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QUALITY AND MEASURING OF CHIPS

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PREFACE

Scientific-technological cooperation between the Republic of Finland and the Union of Soviet Socialist Republics is based on an agreement concluded between the governments on August 16, 1955. A part of this cooperation is the project, the launching of which was agreed on in 1974. This was titled "A study of the methods of loading, transporting and unloading industrial chips, and of the technical equipment, and coordination of the methods of chip measurement and quality determination as well as of the measuring equipment". This project, it was agreed, was to be carried out by TSNIIME (Moscow) and TSNIIMOD (Archangel) on the side of the Union of Soviet Socialist Republics. On the Finnish side, the project was to be carried out by Metsäteho and the Finnish Forest Research Institute, both of Helsinki. The progress of the project has been supervised by the Finnish and the Soviet parties of the Forest and Mechanical Wood-processing Industry working group.

In accordance with the agreed programme, the cooperation has included visits by Soviet experts to Finland on three occasions and, similarly, by Finnish experts to the Soviet Union on three occasions. Study reports have been published during the course of the project as a result of the cooperation.

The present paper is the final report by the Finnish party on the problem agreed as the subject of the cooperation. To facilitate the use of the report, it has been written in English, as was agreed in the spring of 1976 between the parties to the cooperation. In part, the same subject is discussed in the report by Veijo Heiskanen and Olli Uusvaara on "Preparation, handling, measurements and quality determination of sawmill chips in Finland", published as No. 234 in the Folia Forestalia series. That report has also been delivered to the Soviet party.

Of the undersigned, Kärkkäinen wrote chapters 1, 2, 34, 35 and 5, and Uusvaara chapters 31, 32, 33 and 4 for the original manuscript. Kärkkäinen wrote the final version from the original manuscript.

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1. INTRODUCTION

In the last few decades, chips have entered the international trade as a new timber assortment additional to the traditional assortments. Earlier, the sale and purchase of chips within national frontiers were limited, and international trade was practically non-existent. Hence, it was not necessary to define the properties of this new timber assortment, its determination, weight or volume measurement.

International trade in chips has recently increased strongly, and it has become necessary to pay attention to these quality and quantity factors. No uniform international practice has emerged. Even intranationally, practices have varied considerably.

This report discusses the measuring of the mass and volume of chips, as well as the quality and the factors influencing it. The aim was to increase the knowledge of chip measurement and quality, and, by this route, to contribute to a gradual attainment in the chip trade of better measurement and quality bases for sales contracts.

2. FACTORS AFFECTING THE CHARACTERISTICS OF CHIPS

21. Tree species

In a review of chip characteristics and especially those that are customarily considered in quality assessments, the first factor is the tree species. It is well known that the structure and properties of wood material depend on the tree species. For example, wood density decides the mass of the wood material contained in a given volume unit. This parameter is also affected by the size and shape of the chip particles, but if these factors are stable it is, broadly, the tree species that decides.

The tree species also has an indirect effect on the quality of the chips. For example, since the difficulty of barking in the winter depends on the tree species, it may be assumed that the bark percentage to be measured from the chips depends on the tree species. Similarly, the tendency to rot depends on tree species and, therefore, so does the proportion of unusable material in the measurement of the chips. Furthermore, it is known that the moisture and strength of wood material varies from one tree species to another. It is therefore understandable that, especially in winter, the particle size distribution and other corresponding characteristics of the chips can depend on the tree species.

The importance of indicating the tree species when chip deals are agreed is evident also for the suitability of the chemical processes. It is known that the absorption of the cooking liquor and the most economical method to be used are greatly dependent on the tree species. Therefore, to achieve the optimal cook for the process, the tree species or, in the event of mixed chips, the relative shares of the various tree species must be known. In some cases it is necessary to take a negative attitude to mixed chips containing several tree species. Not all tree species are utilisable in mixtures of chips.

In some cases it is advisable to indicate not only the tree species but also the site of growth, since the characteristics of geographical races are different. For example, in Finland the density of the northern pine race is lower than that from the middle Finnish provenance.

22. Different parts of the tree

Not only the tree species but also the part of the tree from which the chips are made affects their properties. Especially when unconventional parts of the tree are used as raw material for chips, it is important e.g. in trading that there is agreement on such factors affecting the chip characteristics and on how they are to be taken into consideration.

Chip characteristics depend both directly and indirectly on the properties of the chipped raw material. For example, the mass of chips per volume unit depends directly on the part of the tree, for in many tree species the wood density depends on the part of the tree involved. Indirectly, the chip characteristics can depend on the part of tree used, because e.g. moisture and mechanical strength can depend on the location of the point reviewed. An indirect dependence also exists in the possible dependence of the chipping techniques and equipment on the part of tree to be chipped. Stumps, for instance, usually cannot be chipped with ordinary chippers, and crushers must usually be employed because of stones and loose soil. Chips produced by crushing are obviously qualitatively different from those produced by chipping, although the tree material characteristics may be identical. It is evident in this example that the wood properties of the stump and stem are not identical.

It is not possible here to discuss in depth the variation in the properties of the wood material and the resulting chips according to the location in the tree. However, it will be useful to examine certain common possibilities because they are of great importance.

Compared with chips made of whole stems, those made of the upper parts of the stem only are so different in their characteristics that a separate contract is always advisable for such exceptional raw material. For example, in pine the wood density decreases so sharply from but to top that the mass per volume unit is essentially smaller for chips made of the top parts of a tree than it is for stemwood chips. In the spruce the difference is not so pronounced. If volume measurement is used, it is evident that chips made of the upper parts of the stem are inferior in value to the conventional whole stem chips. It is also clear that if weight measurement is used, such variation in wood density is not unfavourable if the characteristics of the wood material otherwise remain the same.

Chips made of the upper part of the stem, e.g. sawlog tops, also differ in other respects from stemwood chips. The share of heartwood in the top is lower than the average for stemwood. Especially in pine, but also in spruce, the knotwood content in chips made of the top parts of the stem is higher than in stemwood chips. Not only the knotwood itself but also the surrounding wood differs from normal wood material, and thus the share of inferior quality chips exceeds that of the knots themselves.

Nothing has been found in the literature on which to base a reliable estimate of the inferiority of chips made of the top part of the stem alone compared with stemwood chips. It is clear that this inferiority depends on the age of the growing stock, the minimum diameter of the stem part used as sawlog or for other purposes, and, of course, on the tree species. But the trend is evident: because of the often low density of the knotwood and the exceptional wood material, chips made of the upper part of the stem are commensurate with conventional stemwood chips. This point deserves attention when the quality of the chips is assessed.

The inferior quality of the chips made from the top part of the stem compared with whole-stem chips arises from the fact that in many tree species the wood properties change along the length of the stem from butt to top. In addition to this, a change in properties is often observable from pith to surface. As a result, chips made of surface layers are often different from those made of the round stems. An example is sawmill chips made mainly of the surface layers of a stem, though of course they also contain end trimmings and other parts taken from places other than the stem surface.

The pine is of particular interest for the volume measurement and wood density of the chips. The wood density in pine increases steeply from pith to surface, and hence chips made of the surface layers of a stem are distinctly heavier than those made of whole stems. In sawmill chips, this phenomenon is accentuated by the fact that sawlogs are made of large-sized and old stems, in which particularly the density increases from pith to surface. On the other hand, in over-aged pines the density increase slows and may even begin to decline. According to some estimates, this decrease in density in pine begins some time after the age of a hundred years.

Spruce displays no phenomenon similar to this in pine, at least not so clearly. Many authors have reported that the density at first declines from pith to surface and then rises to a maximum. The difference between the minimum and maximum densities in cross sections is, however, considerably smaller than in pine. As a result, the chips made of the surface layers of spruce do not differ so much as in pine from those made from stemwood.

Not only density but also the share of knotwood changes from pith to surface. Especially in pine, the share of knotwood decreases strongly. The phenomenon is most evident in butt logs with a surface that has often grown over into completely knot-less wood material. In spruce, too, the share of knotwood decreases from pith to surface. This can be deduced from the fact that if the same trees are followed as they age and grow in size the share of knots in the total wood material decreases. These are findings reported from numerous studies.

The share of heartwood in chips made of the surface layers of the stem is smaller than in chips made of whole stems. In practice this means, inter alia, that the share of heartwood in sawmill chips is exceptionally low. This has been confirmed by empirical studies. The difference between stemwood chips and sawmill chips is not self-evident, because stemwood chips are made of small and often also young stems with a smaller proportion of heartwood than in trees made into sawlogs. On average, therefore, sawmill and corresponding types of chips have an exceptionally low heartwood content.

It is evident that pine and spruce differ in this respect. Since spruce has a larger proportion of heartwood than pine, it may be assumed that the heartwood share in sawmill chips made of spruce is higher than in those made of pine.

The quality of chips made solely of stem surface layers is also to some extent affected by the fact that certain anatomical characteristics of wood change on moving from pith to surface. It is probably mostly because the cell length grows in this direction. Also, the length-to-diameter ratio of the cells, the share of thick-walled summer wood cells etc. undergo a change. The result of all these changes makes it probable that the technical properties of paper made of surface wood chips are different from those of paper made of stemwood chips. No reliable investigations on the importance to be attached to these changes have been found in the literature.

It has already been mentioned that surface wood is denser than stemwood on average. This difference is particularly distinct when no allowance is made for the exceptionally high moisture content of surface wood, in other words, for green density. The high moisture content of sawmill chips is due to the low heartwood share and, also, to the higher moisture content of the outermost part of surface wood compared with the inner part. In practice, this varying moisture content means that moisture should be taken into account in weight measurements and dry weight of wood should be studied.

In principle, it can be assumed that the bark content of surface wood chips especially if made in winter, will readily increase immoderately compared with that of stemwood chips. There are two causative factors. The barking of large, thick-barked logs may be more difficult than that of smaller bolts which are chipped in their entirety. On the other hand, when only the surface part of the tree is used for chipping, the share of the bark to be removed is great compared with the wood mass to be chipped. In practice this means that when stems to be wholly chipped and the log surfaces are barked with the same care, the bark content of the chips from surface wood is higher than that from stemwood. The validity of this theory receives some support from the exceptionally high bark content that has often been found in sawmill chips. The adverse effect of bark evidently requires more attention to this problem.

Another practical viewpoint to be considered is that sawmill chips which are mainly surface wood chips may differ from conventional stemwood chips because of chipping techniques. In practice, there may be difficulties about making chips from slabs, trimmings and other sawmill waste, and for this reason the particle size distribution and other qualities determined by the chipper are not always optimal. In fact, these differences are not due to the special properties of the surface wood, but to the techniques used. Naturally, these quality factors must also be taken into account.

The foregoing was a review mainly of chips made of the traditional barked and delimbed stemwood. Recently, attention has begun to be devoted also to other parts of the trees, branches, stump and roots. In addition, the use of chips made of whole undelimbed and unbarked stems has been started experimentally.

On the basis of numerous studies it can be said that the quality of chips made of branchwood is inferior compared with that of chips prepared from stemwood. For instance, the proportion of bark is exceptionally high, since for technical reasons the branches must usually be chipped with the bark intact. In addition, without special measures, the share of needles and leaves is high. Furthermore, branchwood chips do not make suitable raw material for a number of industrial processes, since the properties of their wood material are not fit for the purpose. The high share of reaction wood and the shortness of fibres is a disadvantage in pulp making. It is also clear that the high share of bark also has a negative effect in the cooking process, unless the bark can be removed from the chips before cooking. In some cases, admittedly, certain exceptional characteristics can be assumed to be useful, such as the exceptionally high wood density of spruce branches, but in practice the value of such positive factors is disputable.

In practice, branchwood chips differ in their characteristics from stemwood chips also because the chipping of branches is a more demanding task than the production of conventional stemwood chips. It has been found in practice that the particle size distribution and other properties of branch chips do not always meet reasonable requirements unless they are carefully screened.

It is evident, then, that the use of branches as the starting material for chips affects the product to such an extent that the inclusion of even small quantities of branches in the raw material must always be mentioned. In practice, it is impossible to examine the wood material quality of the chips with methods detailed enough to provide all the necessary information on the wood properties. It is considerably more practical to agree in each individual case how much if any branchwood chips the chips may contain.

Not only branches but also stumps and roots have recently been accepted for chip production. So far, the quantities have been small, but the importance of this raw material is apparently on the increase.

A particular reason why chips made of stumps are not as such comparable with the customary stemwood chips is the currently used crushing and chipping techniques. Especially chips made solely by crushing differ essentially from chips made by cutting, i.e., the conventional chipper. The wood characteristics of stump and root wood differ so much from those of stemwood that it is advisable to agree separately on the use of this exceptional raw material in making chip delivery contracts.

Chips made of stumps have desirable special properties in some cases. An example is the usually exceptionally high resin content of pine stumps, which gives a good talloil yield in the manufacture of sulphate pulp. A typical feature of root wood is the long fibre and the small summer wood share, which mean certain paper-technical qualities. In most cases, however, the truth probably is that stump and root wood are inferior in their properties to stemwood, especially bearing in mind how difficult it is to produce high quality chips from stumps and roots.

In addition to the different parts of the tree as chip raw material, whole-tree chips must also be considered. Whole-tree chips usually mean chips made of the above-ground part of the tree without barking and delimbing the raw material. Hence, the share of bark in the chips is exceptionally high compared with conventional chips. Similarly, the percentage of needles or leaves can be high. The average wood properties of the chips theoretically approximate the weighted mean of the wood properties of the stem and branches. This is not exactly true, since a part of the wood material of the branches is wasted while the chips are being produced.

It should be noted, too, that the standard of whole-tree chips is often inferior to the theoretical maximum. This is because whole-tree chips have to be produced by equipment suitable for handling unhomogeneous material. It means that the stemwood does not yield such high-standard chips as it does with industrial chippers proper in good conditions. It cannot be explicitly assumed, then, that the part of the whole-tree chips made of stemwood equals the traditional chips and the remaining part branchwood chips or some corresponding inferior chip quality. It can be assumed that the average standard deteriorates.

23. Pre-chipping treatment of wood

It was stated above that the quality of the chips depends on the part of the tree from which they are made. It is evident that the pre-chipping treatment of the raw material also influences the quality of the chips. As the quality of the chips is agreed, this means in practice that in many cases it must also be decided how the raw material is treated prior to chipping.

The pre-chipping treatment of wood raw material sometimes considerably affects the characteristics of the chips. For example, the carefulness of barking naturally affects the bark content of the chips. This is especially important when the surface parts of the tree alone are used as raw material for chips. In these parts the share of the removed bark is relatively great compared with the volume of wood to be chipped. According to Finnish experience, this viewpoint can have a practical influence at least in winter.

Especially with pine, the length of storage time and method of storage are important factors influencing the quality of the chips. Long pre-chipping storage of pine, in particular, reduces the talloil yield. However, storage of the chips themselves reduces the amounts of this by-product considerably more than storage of massive wood raw material for a period of identical length. It is also known that when timber is stored in water or in sprayed stacks on land the loss of talloil is less than when it is stored dry. Similarly, decay and blue stain are less in the various forms of moist storage than in storage on land. The role of decay is obvious. According to recent research, it is also economically important to avoid blue stain, for at least in the manufacture of bleached cellulose grades blue-staining increases the consumption of chemicals.

In some cases, the best storage method depends on the tree species. When unbarked spruce is stored in water, some cooking problems may arise because of materials loosened from the bark. In these cases, when the quality of the chips has been agreed, due attention must be given to the pre-chipping treatment of the wood raw material.

According to a rule of relatively universal application, high quality chips are obtained from timber that is as fresh as possible. Chipping of dry wood is particularly uneconomical. The more the timber to be chipped differs from this optimal situation, the more important is it to agree on the pre-chipping treatment of the raw material. For practical reasons it is not worth considering slight deviations. However, year-long timber storage, for exaple, will evidently affect the quality of the chips so much that this exceptional factor influencing the quality of the chips should be agreed on separately.

The use of sinkers as raw material for chipping is a special question. It is known that long-term immersion of timber produces certain changes in the wood material. It is to be assumed that in dried sinkers the absorption of cooking liquor improves, since in many cases the pores of the wood are destroyed by bacterial action. On the other hand, pulp making suffers to a certain extent when water-soaked wood is used. The ultimate effects may be small on the cooking and bleaching. In using weight measurement without correction for moisture, however, it is important to know whether the material contains chips made of sinkers.

In some cases the pre-chipping treatment of wood can improve the value of the chips. For example, when pine has been treated with chemical or in other ways to raise its resin content, it can be assumed that the value of the chips increases because of the higher talloil yield. If treatment to raise the resin content is systematically applied to the trees to be chipped, it is appropriate to agree on this factor affecting the quality of the chips when making the contract.

24. Chippers and crushers

Not only the wood properties but also the chipping method and the equipment used for chipping affect the chip characteristics. Poor quality raw material will not result in good chips however good the chippers used. Equally, even good raw material can be spoiled by poor chippers. In principle, a good chipping method may result in inferior quality chips if the chipper is not used correctly and well maintained. The condition of the chipper blades often means a great deal for the quality of the chips. Especially for the sulphite process, it is important to avoid chip damage.

The various aspects of chipper maintenance will not be discussed here, but it is assumed that these factors affecting the quality will be taken into account in chip production. However, certain chipper types and their effect on the characteristics of the chips are reviewed here.

The chippers are divided into three groups, viz. disc chippers, drum chippers and conical disc chippers. The drum chippers are further divided into two sub-groups. In one the trees or bolts are fed longitudinally parallel to the drum radius, against the drum. In the other the raw material is fed transversally to the drum, in other words, the longitudinal axis of the timber is parallel to the drum shaft, and the feeding direction is that of the drum radius. The latter type is used to produce parallel chips.

In practice, chippers within any one of the groups are very different. The number and location of blades, the feeding equipment, etc., are factors that may greatly affect the quality of the chips, especially when the raw material is unhomogeneous. Sawmill chips are made of such difficult raw material. In addition, many variable factors, e.g. temperature, affect the difference between chippers and the quality of the chips obtained.

The traditional disc chipper produces good-quality chips provided the equipment is well maintained and correctly used. An approximately linear correlation exists between chip length parallel to grain and the thickness of the chip. Hence adjustment of length is a means of adjusting also thickness. For sulphite cooking the length is a more decisive variable than thickness in the chips, whereas in sulphate cooking thickness is the more important factor. The optimal thickness for the sulphite process is c. 5 mm, for sulphate 3...5 mm. The optimal length in both cases is c. 15...25 mm, but an overlong chip has an essentially negative effect only in the sulphite process.

Drum chippers are comparable to disc chippers. The trees are fed end-first. Drum chippers usually do not produce chips of as high a quality as wheel chippers. Usually, these chippers are small or medium-sized, intended for the chipping of e.g. whole trees or wood residues.

In good conditions, the drum chipper for the production of parallel chips makes chips of excellent quality. The properties of these chips differ so much from those of other chips that it usually does not pay to mix them with other types. On the other hand, it seems that these chippers are few, used mainly by the sulphite pulp industry.

Conical disc chippers also are of little importance because of their rarity. Depending on the type, their chips may be of very high quality, but this also presupposes good raw material. In some cases the chips are parallel chips.

In addition to the chippers described above, there are chippers with exceptional qualities that cannot be referred to the above groups. Most important for the present are chipper canters which make the surface part of the logs directly into chips. The characteristics of these chips are comparable in the main with those of the chips produced by the conical disc chipper. However, these chips differ so much from those produced e.g. by the disc chipper that it is advisable to mention the use of such an exceptional method of chipping. Another reason, naturally, is that the chipper canter is used to chip only the surface of the wood.

In some cases the cutting chippers have been replaced by crushers which are suitable for splitting stumps. This crushed product may be usable in many industrial applications.

However, since the crushed product differs a great deal from the customary chips even after screening, the use of crushers instead of cutting blades is definitely a factor affecting quality, and its use must be agreed separately. Since crushers are usually used only to produce stumpwood chips, the question of crushed wood has so far been mainly theoretical. As the use of stump chips increases, it may become topical.

On average, it may be said that the use of crushers should be followed by careful screening and an industrial use suitable for the crushed product.

25. Screens

Chip quality can be effectively influenced by eliminating all the chip particles that do not meet the stipulated length and thickness requirements. Screening, however, must in most cases be understood as a step supplementary to chipping. This means that chipping should tend to produce chips of such a high standard that screening is required to remove only a small proportion of the chips as unacceptable fractions. If a large proportion of the chips is to be removed by screening, the profitability of chip making will suffer. This is, however, necessary in special cases, e.g. the production of whole-tree chips.

If screening is to be successful in improving chip quality, the length of the chip particles parallel to the grain must exceed the width of the particles. Large width alone is not a disadvantage in industrial processes, but from the point of view of screening it is essential that length should exceed width. Usually the production of such chips encounters no difficulties.

Screening usually removes chip particles that are too long, short and thick. Length control can be achieved with perforated plates. It is customary to remove particles less than 6 mm or over 32 mm long. Stricter standards of chip uniformity are also used.

If screening is to achieve control of not only the chip length but also its thickness the screen plate may be a wire screen or some corresponding equipment. The accepted particle then falls through the wires while the over-thick particles are trapped. Usually the particles are not separated according to thickness. It often suffices to ensure that the correlation between length and thickness of the chip particle is maintained.

Since a satisfactory screening result can be obtained in many different ways, the different screening methods are not discussed here. On average, shaker screens give an inferior result to refiner screens, but this is of hardly any practical importance. The biggest differences arise from the number of screen plates and the size of their perforated holes. Their influence is self-evident.

26. Storing the chips

In many cases the quality of the chips is also influenced by the way in which they are stored. In practice the most important factor is the storage time. It is also of considerable importance whether the chips are stored in covered silos and containers, or under the open sky exposed to the weather.

When chips are stored, especially in the hot season of the year, a biological process starts as a result of which many chemical substances in the chips are converted into other chemical substances and possibly eliminated. The cause of this conversion is the respiration of the living cells in the wood, bacterial activity, and other wood destruction by fungi and other micro-organisms. The longer the storage time, the greater are the changes in the chips. The changes are particularly marked and harmful in pine chips, since the talloil yield is continuously reduced during storage. Similarly, changes in whole-tree chips are drastic.

Storage may sometimes be even useful in preventing resin problems in paper making. Broadly speaking, however, storage for more than some months affects the chips to such an extent that it must be taken into consideration separately.

The storage method affects mainly the humidity and the ease of handling of the chips. Chips stored uncovered will get wet, or dry, and in some cases dirty, lowering the quality. The differences between storage methods are accentuated as the storage is prolonged. The extent to which the differences between the storage methods are of essential importance depends on many factors.

For instance, if volume measurement is used snow and ice in open storage obviously complicate measurement even after the chips are moved e.g. to railway waggons. Snow and ice are negative also in weight measurement when moisture variations are disregarded. A frozen state naturally affects the productivity of work in many methods of transportation, loading and unloading.

Although the storage method usually is not agreed in the sales contract, at least long-term storage and exceptional storage conditions should be taken into account when agreement is made on the quality of the chips.

3. SOME CHIP QUALITY CHARACTERISTICS AND THEIR MEASUREMENT

31. Particle size

Particle size was mentioned in discussing the quality characteristics of the chips. It was stated that the important dimensions are the length in the grain direction and the thickness of the particle. Width is of importance only for screening. The width must be smaller than the length of the chip particle to enable proper screening. It was noted, too, that for the sulphite but not the sulphate industry length is an important variable, since the cooking liquor is absorbed through the ends of the chip particles, whereas in the sulphate process the thickness is important because in alkaline cooking the smallest dimension determines the absorption. The target chip length in Finland is usually 15...25 mm. The optimal thickness for sulphate cooking is 3...5 mm and for sulphite c. 5 mm. In practice, particles that are shorter than 6 mm or longer than 32 mm are removed if possible.

It must be emphasised, however, that agreement on chip particle dimensions is a commercial question. In some cases it is worthwhile to agree on particle size requirements stricter than those outlined above, since the result obtained from the cooking process may then be better. In other cases very unfavourable fractions of particle size may suffice, if weakened profitability can be taken into account in the price of the chips.

By way of an example, the following extract concerning the agreed particle size can be taken from a Finnish sales contract:

"A minimum of 95 % of cooking chips must belong to the 6...32 mm length category. If the percentage is below 95, the price will be reduced by 2 % per every full per cent below this figure. If the percentage is below 90, the price will be cut by 5 % per every full per cent starting from the said 90 %. If the percentage is below 80, the chips are not acceptable as cooking chips. - If the sawdust fraction less than 6 mm in length exceeds 2 % measured from fresh mass, the price will be reduced by 1 % per every exceeding per cent, but invoiced at 0.1 % steps."

The measurement of particle size is a problem in itself. In many cases control of fraction length alone is considered sufficient, because thickness usually is linearly correlated with length.

Particle size can be most accurately determined by inspecting the chip particles singly and measuring the dimensions desired. This method is suitable for small quantities only, and is not in general use e.g. in the control of chip deliveries. Instead, standardised screening is used.

A problem in addition to screening techniques is sampling. Theoretically, it is reasonable to hold that two-phase sampling is best. In the first phase, a sufficient amount of chips is collected e.g. when the load is unloaded into a container. Chips can be taken at random intervals or by uniformly spaced sampling from the conveyor or other flow of chips. When a sufficient amount of chips has entered the container, they are carefully mixed, and a sample is taken from the homogeneous mass for inspection. In practice, a suitable sample size for loose volume has proved to be 1 dm^3.

The types of samples used to analyse different characteristics will be discussed in the light of examples in connection with the recommendations given later.

The distribution of the chips according to the length of the chip particles is customarily ascertained with a standardised test screen. The one most commonly used today, also internationally, is the Williams type test screen. A description of this equipment may be of general interest:

"The Williams type is a screen fitted with a rotating pendulum mechanism, with a swing of 50 mm and 200 ± 5 strikes per minute. The screen plates are square in shape and their effective screen surface is 0.30...0.35 m^2. In the screening position the screen plates are spaced 100 mm apart, or if the hole diameter is under 13 mm, 70 mm apart. The screen plates are 2 mm thick. The screen plate holes are circular and their diameters (A) and the corresponding widths of the space between the hole (B) are as follows:

A = in millimetres, 6, 13, 16, 19, 25 and 32.
The corresponding tolerances, in millimetres, are
0.1, 0.1, 0.1, 0.2, 0.2 and 0.3.

The corresponding widths of the space between the holes (B), in millimetres, are 4, 5, 6, 7, 10 and 10. Tolerance ± 20 %.

In addition to the screen plates, a closed box is placed at the bottom to collect the fines. All the screen plates are used in the screening. The plates are fixed to their frames with the smoother side upward.

If a slot screen is used to check the thickness, the slot widths are 2, 4, 6, 8 and 10 mm.

The Williams type screen is used as follows. The screen plates are fixed on top of one another so that the hole size diminishes from top to bottom, where the box for the fines is placed. The dose of chips to be studied, 15 dm^3 loose volume, is poured onto the topmost plate. The screening time is 5 min. The fractions left on each plate after screening are weighed and recorded as a percentage of the fresh mass of the total chip dose, to an accuracy of 0.1 %.

It has appeared in practice that the moisture of the chips screened should exceed 20 % of the fresh weight, for lower humidities affect considerably the distribution of the fractions. On the other hand, no surface water is permissible in the chips. The chip moisture content should be stated with the screening result if a moisture determination was considered necessary.

If it is desired to make a special analysis of the composition of the fines, a plate with 3 mm holes can be added. The hole tolerance in this case is 0.1 mm.

Drawings of the Williams type test screen as described above are supplied e.g. by Oy Keskuslaboratorio Ab, Finland.

32. Bark content and foreign materials

The chips used in the sulphite pulp industry must be absolutely bark-free, whereas the sulphate process is not so sensitive to bark. Especially when unbleached sulphate pulp is produced a reasonably high bark content is acceptable, although the yield will decrease in ratio to the increase in the proportion of bark. In making bleached pulp, bark cannot be permitted even in the sulphate process. Bark consumes more chemicals than wood does, increases the litter in the pulp, and weakens its light colour.

The adverse effects of inner bark are considerably smaller than those of outer bark.

When chips are stored in the open they may gather dirt in the form of soot, dust, etc. Usually these impurities disappear relatively well before the cooking. A worse drawback is that stones and sand can be mixed with the chips when they are stacked uncovered on the ground. In railway waggons and other transport vehicles, coal left from earlier loads may be mingled with the chips. Even small quantities of coal in chips may cause the cook to fail. Clean waggons must be used to carry chips, preferably such as are only intended to carry chips.

Standardised methods exist for the determination only of the bark proportion. The amount of foreign material in the chips is usually so small that it cannot be reliably determined by the usual sampling. It must simply be assumed that no foreign material gains access to the chips. If necessary, the sales contract can stipulate the procedure if detrimental foreign material is nevertheless found.

Nor is there any standard method for the determination of bark content, although certain general principles are apparently followed everywhere. In some cases the bark content is determined from regular samples at the same time as the particle size is controlled, in other cases only when visual assessment shows an apparently excessive bark content. The usual requirement in sulphate pulp production is a maximum of 1 % bark, measured from the dry mass of the chips. In the sulphite pulp industry the requirements are considerably stricter, although there seems to be no uniform practice.

No such simple mechanical method has been developed for the determination of the bark content comparable to the screen used for determining particle size. Bark must be removed from chip particles by hand. According to Finnish experience, the time expenditure on removing bark from chip particles is c. 10 min. per dm^3 loose volume. In practice such a high expenditure of time strictly limits the size of the sample for examination. Bark content determination can be accelerated slightly by taking into account only the dark outer bark and disregarding the inner bark. This simplication is to be recommended since outer bark creates substantial difficulties in the process, and the share of inner bark is negligible compared with outer bark.

As stated above, there is no uniform practice for the determination of bark content. However, it is evident that in this case too, two-phase sampling is the most effective method of sampling. When a load is unloaded, or on some other occasion, a chip sample is collected in a container from which the sample proper is taken for study after careful mixing. In some cases, a sample of 1 dm^3 per load has been considered sufficient when the number of loads to be checked is high. In many cases a chip volume of no less than 15 dm^3 has been used if the quantity of the chip consignment to be checked has been small.

A load in this context refers to a lorry load or a railway waggon of chips.

According to practical experience, the bark is best removed while fresh. Despite this, the bark content is mostly expressed as a share of the dry mass. This presupposes that both the bark and the other part of the chip sample are dried to absolute dryness. In many cases it is found sufficient to express the bark content in ratio to the fresh mass. The shares of dry mass and fresh mass are usually different since the bark is often more moist than the rest of the chip material. This is true especially of inner bark.

33. Moisture

The moisture of chips depends on the original moisture of the raw material. This is influenced by the innate moisture of each tree species, the way the raw material is stored, and the weather conditions. In the cold season humidity can be increased by the snow and ice entering among the chips.

Moisture is of importance both in the woodworking process and in weighing the chips. The weight of the chips affects the cost of transport. Moisture may also influence the settling of the chips, and in some cases the screening result.

In principle, it is desirable that all the chips in any one cooking batch have the same moisture content. Raw material containing both dry and wet chip particles results in uneven absorption of the cooking liquor.

According to experience gained in industry, the best chip moisture content for mass yield and strength is 30 % of the fresh mass. For dry mass, the moisture ratio is 43 %. In practice, considerable deviations from this optimal situation must be accepted, for the mean moisture level of sawmill chips is usually over 100 for dry mass. More important in practice than the absolute moisture level is the knowledge that the raw material is evenly humid throughout.

The sampling methods will not be discussed here as a suitable sample size will be examined in connection with the recommendations to be given later. In principle, however, it can be repeated that two-phase sampling is also suitable for obtaining a moisture sample. In practice, the procedure could be to collect a representative chip sample in a container when the chips are unloaded and then, after careful mixing, take a smaller sample from the container for the moisture determination.

All the possible ways of determining the moisture from a chip sample will not be examined here, but only those that enter into question for controlling the moisture of chip consignments.

A traditional and relatively accurate method is to weigh the chip sample in the fresh state and after drying in an owen. The disadvantage of this method is its slowness, and the resulting problem of storing the samples awaiting treatment. The capacity of the drying owen can be improved by hot-air blowing. In some cases the drying can also be done with infrared radiators with which the moisture of small lots can be determined quickly.

It is often worth determining the chip moisture not from small samples but from the flow of chips on, e.g., the conveyor. Several continuously-functioning meters have been constructed, but they do not always work satisfactorily. Frozen chips, for example, may pose problems.

An example of a continuously-functioning meter is the device based on capacitance measurement, which works in the temperature range +1°C...+50°C. Its accuracy is ± 1 % moisture. The principle of another continuously-functioning meter is microwave damping. This measures the moisture under the chip stream on the conveyor. The accuracy is 2 % in the temperature range 0...+50°C.

Of the rapid moisture determination methods, only the meter operating on the principle of neutron-gamma radiation is suitable for frozen chips. The measurement range is 0...80 % moisture of the fresh weight, and the temperature range -15...+70°C. The accuracy is c. 1 %. Experience of the reliability of this moisture measuring apparatus is good. However, the accuracy of the measurement result depends on successful compensation for wood density.

It is evident from experience that in simple field conditions the best thing is to be satisfied with the traditional drying of the chip sample in the owen and determination of moisture by this route.

34. Wood density and chip density

In principle, the wood density of small chip particles can be determined in numerous ways. There is no point in reviewing all the methods. Attention will be focused on those whose simplicity makes them eligible for controlling the wood density of chips. Methods requiring complicated measuring equipment and carefully controlled conditions will be disregarded.

The most serviceable of the various density parameters in this connection is perhaps the basic density. To obtain it, the mass of the sample must be determined in an absolutely dry state, and the volume in its natural condition. Since no essential changes in wood volume take place at moisture contents exceeding the saturation point of the fibres, the natural-condition volume is approximately the same as that of a wood sample saturated with water.

It can also be thought that green density may be used when both mass and volume are measured in the natural condition or at a moisture approaching the natural condition. Since the chips may dry in many different ways, green density as a wood characteristic is not of particular interest in this connection.

In principle, dry density can also be used as a density parameter when both mass and volume are measured in an absolutely dry state. In practice, this parameter is difficult to measure with simple equipment.

When wood density is expressed in terms of basic density, a good method is to measure first the volume of the wood material by immersion in water and, then, after kiln drying, determine the absolute dry mass. Since chip particles are small, the problem is how to immerse the sample and measure its volume.

In principle, collective measurement of the chip particles, with no separation of particles, may be assumed. An alternative is to measure them singly, determining the volume of each chip particle separately. It is evident that the collective methods are faster and cheaper than those involving single particles.

Some studies suggest that when chip particles are immersed collectively in a perforated container or net bag, it is important that the chips should have been screened. It seems that the large surface area of small particles related to their mass makes the exact determination of volume difficult. Hence it is essential that particles under 6 mm in length are separated from the chips measured.

A special problem is the elimination of air bubbles. To avoid them, it is worth saturating the chips with water before measurement, if possible. An agent reducing the surface tension of water might also be added to reduce the probability of air bubbles.

After the chip particles have been more or less saturated, the superfluous water must be removed before the immersion measurement is carried out. This can be done by dumping the chip sample onto blotting paper, mixing it and replacing it in the container for immersion. The quantity of chips cannot be too large with this method. A convenient size is 0.5...1.0 dm^3.

If the chip sample is small and the particles are big, the superfluous water can be removed by shaking. A centrifuge will seldom be available, but if it is the removal of water from the chip surfaces and the biggest cavities can be standardised. The standardisation is the same in practice for all tree species. This suggests that in approximate density determinations an indefinite procedure such as removal of the superfluous water from the chip sample by shaking can be considered sufficient.

The immersion measurement itself is a special problem. In principle, there are two ways of doing this. In one, the chip sample is weighed in water and in air, and the difference between the weight readings indicates the volume of the sample. In the other, the sample is immersed in a water container placed on top of the weighing machine, and the reading on the weighing machine indicates the sample volume directly. No reliable studies are available on the accuracy or ease of work involved in the two methods. But the choice may well be to immerse the sample in a water container placed on top of the weighing machine.

There are no standard methods of determining chip bulk density. Most proposals are based on placing the chips under standardised conditions in a known container, as for all determinations, and measuring the bulk density in this way.

35. Frozen state

There is no standard method of measuring the frozen state of chips. Freezing is mostly associated with surface moisture, from snow or rain, and therefore one possibility is to analyse the moisture content of the chips. It may be assumed in any case that chips frozen into a lump have an unusually high moisture content. It can be agreed, especially for winter determinations, that moisture is to be one of the quality factors to be considered.

4. MEASURING THE CHIP QUANTITY

41. Measuring the volume

A bulk article like chips must be placed in some kind of measuring box for volume determination. For practical reasons, the box is usually of regular shape so that its volume can be readily calculated from the length of the sides. The measuring box often is the high-walled platform of the transport vehicle, railway waggon or lorry. The common way is to measure the loose volume of the chips, that is the volume of the measuring box filled with chips. This is analogous to the frame measurement of cordwood. Loose volume comprises both chips and air spaces between the chips.

The solid volume of chips, that is to say, the volume of the chips themselves without the air spaces in the container, is measured only exceptionally. In practice, the solid volume is very difficult to determine and has not been determined for other than research purposes. A parameter often used to characterise different chip qualities is a ratio with the solid volume of the chips as the numerator and the loose volume as the denominator. This parameter is often called chip density.

Since the determination of the solid volume of chips is difficult in practice the chip mass is often measured in its stead. The chips are often denoted with the mass of the chips as the numerator and loose volume as the denominator. The unit is mostly kg/m^3. When the green density of the wood of the chips is known, the loose volume can be converted into solid volume by means of this parameter.

Measurement of the loose volume of chips is very uniform in Finland. The inner dimensions of the container are usually rounded off to the nearest full centimetre. After smoothing the chip surface in the container, its height is measured and rounded off to the nearest full or half decimetre. The result of loose measurement is usually recorded to an accuracy of one-tenth of a cubic metre.

The practice is to allow for snow, ice and other irrelevant material in the measurement result. In fact, these materials are difficult to measure.

42. Accuracy of volume measurement

According to Finnish practice, the loose volume of market chips is measured in the vehicle at destination. The chips are then more closely packed than when they start on their journey, not only because of mechanical settling, but also because of changes in the load space and the loss of chip particles from the load. The most important of these factors in practice is mechanical settling. Other important factors are the method and distance of transport, moisture and particle size of the chips, height of the load and, if transported by motor vehicle, the quality of the road.

According to Finnish studies, the settling over a distance of 80 km in the motor vehicle is 4.0 % and in the trailer 6.6 %. The settling is different in different parts of the load. It is greater near the walls of the load space and especially at the back of the load than elsewhere. Some of the settling in truck transport is due to changes in the load space.

Chip settling in rail transport is probably of the same magnitude as in road transport. The mean settling in railway transport, however, is probably greater than in road transport since the average transport distance is longer. If the right kind of chip transport waggons are available, the change in load space affects the settling less than in road transport.

It is also worthwhile in volume measurement to consider other factors which affect the ratio of solid volume to loose volume for chips. The mode of loading is a factor known to have some effect. It is evident when the chips are blown by the chipper they are more densely packed than when they are dumped from a silo or loaded with a shovel loader or conveyor. Chips can, of course, be packed in many ways to make them tighter.

Another factor to be taken into account in practice is that chip density is also influenced by the particle distribution and, hence, all the factors that affect this distribution. For example, chippers are different in type. It may be advisable in some cases to consider questions of this kind in the sales contracts.

43. Weighing

431. Reasons for determining the mass

The solid:loose volume ratio of chips is influenced by numerous factors. Hence, measurement of the loose volume does not give a precise idea of the solid volume. The raw material quantity bought in conventional chip deals, if measured as solid content, may vary from one occasion to the next although the loose volume remains unchanged. Because of this variation, it is worth considering weighing the chips, which gives an accurate picture of the mass. In fact, the raw material weight is a more important parameter than volume e.g. in pulp production.

In many cases the weighing of chips is a more favourable method than determining the loose volume in other respects also. Once the weighing equipment has been installed, weighing is a cheap means of determining the amount of chips.

In principle, weighing can be applied to the chips in two ways. It may suffice to determine the green mass, disregarding the moisture variation. A second method, and one to be recommended, is to determine the mass of the chips in the green state but to correct the value to equal a given moisture content, by taking moisture samples from the chips.

432. Equipment and machines used for weighing

A lorry or railway waggon weighing machine of sufficient capacity is required to weigh chips. Many industrial plants in Finland use weighing machines that are suitable for weighing chips.

The weighing machine is usually installed on a concrete base, with the bridge level with road surface. The vehicle to be weighed can thus easily be driven onto the weighing machine. The machinery is housed in a building which is also the working space for the operator. The machinery usually comprises a weight stamping device, which registers the vehicle weight with load and, after unloading, empty. The information registered by the weighing equipment can be stored on punched cards, or punched or magnetic tape, or it can be fed straight into a computer. Several constructions of Finnish make are available.

If the green weight is converted to a given moisture content with the aid of the recorded moisture, a moisture sample must be taken from the chips during the unloading. This was discussed in connection with the measuring of moisture. After the moisture has been determined, the mass can be converted to correspond to any desired moisture content.

433. An application

As described in the foregoing, the most reasonable way of applying chip weighing is to determine its mass in the green state and then convert the measured mass to correspond to a given moisture content. This procedure is applied by at least one Finnish mill:

> The chip lorries are weighed loaded and, after unloading, empty. The difference between the weights is the green mass of the chips. All the chips received at the mill are weighed in this way. To determine the moisture, samples are taken from the loads, at most 50 sample loads per month. In unloading, a sample of 10 dm^3 loose density is taken from different parts of the load. This is mixed, and the moisture content is determined in the usual way from a 0.5 dm^3 sample taken from it.

5. RECOMMENDATIONS FOR A UNIFORM PROCEDURE

51. Determination of quality

Chapters 2...4 reiterated the general principles that can be applied in many different ways to commercial contracts. Presented in the following are certain viewpoints that can be considered as a recommendation towards achieving a uniform procedure.

In the chip trade, the commercial contract should indicate the tree species from which the chips are made. If mixed chips of several tree species are involved, the contract should specify the maximum and minimum shares of each species. If necessary, additional data on site, age, condition, etc., can also be included by agreement.

The chip contract should also specify whether the goods are stemwood chips of barked roundwood or some other type of chips. The other types may perhaps include sawmill chips made mainly of barked sawn surface and other sawmill residues, or top chips in which the raw material is barked wood made of stem tops. Furthermore, there are stump chips, branchwood chips made of unbarked branches, and whole-tree chips.

In many cases it is necessary to agree on the chip species in greater detail than is indicated above. Sufficient attention must be devoted e.g. to the bark content.

The minimum requirement for the pre-chipping treatment of the raw material is a mention of whether green or stored timber is involved. If it is timber which has been stored for an unusually long time, the chip contract should indicate the method and period of storage. Storage methods are storage in dry heaps on the ground, sprayed heaps on the ground, bundles in the water, and sunken logs. In many cases it is also necessary to mention whether the timber was stored with or without bark.

The chipper types used to make the chips must be specified when the chip quality is greed. A distinction should be made at least between disc chippers, drum chippers corresponding to the disc chipper, drum chippers producing parallel chips, and cone disc chippers. In addition, a chipper canter or some other, new chipper type may have been used.

It is also often useful to specify the screening method used, and especially the type of fractions that have been eliminated from the original chips. It is usually enough to mention the shortest and the longest fractions eliminated.

If the chips have been in storage before delivery, the type and period of this storage should also be indicated. It is possible to store chips in a silo, in the open, etc. If stored in an open field, it should be stated whether the standing was paved or not as this would help the check for foreign material.

To ensure the cleanness of the chips the transport equipment should also be agreed. The use of waggons other than clean chip waggons must always be stated separately in the contract, if such transport equipment must be used. The harm that may be caused by possible impurities must also be agreed.

The following can be mentioned concerning the control of certain quality characteristics of the chips. The particle size distribution is studied by the Williams type screen. The particle size requirements should in any case stipulate the amount of extreme (short and long) particles permissible, measured from green mass. The particle size distribution and permissible deviations can also be agreed in greater detail.

It is worth determining the bark content of the chips by sampling, indicating the content as a percentage of the dry mass measured. An acceptable way in practice is to take into account only the dark outer bark in the determination of bark content.

There are many ways of determining moisture. The most reasonable way is perhaps to agree on moisture determination by sampling. It is recommended that moisture, in ordinary conditions, be determined by the traditional owen-drying method.

In concluding a deal it must be agreed how the sampling is to be done for determination of particle size distribution, bark content and moisture. Since on all these points the agreed quality is to be controlled, they can be left open so that the buyer can try to achieve the accuracy he desires. The standard deviation of the sample provides a basis for calculating the reliability of the mean parameters, from which it can be concluded whether the chips meet the agreed quality standards.

52. Measurement of quantity

The contract must always state how the quantity of the chips is to be controlled. The usual methods are determination of loose volume or mass.

If it is decided to use loose volume, it must be agreed where the determination is to be made. A practical suggestion is at either the supplier's or the recipient's premises. Some other appropriate place can be agreed if necessary. As regards loose volume, it must also be agreed how the loose volume is to be determined. It is recommended that the volume of the means of transport be determined and the height of the chip surface in this vehicle be measured.

If weighing is used to determine the mass, it must be agreed whether the chip quantity is to equal green-measured mass or whether a moisture sample is to be taken in connection with the weighing. The green-measured mass is then converted by means of such a sample to equal a desired moisture content. It is usual in the latter case to determine the absolute dry mass.

The place of weighing can be agreed in the same way as with loose volume. If moisture samples are taken, it is worth concentrating the taking of weighing and moisture samples at the unloading site. This is because the most reliable moisture sample is obtained in unloading the load.

The principle should be that all transport vehicles are weighed. If large chip quantities are involved, sampling may also be agreed, that is to say, only a certain number of the transport units received is weighed and their total number is counted. The mass of the whole consignment to be supplied is then determined on the basis of the completed weighings.

If moisture samples are taken, the extent of the sampling must be agreed in the contract. For example, it can be agreed that thirty 1 dm^3 loose volume samples are taken at random from every homogeneous consignment of chips delivered at any one time. These samples are mixed carefully, and five 1 dm^3 samples are taken from the mixture for moisture determination. The reliability of the result can be calculated from these five samples. If the homogeneous chip consignments are large, it may be stipulated that e.g. 60 samples of 1 dm^3 each be taken. After careful mixing, five 1 dm^3 samples can again be selected for a final measurement. These figures are only examples of the possible procedures.

If the chips to be supplied are not homogeneous but consist of various chip qualities (stemwood chips, sawmill chips, etc.), the moisture of each quality should be studied separately.

6. REMARKS

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5	In this connection the analysis is devoted only in the measurement of chips and their quality. The problems of loading, unloading, and transporting of chips have been discussed during the excursions made in Finland and Soviet Union. Many efficient solutions have been seen.
28	There are observations that some chemicals used against insects and blue stain can be harmful in pulping processes. Therefore, their use in chip protectiono should be avaided and mentioned if unavoidable.
28	It is natural to assume that the residues containing glue stock or other similar materials are not approriate for the production of chips. This point of view is important in plywood mills, etc.
39	There are also such railway weighing machines which permit the waggons move while weighing. The marketing of this modern techniques is made by the company Pivotex, Helsinki, Finland. (Also in Soviet Union). Usual weighing machines are made by Lahden Vaaka, Finland.