Influence of Biomass Absorptivity on the Process of Sinter Charge Pelletisation

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Abstract: Capillary water absorption of materials is a very important factor in the process of pre-treatment of fine-grained materials. Materials that are in a moisturized state capable of forming a firm, compact pellet are, thanks to this particular physical property, suitable for utilisation in sinter charge preparation within the process of sintering iron-ore raw materials. The pelletising ability of coke dust is generally known and coke dust exhibits good pelletisability. From the ecological point of view, an alternative to coke dust is currently biomass, which has a great potential for industrial applications, including use in the agglomeration process. Understanding of how biomass behaves during pre-pelletisation is very important and for the sintering process, it is essential. The purpose of pre-pelletisation of the sinter charge is to achieve its optimal permeability in the sintering process. The experiment described in the article was carried out using wood biomass—oak and pine sawdust, as well as plant biomass—Miscanthus sinensis and Lavandula angustifolia. The evaluation was carried out by applying the capillary water absorption test and the free-fall drop test. As different types of biomass have different chemical compositions, heating capacities, grain morphologies, and chemical and physical properties, the testing was carried out with several types of biomass. The capillary water absorption was examined in terms of different granulometries, and the impact of the type of liquid medium was analysed. It was observed that different types of biomass differ in their ability to absorb liquids. Another finding was that the type of a liquid medium had a significant effect on the pelletising ability of biomass, which was determined by the surface tension and the ability to form liquid bridges between the grains. Research results indicate an excellent pelletising ability of the Miscanthus sinensis grass. The wettability of oak and pine sawdust determines its application in the pelletising process. It may be concluded, based on the research, that Lavandula angustifolia is not a suitable alternative to coke dust due to its low ability to form pellets.

Keywords: wettability; pelletisability; biomass; fuel; sintering process; permeability

1. Introduction

Ecological aspects of industrial production are currently paid a great deal of attention. It is extremely important to monitor the carbon footprint at every stage of production processes, including the process of sintering iron-ore raw materials within the production of pig iron. In order to avoid excessive releasing of pollutants into the air, there is an ongoing search for different methods of replacing coke dust in the sintering process. Plenty of studies have been carried out with the aim of substituting coke dust by biomass at different substitution degrees of replacement fuel [1–6].
using biomass in the sintering process is its significantly lower ash content and lower proportion of heavy metals in biomass. The results of studies show that the replacement of fossil fuel in the sintering process by biomass is limited to the level of about 10–30%. With such replacement, using certain types of biomass, emissions of oxides of carbon, nitrogen and sulfur would be reduced by 5–40%. The basic criteria of use of biomass for energy purposes are, in particular, the analysis and balance of environmental and economic perspectives. The environmental criterion is connected primarily to the evaluation of the impact of biomass energy use on the environment, the economic criterion is connected on the assessment of the possibilities of economically efficient processing of biomass. The analysis of the costs and competitiveness of using various types of biomass shows that in the area of plant biomass, it appears advantageous to use waste biomass, which is cheaper as fossil fuel [7].

It has been well known that different types of biomass exhibit different properties. These properties must be examined before the sintering is carried out in order to predict how a given material will behave in the process of sinter charge preparation and in the sintering process. The rigidity of micro-pellets charged onto a sintering line is essential for achieving optimal permeability of the sinter charge. Therefore, testing of biomass properties was carried out with a focus on its ability to form compact, firm pellets. Obtaining the valuable information on biomass’ ability to absorb liquids is important for further utilisation of biomass in the sintering process, within pre-pelletising of the sinter charge. The wetting of solid materials by liquids is accompanied with marked manifestations of the properties of individual phases that are closely related to the wettability of the surface and the ability of a liquid to wet solid materials. The wetting of a solid material by a liquid medium occurs as a result of forces acting between the solid and liquid phases [8].

The wetting of solid materials is most significantly affected by the surface tension of a liquid, free surface energy, interfacial tension at a phase boundary, chemical structure of the surface of the solid phase, temperature, etc. Figure 1 [9] shows the contact angles (δ) and surfaces of a liquid.

The surface tension is defined on the basis of a kinetic model of a liquid as a result of mutual effects of particles in the liquid. The forces acting on the molecules contained in the surface layer of the liquid are directed towards its volume. These forces try to drag the molecules from the surface into the liquid volume—this is referred to as surface tension. It is the most important parameter, which characterises the surface of liquids [10]. The values of surface tension depend on the composition of the liquid phase, temperature, or pressure and electric charge. Hence, the wetting of a solid material occurs as a result of the effects of forces acting between the solid and liquid phases. In the case of

![Figure 1. Hydrophilic and hydrophobic surfaces](source)
using water as the liquid phase, molecules of water primarily adsorb on surfaces with a negative charge. From the physical point of view, water absorption on the surface of a material is regarded as a system consisting of the solid phase (particles of the material), liquid phase (water) and gaseous phase (air). This system tries to achieve the most convenient energy state; in other words, there is an effort to minimize the surface energy. Such effort is manifested by reduced surface tension on the solid material/water phase boundary and a lower degree of dispersion. For the purpose of identifying absorptivity, it is very important to know the wettability value expressed as the size of the contact angle, i.e., the angle between the drop surface and the surface of the solid material.

The directions of forces acting on the boundaries between individual phases are shown in Figure 2.

The surface tension contracts the water drop; tension \( \sigma = 2.3 \) has the opposite direction and induces drop expansion over the surface. Tension \( \sigma = 1.3 \) acts in the direction of the tangent line. The angle formed between the tangent line and the surface of the wetted material is referred to as the contact angle with the symbol \( \psi \). If the forces with magnitudes \( \sigma = 1.3 \) and \( \sigma = 2.3 \) act in approximately identical directions, wetting occurs. If these forces act in the opposite directions, wetting does not occur.

The lower the value of surface tension is, the better the wettability of solid surfaces; this increases the rigidity of pellets. This means that materials may be wetted by water or any other medium that exhibits lower surface tension. Various tensides may also be used as they are capable of wetting materials that are otherwise water proof [11]. Grains of biomass, which may be used in the sintering process, are characterised by a rough surface and a porous structure. The shapes of grains are strongly affected by processing and crushing techniques. The shapes of raw pellets depend on the pelletisability of the material and its homogeneity. By adding minimum amounts of the same material with a different grain size, or by adding different additives, or by changing the liquid, it is possible to produce regularly shaped pellets even from a mixture that is difficult to pelletise.

As the charge materials are pre-pelletised before they are sintered, a biomass intended for substituting coke dust must be wettable to the extent that it is able to form rigid micro-pellets. This has been the purpose of the research on the absorptivity of coke dust, which resulted in an unambiguous conclusion that its absorptivity was excellent. Absorptive media selected for this investigation included water of a laboratory temperature of 20 °C, water of a temperature of 50 °C, industrial tenside, and soapy water. Prior to testing, all analysed materials were dried at the temperature of 110 °C. The temperature of water has a significant effect on the absorptivity of materials, and this has also been confirmed in the tests with biomass. Table 1 presents the correlation between changes in surface tension (\( \sigma \)) and water density (\( \rho \)) at different temperatures [12].
Soapy water and industrial tenside are liquid media that were used in order to compare their ability to wet wood or plant biomass. They belong to surfactants reducing the surface tension of liquids through adsorption on the liquid/gas interface. They reduce interfacial tension between oil and water by adsorbing on the liquid/liquid interface. A functional group of a soap solution consists of COOH, SO$_3$H, etc. Tensides are surface-active substances, which are absorbed on the phase boundary already at low concentrations and thus reduce the surface tension of liquids; this may eventually lead to wetting materials [13]. As soap acts on the material surface, the surface acquires a negative charge due to the effects of anions.

According to a number of scientific studies, capillary water absorption is affected by several factors: granulometric composition of a material, shape and surface of grains, electric charge on the grain surface, chemical and mineralogical composition, and the wetting agent’s type and temperature [10,14].

The formation of capillary forces is related to the formation of liquid bridges between solid grains of a pelletised material and a liquid. The pressure inside the liquid bridge is caused by the capillary force, which tries to spread the liquid all over the surface of the grains. The opposite surface tension force tries to reduce the free surface of the liquid volume and drag it into the point where the grains contact each other.

Hence, cohesion of a raw pellet is determined by surface forces and capillary pressure on the surface of liquids and by attractive forces acting between solid particles, i.e., molecular, valence, attractive, electrostatic and magnetic forces.

In many studies, Miscanthus sinensis has been selected as the biomass substitute for conventional fuels [15–18]. Due to optimal properties and a growing potential, this plant is predestined to be a promising substitute to be subjected to extensive investigation. It may be used not only in the sintering process, but also as a very important contributor to the recovery of hydrogen as a fuel through gasification procedures. Due to the potential of this plant in particular, it was selected for the present research on absorptivity. Lavender has been subjected to fewer investigations aimed at identifying its qualitative parameters. However, in one study, this plant has been evaluated as the one with a promising heating capacity value amounting to 20.66 MJ·kg$^{-1}$ [19]. Due to its growing potential and simple growing requirements, it might be used, after examining its properties, in the process of iron ore sintering.

2. Materials and Methods

The present study comprised the investigation of the absorptivity of pine and oak sawdust, as well as plant biomass consisting of Miscanthus sinensis grass and Lavandula angustifolia. The chemical composition of biomass and coke breeze according to ultimate analysis is shown in Table 2.
Table 2. Chemical composition of biomass (ultimate analysis).

| Chemical Composition in Dry State [wt.%] | ash | C   | H   | O   | N   | S   |
|----------------------------------------|-----|-----|-----|-----|-----|-----|
| Lavender Angustifolia                 | 0.80| 49.50| 5.20| 43.04| 1.32| 0.14|
| Miscanthus Sinensis                   | 1.45| 47.85| 6.10| 43.73| 0.72| 0.15|
| Scots Pine                            | 2.14| 50.51| 6.22| 41.00| 0.08| 0.05|
| English Oak                           | 1.97| 50.6 | 6.15| 41.04| 0.19| 0.05|
| Coke breeze                           | 12.10| 85.40| 0.30| 0.60 | 1.30| 0.30|

The used industrial tenside contained less than 5% surface-active substances, such as 5-Chloro-2-methyl-4-isothiazolin-3-one. A soapy water was used, containing 1% soap solution from glycerine. The main chemical composition of the soap was sodium laureth sulfate, glycerine, sodium chloride, cocamidopropyl betaine and polyquaternium 7. As already mentioned above, one of the factors affecting absorptivity of materials is the granulometric composition. Therefore, wood and plant biomasses were crushed to achieve granulometries below 0.5 mm, 0.5–1 mm and 1–2 mm. For fractions of materials, a vibrating mill and, subsequently, particle size distribution were used. The absorptivity test is based on the method of monitoring absorption of liquid by a tested material over time. Hence, the time was continuously measured and so was the height to which the liquid was absorbed.

Figure 3 shows the apparatus for determining the absorbency of fine-grained materials by the method of capillary absorption height. The material to be analysed is poured into the capillary. The capillary is attached to the stand so that the lower end touches a material that is completely saturated with liquid. The difference between the force of capillary pressure of the liquid and the weight of the material causes the liquid to move towards the intergranular spaces to a certain maximum height, when the two opposing forces balance. The height of capillary absorption increases with time as it reaches equilibrium.

The rate of capillary absorption depends on the surface properties of the material.

The liquid columns in cylindrical capillaries are exposed to the force of capillary pressure \( P \) (1) and the gravity force \( G \) (2),

\[
P = \frac{2\sigma}{r} \quad [\text{Pa}]\]

\[
G = \rho g h \quad [\text{N}]\]
where \( \rho \) = density of liquid, \( g \) = gravity acceleration, \( h \) = height of liquid column, \( \sigma \) = surface tension of the liquid, \( r \) = capillary radius.

The maximum height of liquid column resulting from the condition \( P = G \) is given by Equation (3):

\[
h_{\text{max}} = \frac{2\sigma}{\rho g r} \text{[m]}
\]

The criterion for evaluating the results of measuring the height of capillary absorption is the equilibrium value of the height for a specific time. This value is read from the capillary at specified times.

The height and velocity of capillary water absorption depend on the properties of the fine-grained material, such as capillary diameter and surface properties of the material, and on the properties of the liquid, such as surface tension, viscosity and density.

In addition to monitoring the height of capillary water absorption, the pelletisability was tested as well by the free-fall drop test. The free drop method is used to evaluate the absorbency of the analysed fine-grained materials. The test procedure was carried out by applying a determined amount of liquid onto the surface of the dried material and the liquid was left to penetrate the material, as shown in Figure 4. During the experiment, the examined material was loosely poured on the mat and a determined amount of water was dropped onto the material. In this case, it was 0.6 mL of water. After one minute, the pellet was taken out and examined. As water penetrates into a material, a green pellet is formed. If the examined material exhibits sufficient pelletisability, it forms separate units without any mechanical effects. Penetration of water into the volume of the material depends on many factors, including the sizes of pores among the particles. The test evaluates the weight and size of the self-packages and the wetting angle.

![Figure 4](https://example.com/figure4.png)

**Figure 4.** Apparatus for the free-fall drop test: (a) Scheme; (b) Photo; 1—Burette containing the liquid, 2—Analysed material, 3—Cock, 4—Balloon.

For better study of biomass absorptivity, the microscopic observation of biomass structures was also performed. The structure of Miscanthus sinensis and Lavandula angustifolia was observed on the Leica Wild M3Z stereomicroscope. Determination of ash content was realised according norm ISO 1171 (applied method is gravimetry). Ultimate chemical analysis was realised according norm PP1-ZT21 (applied method is IR absorbance after the burn.).

3. Results

With regard to plant biomass, Lavandula angustifolia and Miscanthus sinensis were tested for absorptivity depending on the granulometric composition. The achieved values of absorptivity are shown in Figures 5 and 6.
The ability of lavender to absorb liquids is very low. The best results were achieved when industrial tenside was used; however, it must be noted that the influence of the used type of liquid was evident—there was a 3-fold difference between soapy water and tenside. With lavender, the highest value of capillary water absorption (24 mm) was achieved when tenside was used. Nevertheless, in general the absorptivity of lavender biomass was not as “dynamic” as that of Miscanthus sinensis. Wetting was very slow and gradual, in some cases it may be concluded that out of all grain size categories, the category of 1–2 mm exhibited the lowest absorptivity value.

Wettability of Miscanthus sinensis grass may be regarded as very good. In this case, the best absorptivity was observed at a fraction of 0.5–1 mm (24 mm). The highest absorptivity of Lavandula angustifolia was observed at a fraction of 0.5–1 mm (24 mm). In general, the absorptivity values were different and this was also confirmed by the relevant graph curves. The research indicates that different media have different effects on absorptivity. The best absorptivity was achieved when industrial tenside was used; however, it must be noted that the influence of the used type of liquid was evident—there was a 3-fold difference between soapy water and tenside. With lavender, the highest value of capillary water absorption (24 mm) was achieved when tenside was used. Nevertheless, in general the absorptivity of lavender biomass was not as “dynamic” as that of Miscanthus sinensis. Wetting was very slow and gradual, in some cases it may be concluded that out of all grain size categories, the category of 1–2 mm exhibited the lowest absorptivity value.

Figure 5. Wetting of biomass consisting of Lavandula angustifolia at granulometric compositions: (a) Under 0.5 mm; (b) 0.5–1 mm; (c) 1–2 mm.

Figure 6. Wetting of biomass consisting of Miscanthus sinensis at granulometric compositions: (a) Under 0.5 mm; (b) 0.5–1 mm; (c) 1–2 mm.
The highest absorptivity of Lavandula angustifolia was observed at a fraction of 0.5–1 mm (24 mm) with the use of tenside. The lowest absorptivity was exhibited at a fraction of 1–2 mm, with the highest value amounting to only 9 mm when tenside was used. With other wetting media, absorptivity values were low and they exhibited very similar curves. The other three liquids had very similar courses of effects on wetting Lavandula angustifolia, at all three fractions. The lowest wettability, at fractions below 0.5 mm and of 0.5–1 mm, was observed when cold water was used; this indicated a correlation between the effect of the liquid on the surface tension, the value of which decreased as the temperature increased [10]. The aforementioned facts indicate that at all fractions the best results were achieved when industrial tenside was used; however, it must be noted that the ability of lavender to absorb liquids is very low.

Wettability of Miscanthus sinensis grass may be regarded as very good. In this case, the best results were achieved at a fraction below 0.5 mm.

A comparison of the results showed that, at various granulometric compositions, the absorptivity values were different and this was also confirmed by the relevant graph curves. The research indicates that different media have different effects on absorptivity. The best absorptivity was observed with both analysed types of plant biomass, at the granulometric composition in the category of below 0.5 mm and from 0.5 to 1 mm. From the granulometry point of view, the lowest absorptivity was observed in both cases with the grain size category of 1–2 mm. In this case, however, the influence of the used type of liquid was evident—there was a 3-fold difference between soapy water and tenside. With lavender, the highest value of capillary water absorption (24 mm) was achieved when tenside was used. Nevertheless, in general the absorptivity of lavender biomass was not as “dynamic” as that of Miscanthus sinensis. Wetting was very slow and gradual, in some cases millimetre by millimetre, regardless of the used medium. In the initial stage, the wetting process was fast, but gradually it became slower and slower, and eventually the process stopped completely. In the case of granulometry below 0.5 mm and with the use of cold water, the wetting speed was very low from the beginning. In this grain size category, the highest absorptivity values were observed at the level of 14 to 15 mm, and the effects of soapy water and tenside were almost identical. In general, it may be concluded that out of all grain size categories, the category of 1–2 mm exhibited the lowest absorptivity values. The same effect was also demonstrated in the wetting of Miscanthus—at the granulometry of 1–2 mm, the highest absorptivity value was 15 mm with the use of industrial tenside. The effect of industrial tenside was very strong as the highest achieved absorptivity value was 34 mm (at a granulometric fraction below 0.5 mm). There was an interesting finding that the use of tenside resulted in a fast onset of wetting of Miscanthus sinensis. This tendency continued during the entire test, whereas with lavender the onset was fast, but then the process slowed down significantly. This phenomenon was observed in all grain size categories. The highest absorptivity of all the examined materials was observed in the granulometric category below 0.5 mm in Miscanthus grass. Miscanthus also exhibited a good pelletising ability, as may be seen in Figure 7a,b, which also shows lavender of the same grain size of 0.5–1 mm. In order to verify the absorptivity of the material, the free-fall drop test was carried out. The purpose of the test was to assess the ability of the material to sustain in the form of a compact unit after the application of water drops.

The figure clearly shows that lavender did not exhibit any pelletising ability as the grains did not amalgamate after water was applied and did not form a compact unit. The behaviour of lavender with the grain size of 0.5–1 mm was almost hydrophobic. This test confirmed the test of capillary water absorption in which lavender exhibited the worst absorptivity in all grain size categories.

Results of the test of the absorptivity of wood biomass consisting of pine and oak sawdust are documented in Figures 8 and 9.
The highest absorptivity of all the examined materials was observed in the granulometric category below 0.5 mm in Miscanthus grass. Miscanthus materials did not amalgamate after water was applied and did not form a compact unit. The behaviour of lavender was different; whereas with lavender the onset was fast, but then the process slowed down significantly. This tendency continued during the entire test, whereas with lavender the onset was fast, but then the process slowed down significantly. This phenomenon was observed in all grain size categories. The highest absorptivity of all the examined materials resulted in a fast onset of wetting of Miscanthus sinensis. This tendency continued during the entire test, whereas with lavender the onset was fast, but then the process slowed down significantly. This test confirmed the test of capillary water absorption in which lavender exhibited the worst absorptivity in all grain size categories.

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Wood biomass was also subjected to absorptivity testing carried out by applying the free-fall drop test, at the granulometry of 0.5–1 mm (Figure 10a,b). The figure clearly shows that lavender did not exhibit any pelletising ability as the grains did not amalgamate after water was applied and did not form a compact unit.
Wood biomass was also subjected to absorptivity testing carried out by applying the free-fall drop test, at the granulometry of 0.5–1 mm (Figure 10a,b).

The Figures clearly show that in the experiment the pine and oak sawdust formed only a few compact pellets, while oak sawdust exhibited better absorptivity and better grain amalgamation. This test confirmed the results of the absorptivity test at which the maximum values of the height of absorption were low at the given fraction of 0.5–1 mm and with the given type of the used liquid (cold water).

Pine sawdust absorptivity values were much diversified with different types of liquids. Moreover, at a fraction of 0.5–1 mm and 1–2 mm and with the use of cold water, there was almost zero absorption. In this case, wetting was only achieved when tenside and a soap solution were used.
In the case of English oak, at the granulometry of 0.5–1 mm, the best absorptivity values were observed, amounting to 26 mm. A higher value was also observed at a fraction of 1–2 mm—in particular 20 mm. Compared to pine sawdust, oak sawdust was absorptive in all selected grain size categories. As for oak sawdust, the lowest absorptivity value of 5 mm was observed at a fraction of 1–2 mm. Plant biomass (Miscanthus sinensis) exhibited the highest absorptivity at a fraction below 0.5 mm; with lavender, the highest value in this category was 14 mm (when tenside was used as the medium); with other liquids, the maximum value was 10–15 mm in the grain size category below 0.5 mm. The absorptivity curves for Miscanthus grass in the granulometry category below 0.5 mm were very similar to those of lavender, but the maximum value achieved was 34 mm. In terms of the used liquid medium, tenside was the most suitable liquid for pelletisation; warm water and a soap solution were, in some cases, more efficient, depending on the granulometric composition and the type of the used biomass. The least satisfactory results have been observed with the use of cold water.

The study also brought a conclusion that the best absorptivity, out of the selected types of biomass, was observed in Miscanthus, and the behaviours of oak and pine sawdust were very similar in terms of absorption. Nevertheless, oak sawdust exhibited slightly better absorptivity than pine sawdust. These lower values of absorption identified for pine and oak sawdust may be attributed to their structure. Pine wood has a fine porous structure consisting of thin-walled tubular cells called tracheids. The lengths of longitudinal tracheids were approximately 3 to 5 micrometers and their diameters ranged from approximately 20 to 80 micrometers. They form approximately 90% of the wood mass volume. Spring wood exhibits larger cell diameters, thinner walls and smaller cellular cavities. Cells of summer wood have smaller diameters, thicker walls and smaller cellular cavities. On the basis of different studies [20], it may be stated that the absorptivity of sawdust is affected by its structure.

Figure 11 shows the structures of pine and oak obtained using an electron microscope; they indicate that pine has thin capillaries and this may cause worse pelletisability when compared to oak.

![Figure 11. Structure of pine (A) and oak (B) [20].](image)

Thin tracheids—capillaries—in pine had a significant effect on capillarity. A correlation should be sought in capillary pressure. During wetting, the liquid level in the capillary rises, and if the material is unwettable, the liquid level is pressed below the level of the surrounding liquid. The performed investigation showed that wood and plant biomasses exhibit certain structural differences which result in different behaviours of biomass during pre-treatment within the sintering process. Figure 12 presents a microscopic view of the structures of plant biomass made of lavender and Miscanthus. The structure of Miscanthus sinensis and Lavandula angustifolia was observed on the Leica Wild M3Z stereomicroscope.
Microscopic observations of both types of biomass showed that the structures of both lavender and Miscanthus are very similar; they consist of smaller enclosed pores. In lavender, the pores are evenly distributed. In Miscanthus, however, there were differences in form of a significantly larger pore in the central part of the plant. The lower absorptivity of lavender, compared to Miscanthus, may be explained by comparing the structures of both plants in the longitudinal cross-section in terms of specific surface, as shown in Figure 13. After identical magnification of both plants, the specific surface of Miscanthus was 3-fold larger than specific surface of lavender.

The present article points out the importance of investigation of biomass properties within a deeper context and of the search for potential optimisation and utilization of biomass. Table 3 shows the maximum values of absorptivity with the use of different liquids and with different granulometric compositions of biomass.

**Table 3. Maximum values of absorptivity.**

| Granulometry | Warm Water | Cold Water | Soap Water | Tenzide |
|--------------|------------|------------|------------|---------|
| mm           | mm         | mm         | mm         | mm      |
| **Lavender Angustifolia** | | | | |
| 0.5          | 10         | 4          | 15         | 14      |
| 0.5–1        | 10         | 9          | 12         | 22      |
| 1–2          | 4          | 6          | 4          | 9       |
| **Miscanthus Sinensis** | | | | |
| 0.5          | 15         | 11         | 19         | 34      |
| 0.5–1        | 11         | 15         | 20         | 18      |
| 1–2          | 6          | 9          | 5          | 15      |
| **Scots Pine**  | | | | |
| 0.5          | 12         | 6          | 6          | 13      |
| 0.5–1        | 10         | 2          | 15         | 14      |
| 1–2          | 10         | 1          | 15         | 16      |
The table clearly shows that the most significant values of absorptivity were achieved in the majority of the examined samples with the use of tenside. The highest absorptivity, as much as 34 mm, was observed with Miscanthus sinensis at a fraction below 0.5 mm. As for wood biomass, better absorptivity was observed with English oak; with the use of tenside, the highest value was 28 mm at a fraction of 0.5–1 mm. If we compare absorptivity values in terms of granulometry, more significant differences were observed with plant biomass at a fraction of 0.5 and 0.5–1. A fraction of 1–2 mm exhibited very low absorptivity in both types of plant biomass, except for the case when tenside was used with Miscanthus. In both types of wood biomass, absorptivity was most significantly affected by the type of liquid medium used—when cold water was used, the observed absorptivity values were very low.

The absorptivity of the coke breeze (Table 3) shows the comparison of the absorptivity of coke with that of biomass. From the granulometry point of view, the highest absorptivity values were recorded in fraction under 0.5 mm (46 mm). In this fraction, the absorptivity value was significantly reduced when soapy water was used. The least absorbing fraction is 1–2 mm, where the highest value (20 mm) was reached by using of tenzide. The coke absorption test confirmed its excellent absorptivity. The analysed types of biomass had worse absorptivity than coke. By comparing the absorptivity of biomass with coke, it was found that the smallest differences in absorptivity were in English Oak and Miscanthus sinensis. Miscanthus sinensis appears to be the most suitable substitute for coke in sintering charge in terms of its physical properties.

4. Conclusions

The investigation described in the article showed that absorptivity of materials is affected by a number of factors. It has been proved that different types of biomass even differ in their ability to form pellets. Differences in absorptivity have been observed not only between different types of wood biomass, but also between different types of plant biomass. It may be concluded that the utilization of biomass as a substitute in the sintering process is therefore possible and very feasible. Excellent results of absorptivity have been observed with Miscanthus plant, which exhibited the best values of absorption out of all the examined materials. The availability of this plant, as well as its growing potential and speed of growing, have been evaluated in many studies as optimal for the use of Miscanthus as a source of fuel in many industries, including the sintering process. Its excellent properties have been confirmed again in this study. According to the study results, biomass consisting of lavender is not a suitable alternative for the sintering process. The lower absorptivity of lavender, compared to Miscanthus, may be explained by comparing the structures of both plants in the longitudinal cross-section in terms of specific surface. The specific surface of Miscanthus was 3-fold larger than the specific surface of lavender. As for wood biomass, both types of the analysed sawdust (pine and oak) may be recommended as a substitute for coke dust in the sintering process. The least satisfactory results across the examined materials were observed when cold water was used, and the best results were obtained with industrial tenside or soapy water. This phenomenon was identical for both plant and wood biomasses. The research results indicate that partial replacement of coke dust with biomass, wooden or plant, in the sintering process is possible and feasible. Still, further research on biomass and the search for potential biomass optimization should be carried out in the future.
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