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TRANSPORT OF TIMBER AS CHIPS

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## TRANSPORT OF TIMBER AS CHIPS

### Introduction

The chipping of the wood raw material for the pulp and board industries and the debarking that precedes it are generally done by effective apparatus at the processing site. The direct costs of chipping can be minimised in this way, and the quality of the product is more even.

There are, however, situations in which chipping is done in the compartment, on the strip road, at the intermediate storage, central station, or another plant. The timber assortments and conditions vary but a feature common to all the cases is that the raw material arrives at the site of utilization ready chipped (5, 19).

The primary advantage of chipping before long-distance transport is lower transport costs. Chipping methods therefore lend themselves best to timber assortments of low solid volume content or whose transport and mechanised handling cause difficulties. It may suffice to mention the waste wood of the mechanical industry, small-sized trees, hardwood of irregular stem form, and logging residues.

The possibilities offered by chipping methods have been devoted great attention in Finland in recent years in the research and development programme for intensification of wood utilization. Sawmill and plywood industry waste wood has long been delivered to the utilization site almost without exception as chips, and the feasibility of chipping at the forest end is now being explored. Methods are being developed in many countries and certain chipping method solutions have gained permanent application especially in North America. Evidence of the interest in this question was the FAO/NORAD Symposium on Production, Handling and Transport of Wood Chips in Norway in 1972.

The current research situation and the applicability of the chipping methods are reviewed here. Some of them have become established in use and others are gaining ground, but in many cases the situation is only in the exploratory phase.



Properties of chips and transport technique

Moving of timber is generally based on the handling of individual bolts, although a bunch may comprise several bolts. In the chipping process any assortment of timber becomes a mass article the loading and unloading of which may in certain conditions be very extensively mechanized.

In addition to loading and unloading, the cost of transporting a kilogram of dry matter depends above all on the green weight of the timber and its space requirement. Chips require more load space than pulpwood. On the other hand, the solid volume content of e.g. logging residues rises with chipping (cf. 4, 16, 18, 23, 24).

Timber assortment	Dry matter kg/cu.m.		Change in space requirement in chipping, %
	Before chipping	After chipping <sup>x</sup>	
Softwood pulpwood, 2 m	260	150	+74
Softwood pulpwood, 3 m	245	150	+66
Softwood pulpwood, 2-3 m	215	150	+42
Birch pulpwood, 2 m	285	190	+50
Birch pulpwood, 3 m	270	190	+42
Birch pulpwood, 2-3 m	235	190	+24
Sawmill slabs	120	160	-25
Stump-root systems	45	165	-73
Split stump and root wood	135	165	-20
Branches with needles	30	120	-75

<sup>x</sup> before transport

The increased space requirement of chips does not necessarily raise transport costs. It is important to use correctly dimensioned equipment, as is generally done with sawmill chips. No load space is wasted when chips are transported, and this evens out the differences in the space requirement between cordwood and chips, especially on vessels.

Quality losses may also arise in the transport and storage phase. Microbial action is much faster in large chip piles than in pulpwood piles. Deterioration of quality may be prevented, however, by avoidance of a long storage time.



### Chippers in logging

Organizational difficulties may largely explain why chipping methods have not found more general application. Frictionless coordination of chipping and transportation events is difficult to achieve at the forest end. The preparation of fuel chips by transportable chippers gained considerable ground in Finland (10) in the latter half of the 1950s, but it ended with the growth of demand for small-sized wood and the changing of price ratios. However, VAPO (State Fuel Office) still makes a certain amount of fuel chips with Karhula chippers. Puhos particle board mill also has a delivery contract for the harvesting of alder stemwood by the chipping method. The equipment consists of a MF Kärppä tractor with grapple loader, a transportable Bruks-chipper with grapple loader mounted on a truck chassis, and a truck with an interchangeable rack.

The chipping method has not gained a significant position so far anywhere in Europe, though transportable chippers are used to some extent in many countries. For instance, in Poland where the share of young stands is great on account of the reforestation work performed after the war, small-sized delimbed pine stems are harvested by chipping methods as raw material for the fibre board industry. There is comparable activity in many other East and Central European countries. Sweden, too, has a couple of contractors who chip small-sized stems and tree tops that have accumulated at the intermediate storage from processors. Norway is engaged on working out a whole-tree chipper suitable for small-sized wood (21, 22). Branches are chipped at central stations in the USSR as raw material for the fibre and particle board industries or for fuel.

The chipping method has found its broadest practical applications in logging in North America. A harvesting schedule in which the distribution of whole stems into timber assortments and often also the barking and chipping of pulpwood take place at a transportable or stationary central station is relatively common in the yellow-pine region of the southern parts of the USA. From the central station the timber is transported by rail to the mill site. Canada, too, has transportable or semi-stationary barking and chipping plants which are capable of handling timber up to 24 inches in diameter.



The most interesting development prospects are offered by the Morbark whole-tree chippers which are gaining ground rapidly in the USA and seem to be an economically advantageous solution for utilization of the poor-quality hardwood forests of the northern states (6). The quantity of raw material harvested from a unit of area has been doubled in some cases by harvesting the branches, crooked bolts and small-sized stems. Although the industrial utilization of total chips is complicated by the high bark percentage, even some pulp mills have ventured just recently to accept them in a certain ratio to their conventional raw material. A few examples follow the first delivery contracts concluded by contractors using a Morbark chipper. The amounts refer to green weights.

Buyer of total chips	End product	Delivery quantity, tons/year	Contract period, years
1	Corrugating medium	30.000	1
2	Corrugating medium	50.000	1
3	Corrugating medium	40.000	1
4	Fibre board	..	1
5	Particle board	..	2
6	Bleached kraft pulp for fine papers	50.000	3

These first cases are only the beginning of a trend that is quite obviously growing in American logging technics. Many companies use their own equipment in addition to the contractor systems. West Virginia Pulp and Paper Co. has regularly used hardwood total chips, either exclusively or mixed, in two digesters of one of its mills since autumn 1972. The company has two Morbark whole-tree chippers for the purpose. Because of the positive experience gained the other mills of the company will probably also begin to utilize total chips in the near future.

Whole-tree methods are expected to become common in the next few years in the raw material procurement of the board industry, but the pulp industry still needs methods for separation and segregation of bark from chips. Great attention has been paid to this question especially in the USA. Studies have been concentrated mainly in the North Central Forest Experiment Station of the U.S. Forest Service (1, 2),



The mechanization and the productivity of manual labour are perhaps higher in the Morbark method than in any other logging method in use today. The output per man-day inclusive of the felling and skidding phases is 50 tons of green chips.

As regards harvesting and processing technology, studies of the utilization of the entire above-ground portion of the tree have made quite good progress in the pine region of the southern states and elsewhere. The Weyerhaeuser company, after thorough mill-scale experiments, will probably embark on the utilization of total chips made of southern yellow pine. Encouraged by the example of the Morbark company, Nicholson Manufacturing, Caterpillar and other companies are already developing and gearing up for the harvesting schedule of the whole-tree chipping line. The Morbark Super Beaver system is based on a disc chipper with an infeed aperture of 20", whereas the Nicholson method is based on a 24" V-chipper. There is no reason to discount the feasibility of whole-tree chipping for our conditions, although we may have to make do with smaller machines.

Both researchers and the forest industry in Finland are showing a lively interest in the chipping method. Here, in brief, are some of the cases in which a nowadays worthless raw material may be feasible to utilize by developing the chipping method:

- Harvesting of branch raw material. It is estimated that over 8 million tons of dry branch raw material inclusive of needles are left yearly in the forest in Finland (8). It has been proved possible to use this at least in fibre and particle board industries when it can be got to the mill at reasonable cost. The Kockum-Morenius branch chipper was produced in Sweden, but is still in the prototype stage.
- Utilization of needles in the chemical industry or for fodder. The USSR has made practical progress here (11). But the value of needles may be even higher than that of wood in the long-term view also in Finland. Two million tons of dry needle raw material is left in the forest yearly from logging in Finland (8).
- Utilization of small-sized timber left on the ground in precommercial thinnings of young stands. This raw material is considerable, for precommercial thinnings will increase

in the next few years because of the age class distribution of Finnish forests. The HAKO-Committee and A. Ahlström Osa-keyhtiö developed in 1969-1971 a Karhula whole-tree chipper prototype for small-sized wood, but it is not yet ready for harvesting on a large scale (19).

- Unused north Finnish stem wood, largely poor-quality birch. An average of 28 per cent of even the stem portion of hardwood is left in the forest in the forestry board districts of North Ostrobothnia, Kainuu, Lapland and North-East Finland (15). The question is particularly topical now when the man-made lake projects are being undertaken. It is estimated that at present logging rates 400.000 solid cu.m. of stemwood will be left in the basin area of the man-made lake of Kemihaara, and this must be removed in one way or another before the water level is raised (13). The chipping method may be the best solution, either merely for the destruction of waste wood or for its harvesting.
- Fibre material that may be produced in the future within the scope of short rotation forestry. Densely grown small-sized hardwood is probably best harvested by the chipping method. A self-propelled harvester is under development in the Klockner company in the Federal Republic of Germany.

The dual object of the chipping method is to reduce logging costs and to achieve more complete utilization of wood. Environmental protection and even employment considerations enter the picture. Harvesting of logging residues would create new jobs and the State forest employment committee for North Finland, among others, has been looking at these possibilities.

#### Sawmill chips in the timber trade

A considerable part of the raw material of the pulp and board industries is waste wood of the mechanical forest industry. It is generally not feasible to transport slabs and trimmings from sawmills and waste that arises in the production of plywood as such. Timber from the Soviet Union is an exception, but the waste



wood from domestic sawmills is delivered to the site of consumption as chips, a by-product fully comparable in quality with the other raw materials of the mills. The type of chip in question is one that is most common in the timber trade (7). However, it is not economic for the very smallest sawmills to procure expensive barking and chipping equipment. For them, the preparation of unbarked chips by a chipper moving from one sawmill to another might well be feasible.

The Finnish sawmill and plywood industry sold in 1970 a total of 7.2 million loose cu.m. of chips, equivalent to 2.8 million solid cu.m. Most of it went to the pulp industry, 6 per cent to the board industry. The greatest consumer, the sulphate pulp industry, got an average of 15 per cent of its raw material as chips (25).

An estimated two-thirds of the chips are transported by truck, one-third by rail. The vehicle is generally loaded from a chip silo. The trucks are unloaded by tipping in Finland, but the USA, for instance, employs also a method in which, instead of a tipping platform, the vehicle as a whole is tipped to an angle of 60 degrees in its direction of travel.

Fast loading and unloading lowers the transport cost of sawmill chips per solid cu.m. of wood more than might be concluded from the solid volume content of the chips. However, keeping the chip transport costs down presupposes correctly dimensioned equipment. Units equipped with a trailer and taking up to 80 cu.m. have achieved in practical conditions 10-15 per cent lower costs than smaller trucks of 20-30 cu.m.

The following numerical series show the difference between the transport costs of softwood pulpwood and sawmill chips in the first half of 1970. Recommended tariffs intended for average conditions are used for cordwood (17), whereas actual booked costs are used for sawmill chips (20). Chips cannot be transported from the forest at equally low cost because loading is slower.

Driving distance km	Unbarked pulpwood		Sawmill chips	
	Transport cost, marks per			
	piled cu.m.	ton <sup>x</sup>	loose cu.m.	ton <sup>x</sup>
30	4.00	15.10	1.60	9.50
50	5.00	18.90	2.10	12.30
100	6.95	26.10	3.00	17.60
200	10.10	38.10	4.20	24.70

<sup>x</sup> Refers to cost per ton of dry wood when green wood is transported

With cordwood, 10 per cent bark must also be transported if barking is not done until at the mill. The cost of a ton of dry substance calculated in terms of clean wood is thus correspondingly higher. In the light of these figures, barking and chipping at a central station might come into question in some cases even in our conditions.

#### Overseas chip transport

Chips are a new article in the overseas timber trade. The progress made in shipbuilding and chip-handling technique has changed the situation, and ship transport of chips has gained a significant role in the international timber trade in a few years. It started in Japan in 1964, and in 1971 already 6 million solid cu.m. of chips were delivered to that country by sea (26). A considerable proportion of these chips are made from industrial waste wood, but the share of wood arriving from plantations is growing fast. There are ports of departure in many countries, but Japan has so far been almost the sole destination. It is predicted that Japan will be buying 10 million solid cu.m. of chips by 1975. Britain, too, has imported chips from the USA to some extent and Sweden, among others, is studying the possibility of importing chips from the Soviet Union. Chips are shipped to Sweden from the Åland Islands.

The rationalisation of transport calls for long-term delivery contracts. The agreements made by the Japanese in North America have a term of 7-10 years, those with Australia up to 20 years. This has created the conditions for the construction of specialised



wood chip carriers. The majority of them are of the 20.000-40.000 ton class. However, 60.000 ton units have already been built and chip tankers of 150.000 tons are being planned (3, 26). The cargo of such a large vessel can satisfy the raw material requirement of a medium-sized pulp mill for a couple of months.

Air trimmers, conveyors and cranes with a grab size of 10-15 cu.m. are used for loading the ships (12, 14). Underwater pipeline loading as used for oil tankers will be adopted in the future. A loading speed of a thousand tons an hour has already been achieved, and air trimmers can be used at the same time to pack the chips tight.

Most of the chips for Japan come from North America, 69 per cent from the USA and 8 per cent from Canada. The tree species are chiefly Douglas fir, western hemlock and western red cedar. Mainly hardwood chips are obtained from other countries. From South-East Asia the main imports are rubber wood and mangrove chips which represent 11 per cent of the total imports by Japan. Imports from Australia, solely eucalyptus chips, account for 8 per cent (26). Importation of eucalyptus from Brazil in 100.000 ton chip tankers is being planned.

Fleeting mention has been made in various contexts of the possibility of beginning pulpwood, particularly hardwood pulpwood, imports from southern countries to Finland. Softwood plantations, even the yellow pine of the United States whose high basic density would increase the load efficiency, might perhaps come into question. The importation should quite evidently take place as chips. But long-distance sea transport is by no means cheap, however effective it may be. For instance, as much as half of the price of the chips arriving in Japan is made up of transport costs, and the total price is probably high by international standards.

#### Pipeline transportation of chips

Pipeline transportation of chips is an interesting solution which opens up new prospects for the timber transport technology. Low operating costs, but high capital costs, are characteristic of the method. It is thus conceivable only when large quantities of pulpwood are transported regularly between permanent stations.

For instance, a pipe 20 cm in diameter in which water flows at 1 metre per second has a through-put of 500 tons of chips in 24 hours, 180.000 tons in a year, when the mixture used is 20 per cent. A system in which the pipeline connects a few big terminals with the receiving station could be considered in our conditions.

The pipelines can be built above or below ground, in the air or under water. The last-mentioned method permits winter-time transport without thermal insulation, and by using water systems unnecessary undulation of the pipeline can be avoided. Changes in the height of the pipe bed and horizontal zig-zagging add to the power requirement of the pumps.

A per-second speed of 1-3 m and a mixture of under 30 per cent are regarded as the most economic. According to Norwegian calculations, it might in certain conditions be worth transporting an annual wood quantity of 70.000-80.000 solid cu.m. by pipeline. The per-kilometre costs depend fairly little on the distance to be covered, but compared with other methods of transport a pipeline system is most economic over a distance of 80-100 km, at least in American conditions (9).

The negative features of pipeline transport are the high capital requirement and its slow amortisation, the need for large quantities of timber to be handled, inflexibility and the vulnerability of the network as a whole to local damage to the main line and its pumping stations. Its advantages are the high degree of automation, ease and reliability of programming the operations, reduction of heavy road traffic and conservation of the environment.

### Summary

It is fairly commonly held that chips are an uneconomic form of timber to transport. This need not necessarily be true. Correct dimensioning of the equipment can make chip transport costs fully competitive with those of many other timber assortments. There is long-distance transport of chips on a large scale by road, rail and sea, and pipeline transportation may find practical applications before long. The possibilities offered by chipping methods in the



harvesting of timber must be given particularly serious attention. They include simultaneous lowering of costs and increasing the amount of the raw material harvested and, in some cases, increasing employment and improving environmental protection.

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