binders.Pelletization experiments in discontinuous and simulated continuous process were performed. After that, the obtained green pellets were dried at room temperature for 24 h, and then the characterization was performed (pressure resistance test, impact resistance test, abrasion resistance test and complete disintegration in water). After characterization, the obtained results were presented in parallel and based on that conclusions.

2. EXPERIMENTAL

2.1 Baseline samples

The lithotamnian limestone of the Dobrilovići deposit is made of calcite, quartz, clay minerals, and limonite [6]. The most common mineral, calcite, is of organogenic origin, it mainly appears as cryptocrystalline. Fragments of fossil remains appear.

Micronized seaweed (ascophyllum nodosum), is native to the North Sea. It contains natural plant hormones and various natural nutrients, trace minerals, microelements, carbohydrates, such as alginic acids, polysaccharide, etc. [7].

2.2 Determination of chemical composition of starting samples

Tables 1 and 2 show the chemical compositions of the starting samples of lithotamnian limestone and seaweed.

Table 1. Chemical composition of the initial limestone sample

Element	CaO	SiO_2	Al_2O_3	MgO	Na_2O	K_2O	Fe_2O_3	MnO	P_2O_5	TiO_2	G.Ž.
Content %	52.55	3.87	0.50	0.41	0.204	0.104	0.461	0.07	0.032	---	41.81

Table 2. Chemical composition of the initial sample of seaweed

Element	C	O	Na	Mg	Al	Si	S	Cl	K	Ca	Fe
Content %	37,92	26,23	13,52	0,61	0,23	0,37	1,75	14,99	2,54	0,98	0,86

2.3 Pelletization

For the pelletization of limestone, a laboratory pelletizing plate of the “Unalmuhendislikvemakinasanay” brand was used. For homogenization of limestone samples with seaweed, a mixer "Toni Technik" was used. In order to simulate the continuous dosing of the homogenized material on the pelletizing plate, the laboratory vibrating feeder "Retsch" was used.Homogenization of limestone and the required proportion of seaweed was performed, with the addition of water, after which the entire sample was homogenized and added to the pelletizing plate, on which the required minimum amount of additional water was added. The inclination of the plate (60^o) and the number of revolutions ($50\ min^{-1}$) were constant, while the amount of binder was changed. The formed "green" pellets were stored for 24 h at room temperature.In the process of simulation of the continuous pelletization, the homogenization of limestone and the required proportion of seaweed was performed without the addition of water, after which the homogenized sample was continuously added to the pelletizing plate with a vibrating feeder, to which the required amount of water was added. All other pelletization conditions were identical to the discontinuous pelletization process.This way, the following samples were obtained (according to the % ratio of seaweed and limestone):

• Sample 1L: 50: 50%;• Sample 2K: 50: 50%;• Sample 3L: 70: 30%;• Sample 4K: 70: 30%

2.4 Determination of mechanical properties of pellets

Impact resistance of pellets is tested by dropping a group (set) of pellets with a total mass of 100g 25 times, from a height of 457 mm on a steel plate 9 mm thick, after which the sample is sieved on a sieve with a mesh size of 2 mm and the sieve mass is measured, which should not exceed 5% (rarely 10%) of the total sample mass [8].

The resistance of pellets to pressure was tested on a group (set) of 10 pellets on a standard hydraulic laboratory press, in order to determine the maximum pressure that the pellet can withstand without breaking. The results obtained by the Mars Minerals company, which has been dealing with agglomeration of limestone for many years, show that pellets should withstand a minimum of 0.5 kg/pellet, which is considered satisfactory for further manipulation [8].

The resistance of pellets to abrasion is tested by sieving a group of pellets weighing 100 g on a mechanical laboratory sieving device with a sieve with a mesh size of 2 mm, in a time of 5 min. After that, the mass share of class -2 mm is determined, which should not exceed 5% of the total mass of the sample [8].

The time of disintegration of pellets in water is examined by immersing the pellets from each group in water, at room temperature, measuring the time required for complete disintegration of the pellets. Disintegration is determined visually.

3. RESULTS AND DISCUSSION

Table 3 shows the summary results of testing the mechanical properties of limestone and seaweed pellets, obtained by the discontinuous process and the simulated continuous pelletization process.

Table 3. Aggregate test results of "green" pellets;

Sample		Resistance to			Time to desintegration
		impact	pressure	abrasion	
No.	seawead ratio : CaO, %	-2 mm, %	kg/pelet	-2 mm, %	s
1L	50 : 50	19,40	2,65	4,8	25,5
2K	50 : 50	70,24	2,67	0,84	28,9
3L	70 : 30	19,00	9,63	3,0	5,6
4K	70 : 30	5,06	3,51	4,22	7,4
Required value		Max. 5 - 10	Min. 0,5	Max. 3 to 5	As long as possible

Based on the results of testing the mechanical properties of "green" pellets obtained by laboratory procedures, we can conclude that they have satisfactory resistance to pressure and abrasion, and relatively poor disintegration in water and poor properties related to impact, regardless of the mass ratio of components. As for the pellets obtained by the continuous pelletization process, it can be observed that they have satisfactory resistance to pressure and abrasion and relatively poor resistance to disintegration in water, regardless of the mass ratio of the components. When it comes to the impact resistance of continuously obtained pellets, it can be seen that there is a drastic difference between the 2K and 4K samples. Namely, the sample with a higher seaweed content has a completely satisfactory impact resistance, while the sample with an equal share of seaweed and limestone has an unacceptably poor impact resistance. If you choose between the analyzed pellets, then it can be seen that the most favorable results are obtained with the ratio of seaweed and limestone of 50:50%. Due to the relatively poor resistance to disintegration in water, the practical usability of the "green" pellets obtained in this way is quite limited.

4. CONCLUSION

Pelletization experiments of lithotamnian limestone dust and seaweed, size 100% -100 μm, were performed on a pelletizing plate by discontinuous and continuous procedure. The pellets obtained in this way were tested for impact resistance, pressure resistance, abrasion resistance and time required for disintegration of pellets in water.Tests of mechanical properties of pellets showed that the obtained pellets do not fully meet the usual standards for pellets used in agriculture (for calcification of acid soils), and that among the tested results show the best pellets of sample 4K, obtained by continuous pelletization with the ratio of seaweed and limestone 70: 30%.Namely, the impact resistance of 4K pellets was 5.6% (class -2mm, and the maximum allowable value is up to 10%), the pressure resistance was 3.51 kg/pellet (minimum required 0.5 kg/pellet), while the resistance to abrasion was 4.22% (maximum up to 5%), and the time of disintegration in water was very short and amounted to 74 s.The obtained results show that green pellets need to be dried in order to improve their mechanical properties, but this leads to a significant increase in pelletization costs. It is also necessary to expand the tests with other mutual relations of the input components, in order to obtain the optimal ratio for the required quality of the obtained pellets.

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