DEVELOPMENT OF WOOD GRINDING
5. FINES CONTENT–TO–SHIVES RATIO

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Data by Riissanen were largely applied to learn more about wood grinding and, particularly, possible effects of the moisture content in spruce wood, varying from 65 to 15%, which in terms of moisture ratio covers a range from 1.9 to 0.2 kg water per kg oven dry wood. Tensile index (TI) and light scattering coefficient (LSC) of the pulp sheets were tested corresponding to various wood moisture contents, when the wood samples were ground to pulp by application of 20 and 30 m/s stone surface speeds and 0.7, 1.0 and 1.3 mm/s wood feed rates, respectively.
The fines quantity of the screened pulp was related to the shives quantity that was screened off before testing, and accordingly these data were imitating some relevant grinding conditions. Fines were considered indicative of the fibrillation, as shives were indicative of the average fibre length. The respective TI and LSC values were correlated to the fines content–to–shives ratio for some useful results. The highest TI were obtained with fully water impregnated spruce wood (65% MC) by application of 30 m/s stone surface speed, and the lowest with air-dry wood (15% MC) and 30 m/s as well. Fresh spruce wood (58% MC) resulted in a similar trend as obtained with fully water impregnated wood, but on a lower level. Slightly dried spruce wood (44% MC) showed a further lower level, but surprisingly 30 m/s resulted in lower TI values than 20 m/s stone speed. Spruce wood with water saturated fiber walls (28% MC) appeared to react strongly to 20 m/s, but not to 30 m/s stone surface speed.
The LSC values appeared quite contrary to the TI values, *i.e.* the highest LSC values were obtained by grinding the air-dry spruce wood (15% MC), while the fully water impregnated wood (65% MC) again gave the lowest LSC, when grinding at 20 m/s stone surface speed.

Keywords: fibrillation, fines content, fines–to–shives, grinding, light scattering, wood moisture content, shives content, spruce wood, tensile index

INTRODUCTION

The evaluation of wood grinding by application of a grinding model based on balancing the input and output energies indicated that wood grinding seems to follow some certain mechanism. Plotting (P_c/P_t) *versus* ($\dot{G}_w/P_t$) illustrated that the compression power–to–tension power followed a linear function of the power specific pulp production. If the balance area is represented by a thin fibrous film between the sliding stone surface and the still unaffected wood, the obtained results would perfectly describe the grinding process; however, provided that the dry wood and the moisture in and around the wood appear as having similar temperatures.

Generally speaking, physical treatments improve the temperature of wood as well as that of the present moisture, due to the viscoelastic properties of the wood and particularly the lignin-rich layer around the fiber tubes. However, in wood grinding the true compression and tension speeds in the wood material are just indirectly given by the measurable feeding compression rate and the speed of the stone surface. Due to the various wood viscoelasticity in the active grinding zone, the true compression and tension speeds of the activated wood layer cannot be defined exactly. The most convenient way to describe the velocities of the grinding zone is by application of the technical compression rate and stone surface speed. However, only the fibers releasing from the wood structure maintain probably a speed close to that of the stone surface. The underlying fibre layers are layer by layer less excited, until they finally appear as untreated wood.

The fibrous structure of spruce wood may simply be described by fiber layers that consist of main cellulosic inner walls and thinner, lignin-rich outer walls. Accordingly, the fibers would release as single fibers from the wood matrix, provided that grinding follows some optimum conditions. However, it is not fully understood, which conditional combination would act optimally, since several wood properties and grinding conditions are expected to affect the grinding and the pulp properties. Such wood properties are, for example, spring and summer wood proportions, wood density variations, as well as grindstone groove pattern and grit type and its hardness.

The grinding zone and its temperature distribution between the fibre releasing layers next to the sliding stone surface and the unaffected, opposite wood layers, has not yet been thoroughly studied as a possible parameter of wood grinding. The internationally used methods for determination of the shives content in pulp, the fibre size distribution and the fines content are accepted and accordingly thought to specify the pulp quality, since coarse fibers are supposed to be less fibrillated, while fines again would indicate fibrillation.

Since fines particles of the pulp produce light scattering surfaces under certain conditions, and since well fibrillated fiber walls also provide bondings between the fibers in a paper sheet, there may appear some optimum between the fines and shives in the initial pulp. Fines particles would both increase bonding and light scattering dependent on their properties, as again shives would correlate with the average fibre length. The quantity of shives are commonly a few percentage units, and screening them off the pulp does not considerably affect pulp quantity and final pulp sheet quality. On the other hand, the fines particles represent from one fifth to one third of the entire pulp and accordingly play an important role for the pulp and paper quality. Although the fines content–to–shives ratio would be descriptive of the ground wood pulp quality, it is perhaps not completely relevant, since the distribution of the different fines fractions and the true fiber length evidently relate much better to the pulp sheet properties.

RESULTS AND DISCUSSION

Tensile index

The tensile index values shown in Figure 1 indicate that there is a general increasing trend as a function of the fines content–to–shives ratio. Fully water impregnated wood samples (MC 65%) resulted in the best tensile strength when ground by application of 30 m/s stone surface speed, while 20 m/s resulted in clearly lower strength.

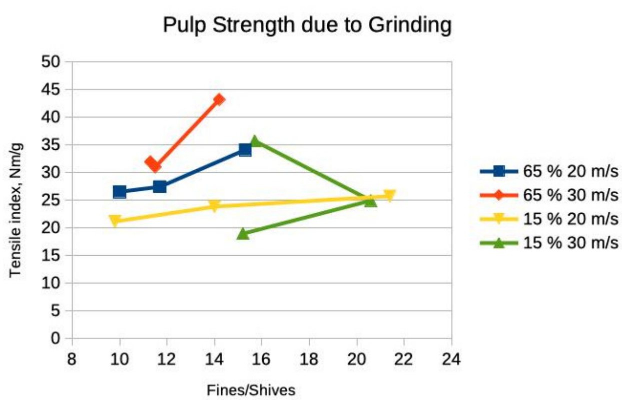

Figure 1: Tensile index as a function of fines content–to–shives ratio (pressurized grinding (2.5 bar) of spruce wood (*Picea abies* C.) as fully water impregnated wood (MC 65%) and air dried wood (MC 15%); stone surface speed 20 and 30 m/s, and wood feed rates 0.7, 1.0 and 1.3 mm/s;[5] – fresh wood (MC 58%), slightly dried wood (MC 44%) and wood having water saturated fibre walls (MC 28%) gave results in between and were not included)

The same was valid for fresh wood (MC 58%), but on a lower strength level and with a smaller difference in strength. However, dried wood samples (MC 44%) acted oppositely in grinding, *i.e.* 20 m/s produced better strength than the 30 m/s speed. For example, wood samples with water saturated fiber walls (MC 28%) showed a practically constant fines content–to–shives ratio close to 12, although the tensile index varied widely from about 20 to 40 Nm/g at the stone surface speed of 20 m/s, while at 30 m/s, it remained nearly unchanged slightly below 30 Nm/g, as the fines content–to–shives remained around 15. The air-dry wood samples (MC 15%) gave the lowest combination of tensile index and fines content–to–shives ratio, irrespective of stone speeds.

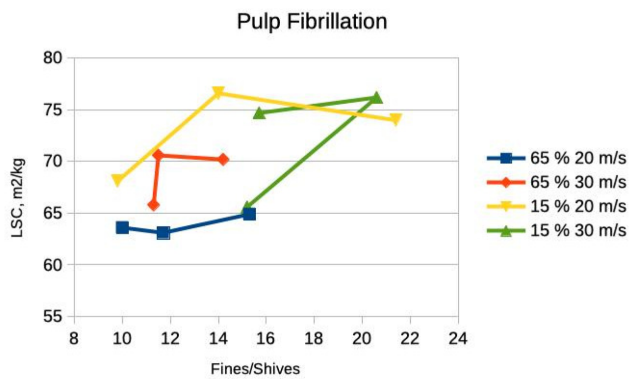

Figure 2: Light scattering coefficient as a function of fines content–to–shives ratio (pressurized grinding (2.5 bar) of spruce wood (*Picea abies* C.) as fully water impregnated wood (MC 65%) and air dried wood (MC 15%); stone surface speed 20 and 30 m/s, and wood feed rates 0.7, 1.0 and 1.3 mm/s;[5] – fresh wood (MC 58%), slightly dried wood (MC 44%) and wood having water saturated fibre walls (MC 28%) gave results in between and were not included)

Light scattering coefficient

The light scattering coefficient (LSC) is also an important property, because mechanical pulps are considered as giving paper printability, providing the paper low or no print-through. If so, the paper may preferably be printed on both sides, which means improved economy. In Figure 2, the LSC is plotted as a function of the fines content–to–shives ratio.

A general trend in Figure 2 seems to be increasing LSC values as a function of the fines content–to–shives ratio, which follows the expectation that increasing fines in a paper sheet also increases its light scattering ability. The evaluation of the data led to some conclusions, as further detailed. Fully water impregnated wood (MC 65%) resulted in LSC slightly below 65 m^2/kg, when ground at stone surface speed of 20 m/s, while 30 m/s resulted in LSC values even as high as about 70 m^2/kg. The air-dry wood (MC 15%) produced LSC from 70 to 75 m^2/kg at both 20 and 30 m/s stone speed. The findings not shown in Figure 2 were as follows. Fresh wood (MC 58%) gave almost similar LSC, independent of the stone surface speed. Dried wood samples (MC 44%) resulted in nearly similar LSC as did fresh wood. For wood having water saturated fiber walls (MC 28%), the wood feeding rate seemed to affect the LSC strongly, but not the fines content–to–shives ratio. It was noteworthy, however, that higher stone surface speed produced higher fines content–to–shives ratio.

CONCLUSION

As fibrillation is generally considered providing fiber bondings, but also light scattering surfaces in paper sheets, tests were conducted to clarify whether the fines content–to–shives ratio would be indicative of some grinding mechanism. The fines content was assumed indicative of the fibrillation degree, and the shives content of the initial pulp was presumed indicative of the average fiber length. Accordingly, the fines content–to–shives ratio might be indicative at least of the final sheet strength, but it should be kept in mind that this evaluation concept has not yet been acknowledged.

However, the fines content–to–shives ratio gave some noteworthy results that might help understanding wood grinding, when the wood moisture content varies from fully water impregnated to air-dried condition. The fully water impregnated spruce wood (MC 65%) resulted in the best tensile index at 30 m/s stone speed, while the air-dry wood (MC 15%) – as a rule – produced the lowest tensile indices, irrespective of the stone surface speed. Fresh wood (MC 58%) resulted in strength properties comparable to those obtained with fully water impregnated wood ground at 20 m/s stone speed.

The slightly dried wood (MC 44%) seemed to turn the grinding mechanism with respect to the pulp strength as now 30 m/s produced poorer pulp strength. However, grinding fiber wall saturated wood (MC 28%) at 20 m/s stone speed gave, dependent on feeding rate, very different tensile indices between 20 and 40 Nm/g, but simultaneously with practically constant fines content–to–shives ratio, as on the other hand, 30 m/s stone speed gave strength values just below 30 Nm/g and simultaneously with only small changes in the fines content–to–shives ratio.

The light scattering values appeared quite contrary to those of tensile indices, *i.e.* the highest light scattering coefficients (LSC) were obtained by grinding air-dry spruce wood (MC 15%), while fully water impregnated wood (MC 65%) resulted in the lowest LSC, when ground at 20 m/s stone speed. In Figures 1 and 2, the increasing feed rates go generally from right to left, but the lines for air-dry wood at 30 m/s stone speed are oriented divergently from left to right.

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