MODELLING OF THE GRANULATION OF DECIDUOUS WOOD RESIDUES

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Abstract

The increased demand for energy and the limited reserves of fossil fuel have induced an increased interest in renewable energy resources. The support for the utilization of renewable resources has become an important constituent of the policy of the European Union. Energetics is a vital component of Latvia's state economy. For all sectors of the national economy – industry, transport, services, as well as trade, household and agriculture, a modern energy service is necessary. This speeds up the economic and social development, increasing the efficiency of production and the incomes. Energy supply influences the creation of new working places and the efficiency of labour. In the present work, studies on granulation and the granules' stability after removing the loads were carried out for the following deciduous tree species: grey alder, black alder, aspen, birch, ash-tree, oak, and, for comparison purposes, the conifer species such as pine and spruce.

Key words: granules, deciduous trees, wood residues

Introduction

Recently, solid biofuel has been widely used worldwide for heat energy production both for household and industrial needs, as well as for cogeneration. In household, the rises in energy prices and the effect on the quality of life are also severely felt. There are numerous phenomena in economy, which are directly derived from the state of the art in energy supply: the permanent growth in crude oil prices in the world' market, and the subsequent rise of prices in the petroleum products' wholesale and retail sale, the uncertainty in the safety of supply in almost all energy supply segments, the necessity to ensure the balance between the energy obtaining, generation, supply and consumption, and sustainable environment quality. Latvia is not the only state, which is affected by the growth in the prices for energy resources – as a global product, which is used in almost all industrial processes, petroleum influences also the economy of other countries. The provision with energy is an essential prerequisite so that to reach the balanced development, and the reasonable planning of energy can play an important part to ensure the state sustainable development. A special place among the energy types is occupied by electricity, which is the dominating form of energy and which ensures the communication, information technology, as well as the industrial and service activities. The energy policy is an element of the state infrastructure policy, and this is an important factor for economic competitiveness and development. Simultaneously, it is a vital environment protection element, because it is known that the biofuel, which is the least harmful to the environment and is one of the most widespread energy resource types in Latvia, is solid biofuel from the logging and wood processing industry residues and agricultural production residues (straw, cereals, nonconforming grain, etc.).

In wood chips granule production, using vertical or horizontal matrix with the material's mechanical supply through filters and in briquette production with gradual compaction in special presses or by the extrusion method, conifer tree softwood sawdust is widely used, assuming that it is most plastic and easier susceptible to granulation, in comparison with deciduous tree sawdust, consuming a lower amount of energy to overcome the friction resistance.

The practitioners' attempts to obtain qualitative granules from deciduous tree sawdust commonly are not successful or result in the mechanical damage of the granulator's mechanism. The obtaining of granules is based on the effect of the material' rheological properties, temperature, moisture and pressure, which applies to different fields of science: material science, rheology, wood science, chemistry, material resistance, etc. Hence, in the present work, the studies were based on the investigation of the rheological properties of the loose wood material depending on the pressure and granulometric composition at the room moisture.

Results and discussion

Studies were carried out on the granulation and granule stability after removing the load for the following deciduous tree species: grey alder, black alder, aspen, birch, ash-tree, oak, and for

comparison purposes, the conifer species: pine and spruce.

Material: ground wood, sieved through a sieve with the mesh size Ø = 2,0 mm, mean initial moisture W_{abs} = 8-9%.

Granulation investigation methods: a dismountable cylindrical auxiliary device with the matrix and punch Ø = 8,0 mm. For granulation regime studies, a universal testing machine „Roel Zwick/Z100" was used, equipped with the software *testXpert Version 11.02* for performing the experiments. The material sample 0.45 g, pressure – 150 MPa. To determine the granules' hardness, a special tester (KAHL) with computer connection was used. The sample of the tested material was placed in a cylindrical auxiliary device with the matrix and punch Ø = 8,0 mm. It was placed into a manual hydraulic press, and preliminary pressing till a known degree was carried out. Then it was transferred to the universal testing machine „Roel Zwick/Z100", and the sample's compaction was continued according to the set program till the pressure 150 MPa. Then the auxiliary device with the sample was taken away, and it was pressed out from the matrix using a manual hydraulic press, weighed with the accuracy up to ±0,0001 g, and the granule length was measured with the accuracy ±0,01 mm in two contrary directions, and the length and diameter in two contrary directions were measured again after 1 min. The same measurement procedure was repeated also after 5 min. With one sample's fractional composition, 5 – 10 replicates were made, from which the average value was calculated. Thus, it was possible to measure the granules' relaxation (in the size change time) and thereby to judge its durability in time. The records of the testing machine made it possible to record the compaction degree depending on the applied load and to analyse the obtained results.

The main granulation – pressing stage mechanisms can be visualized in the following way. The material's exterior compaction at the expense of the voids among the particles occurs at a minor pressure. Then the particles themselves, among which molecular bonds arise, are compacted and deformed. The high pressure at the end of pressing causes the particles' reversible deformation in the transition plasticisation; as a result, the granules' structure will strengthen, and the imparted or reached form will be retained: in this case, the released resin substances and extractives will harden the granules' exterior part. The material's warming-up exactly from friction during the pressing improves the process. The physico-chemical properties of the raw material have a major effect on the deformation.

The characteristic graph for the samples' compression and their relaxation after removing the load is shown in Fig. 1. It can be seen that, at the fractions mixture 2,0–0,05 mm, the total progress of granules relaxation for all the tree species: oak, ash, birch, aspen, spruce, grey alder, black alder and pine is similar. Ash wood has the highest compression strength, but the lowest one is for grey alder wood, although the highest size relaxation is for grey alder wood, but the lowest one for oak wood.

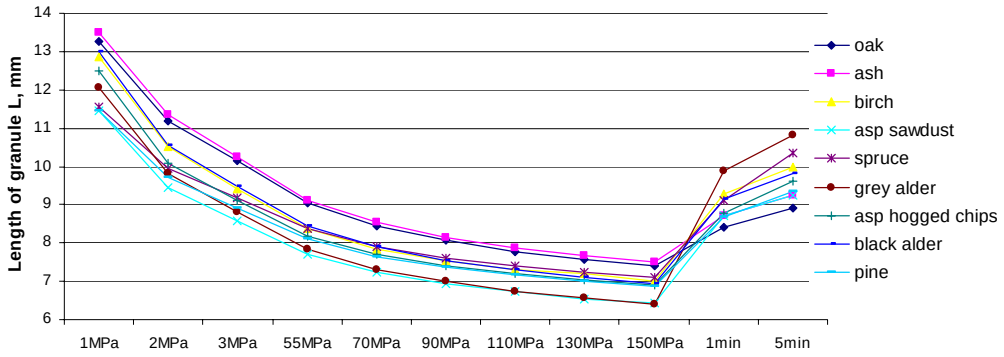

Fig. 1. Characteristic graph for the compaction of the granules of different tree species and their relaxation after removing the load.

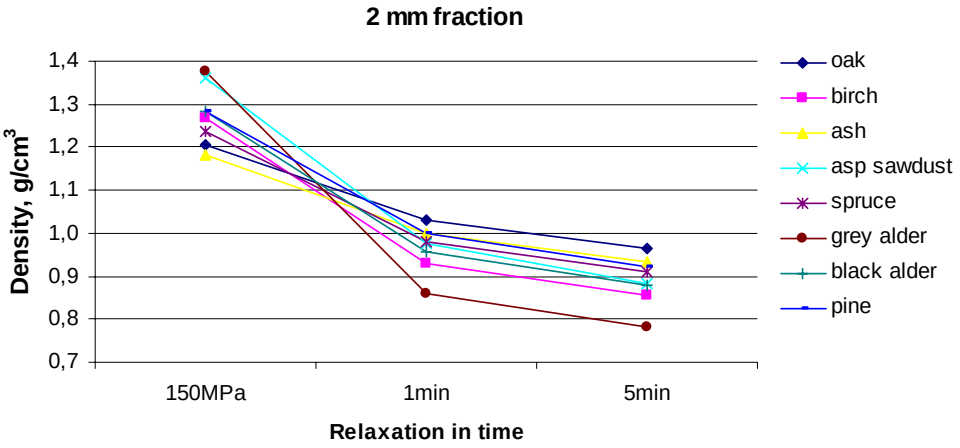

Fig. 2. Changes in the density of granules for different tree species after removing the load.

The changes in the density of granules with the fraction 2,0–0,05 mm for different tree species after removing the load are shown in Fig. 2.

It can be seen that, also in this case, grey alder wood granules have the greatest relaxation scatter: density decreases from the initial density 1,38 g/cm^3 to 0,86 g/cm^3 within the first minute, and to 0,78 g/cm^3 after 5 min. The most stable tree species among the investigated ones, with the lowest relaxation, is oak. The decrease in its granules' density from the initial to 5 min is the lowest, namely only 24%, followed by ash – 27%, spruce – 35%, pine – 39%, black alder – 46%, birch – 49%, aspen – 55% and grey alder – 77%.

It can be seen that the chosen granulation pressure 150 MPa is acceptable, because the final pressing density of all tested tree species exceeds the density required in the granule standards [1 - 3] of 1,0 g/cm^3 (ash – 1,18 g/cm^3, oak – 1,20 g/cm^3, spruce – 1,23 g/cm^3, birch – 1,27 g/cm^3, black alder and pine – 1,28 g/cm^3, and aspen and grey alder – 138 g/cm^3. The relaxation of aspen, grey alder and spruce wood granules' sizes depending on the granulametric composition is shown in Figs. 3 and 4.

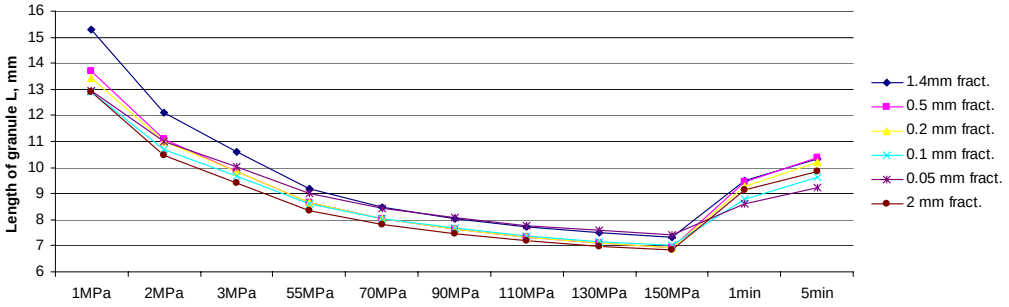

Fig. 3. Size relaxation of grey alder wood granules *versus* the granulometric composition.

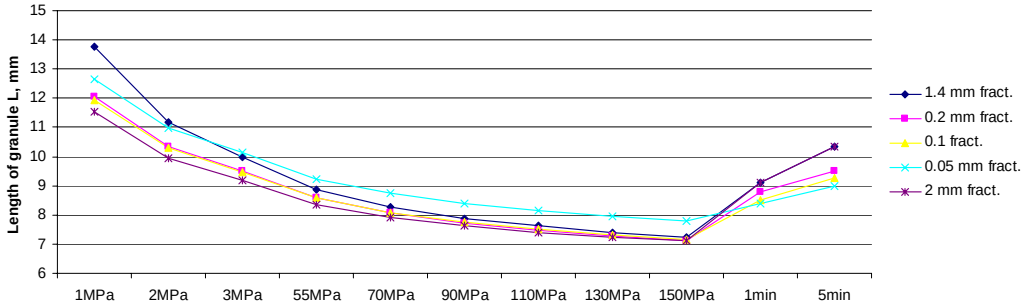

Fig. 4. Size relaxation of spruce wood granules *versus* the granulometric composition.

Figs. 3 and 4 show that a common tendency is retained both for deciduous trees and spruce wood, the compactability of the samples increases and the size relaxation value decreases with decreasing granule fraction sizes.The best granulometric results (respectively, the decrease of density after removing the load) are for the following deciduous tree species: oak, ash, which prevail the coniferous tree species - spruce and pine, regarded as classically suitable for granulation. The highest density relaxation is for grey alder, followed by aspen, birch and black alder.

In terms of the density relaxation value, black alder wood lags behind the pine wood only by 4,2%, and the spruce wood by 8,8% at the relaxation index 145%, common for all species.

Thus, only a part of the deciduous tree species (grey alder, aspen and birch) is less susceptible to granulation than the coniferous tree species – spruce and pine.

Conclusions

All tested tree species (grey alder, black alder, aspen, birch, ash, oak, pine, spruce) are characterised by a similar relationship between the samples' compression and their relaxation after removing the load. Thus, at the fraction mixture 2,0–0,05 mm, the common granules relaxation progress for all tree species: oak, ash, birch, aspen, spruce, grey alder, black alder and pine is similar. The highest compression strength is for ash wood, but the lowest one for grey alder wood, although the highest size relaxation is for grey alder wood, but the lowest one for oak wood. The best granulation results (the lowest size relaxation and, respectively, decrease of density after removing the load) is for the following deciduous tree species: oak, ash, which prevail the coniferous tree species – spruce and pine, regarded as classically suitable for granulation. The greatest relaxation is for grey alder, followed by aspen, birch and black alder.

In terms of the relaxation value, black alder wood lags behind the pine wood only by 4,2% and the spruce wood only by 8,8% at the average relaxation index 145% for all the species.

Thus, as a result of these studies, it is possible to say that only a part of deciduous tree species (grey alder, aspen and birch) is less susceptible to granulation than the coniferous tree species – spruce and pine.

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