TESTING TWO NOVEL STUMP-LIFTING HEADS IN A FINAL FELLING NORWAY SPRUCE STAND

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ABSTRACT: The use of stump and root wood chips has increased very rapidly in the 21st century in Finland: in the year 2000, the total consumption of stump wood chips for energy generation was 10 GWh, while in 2008 it was around 1.2 TWh. Metsäteho Oy and TTS Research tested two new stump-lifting devices for lifting stumps in a final felling Norway spruce (*Picea abies*) stand. In the time study with the Väkevä Stump Processor lifting head, the productivity of stump lifting was 7.5 m^3/E_0-hour when lifting spruce stumps with a diameter of 30 cm from clayey soil, and 8.3 m^3/E_0-hour when lifting spruce stumps from sandy soil. When lifting stumps with a diameter of 40 cm, the stump-lifting productivity was 9.0 m^3/E_0-h (clay) and 10.5 m^3/E_0-h (sand). The results of this relatively restricted test indicated that the Väkevä Stump Processor is a reliable and effective stump-lifting head that enables the harvesting of high-quality stump raw material for energy generation. The stump lifting productivity of the other lifting head (Järvinen) was lower than that of the Väkevä Stump Processor. Some development suggestions for the Järvinen lifting head were presented and discussed.
Keywords: Stumps, Harvesting, Productivity.

1 INTRODUCTION

The harvesting and use of stump and root wood as a raw material in pulp production and energy generation were comprehensively investigated during the 1970's and 1980's in Finland [e.g. 1–7]. However, research on this topic ceased because the costs of stump wood harvesting were too high at that time. The intensive development of stump and root wood harvesting was recommenced by UPM Forest in Finland in the early 2000's [8].

In 2008, the total consumption of forest chips for energy generation in Finland was equivalent to 9.2 TWh (4.6 mill. m^3) [9]. Of the forest chips used in heating and power plants (8.1 TWh), the majority (58%) was produced from logging residues in final cuttings in 2008 [9]. 14% were derived from stump and root wood and 4% from large-sized (rotten) roundwood. 24% of the total amount of commercial forest chips used for energy generation came from the small-diameter thinning wood produced in the tending of young stands [9]. The use of stump and root wood chips has increased very rapidly in the 21st century in Finland (Fig. 1): In the year 2000, the total consumption of stump wood chips for energy generation was 10 GWh (5,000 m^3), while in 2008 it was nearly 1.2 TWh (573,000 m^3) [9].

Development of the supply chain of stump wood chips has contributed to the drastic increase in stump wood consumption. Promising development work has been carried out in the forest, as well as at the energy plants. An important factor in the creation of an operational, cost-effective supply chain has been the development of the stump-lifting technology. However, the cost-effective lifting of stumps in the future requires further development.

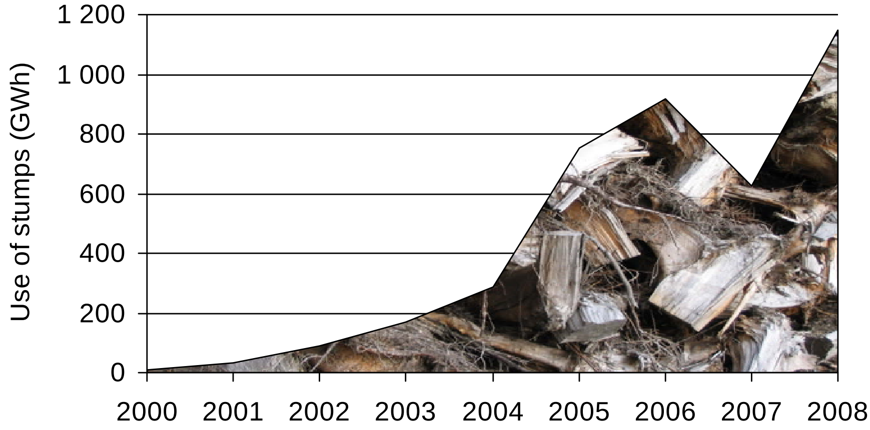

Figure 1. Consumption of stump and root wood chips for energy generation in the 21st century in Finland [9].

There are very challenging targets for the future usage of forest chips in Finland. The aim is to increase the annual consumption of forest chips for energy generation up to 10 TWh by 2010, and up to 24 TWh by 2020 [10–12]. According to the latest calculations [13], the potential amount of techno-economically harvestable forest chips is annually 11–28 TWh, of which stump and root wood accounts for 2–11 TWh, which is strongly dependent on the price level for emission rights. Moreover, when the managers and developers of energy wood procurement companies in Finland were interviewed in 2007, they estimated that the proportion of stump wood chips and chips out of the small-sized thinning wood consumed by energy plants will increase significantly in the future [14].

Metsäteho Oy and TTS Research tested two novel stump-lifting heads (the Väkevä Stump Processor lifting head and the Järvinen stump-lifting device) for lifting stumps in a final felling Norway spruce (*Picea abies* L. Karst.) stand. No time studies had earlier been carried out on either stump-lifting head. The main findings of the study are presented in this conference paper.

2 MATERIAL AND METHODS

2.1 Lifting heads

Armas Hirvonen (A Hirvonen Oy) designed and built the Väkevä Stump Processor lifting head (www.ahirvonenoy.net). The Väkevä Stump Processor has received a warm welcome among the stump-lifting entrepreneurs; it is currently one of the most popular stump-lifting heads in Finland [15]. Considerable interest has also been shown in the Väkevä Stump Processor abroad, for instance in Sweden. So far, the Väkevä Stump Processor lifting head has been supplied for some 70 stump-lifting machines. The weight of the Väkevä Stump Processor tested was about 1.3 tonnes.

The Väkevä lifting head includes two lifting spikes, a hydraulic splitting knife, and a site preparation element, as required by the customer (Fig. 2). The stump is split with the splitting knife while it is being extracted. The splitting knife is also used for chopping and cleaning lifted stumps.

The working principle of the stump-lifting device developed by Markku Järvinen (Oy Kappeliranta - Kapellstrand Ab) is as follows:

1. The lifting device is moved onto the stump.
2. The clamshell bucket, with four spikes on either side, grabs the stump.
3. The stump is lifted from the ground by means of four lifting cylinders attached to the outer ring of the lifting device.
4. The stump is dropped from the lifting device onto the stump heap or windrow on the ground (Fig. 3).

Figure 2. The Väkevä Stump Processor lifting head tested in the time study. Photos: Kalle Kärhä / Metsäteho Oy.

Figure 3. The work cycle of the Järvinen stump-lifting device.

The Järvinen stump-lifting device can be used with excavators, as well as with forest machines. A Yuchai 135 excavator, and Timberjack 1470B and Ponsse HS16 Ergo harvesters have been used as base machines in earlier tests. The current version of the Järvinen lifting device weighs around 1.8 tonnes.

2.2 Study stand

In the time study, both stump-lifting heads were fitted on a Hitachi EX 225 USR tracked excavator that weighed 24 tonnes (Fig. 4). The excavator operator had six years' experience in stump lifting with traditional stump rakes and stump-lifting devices with splitting knives. The operator had lifted stumps with the Väkevä Stump Processor lifting head for about six months. The operator had tested the Järvinen stump-lifting device for less than two days before the time study.

Figure 4. Hitachi EX 225 USR tracked excavator equipped with the Väkevä Stump Processor lifting head in the time study.

The time studies were carried out at the harvesting site of Stora Enso Wood Supply Finland at Siuntio (60°15'N, 24°05'E), Southern Finland, at the turn of September-October, 2008. All the stumps lifted with the Järvinen lifting device were in a clayey soil. Most of the stumps lifted with the Väkevä stump-lifting head were also in a clayey soil. Part of the study site for the Väkevä Stump Processor was in a sandy soil.

Because the felling area was being converted to arable land, all the stumps were lifted from the site during the time study. All the stumps with a diameter larger than 10 cm were measured for the study in advance. Stumps of less than 15 cm in diameter, and Scots pine (*Pinus sylvestris* L.) and hardwood stumps (only a few present), as well as rotten stumps from earlier fellings, were excluded from the time study material. The final material for the Väkevä Stump Processor lifting head included 226 Norway spruce stumps, with an average stump diameter of 33 cm (min: 15 cm … max: 64 cm) (Fig. 5). The final material for the Järvinen stump-lifting device included 207 Norway spruce stumps, with an average stump diameter of 38 cm (min: 15 cm … max: 68 cm) (Fig. 5).

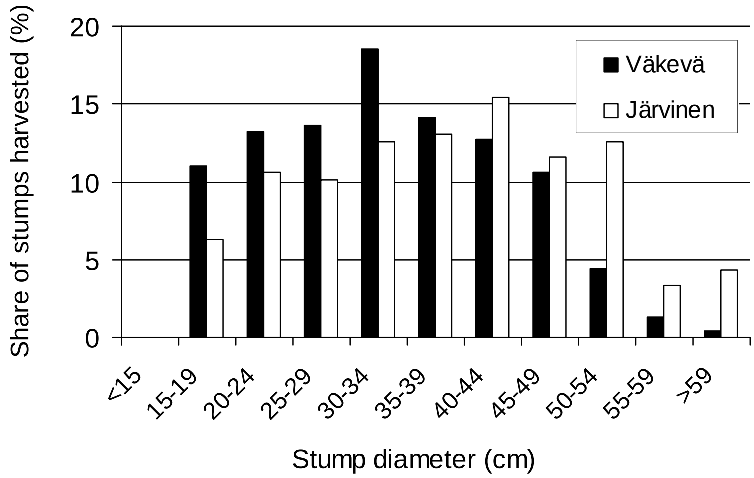

Figure 5. Stump diameter distributions for the Väkevä and Järvinen stump-lifting heads in the time study.

3 RESULTS

3.1 The Väkevä lifting head

41% of the total effective time (excluding delay times) consumption of the time study was used in chopping and cleaning the stumps. Cleaning stumps lifted from clayey soil took more time than those lifted from sandy soil. More than one-fifth of the effective time was consumed in actual lifting the stumps, i.e. extracting them from the ground. Correspondingly, moving the pieces of stump to the heap and heaping them up took less than one-fifth of the effective time. One-tenth of the effective time wa spent in moving the lifting head to the stumps to be lifted, and less than one-tenth in moving from one working location to another at the site.

No site preparation for stand regeneration was carried out because the site was a land clearance site. When generalizing the results, we should remember that the practice of not performing site preparation in connection with stump lifting has recently gained support in traditional forest stump lifting, but it is carried out by a forest tree planting machine bringing up the rear.

In the time study with the Väkevä Stump Processor, the effective hour productivity of stump lifting was 7.5 m^3/E_0-h when lifting Norway spruce stumps with a diameter of 30 cm from clayey soil, and 8.3 m^3/E_0-h when lifting spruce stumps from sandy soil (Fig. 6). When lifting stumps with a diameter of 40 cm, the effective hour productivity of stump lifting was 9.0 m^3/E_0-h (clay) and 10.5 m^3/E_0-h (sand) (Fig. 6).

3.2 The Järvinen lifting head

Almost one half of the total effective time consumption of the time study was used in the stump-lifting operation (i.e. extracting the stump from the ground). The work elements involved in taking the lifting device to the heap and dropping the stump on it took up one quarter of the effective time consumption. Moving the lifting device to the stumps took less than one-fifth of the effective time. Moving from one working location to another took almost one-tenth of the effective time consumption.

Stump chopping was not actually performed by the lifting device. However, some stumps were chopped when the clamshell spikes of the lifting device ripped into them as they were lifted. Some of the stumps came out of the ground intact.

When the diameter of the lifted stump exceeded 40 cm there was a clear increase in the time consumption per stump. The average processing time (from moving the lifting device to the stump to dropping the stump onto the heap) with stumps under 40 cm was 55 seconds/stump. The average processing time with stumps over 40 cm was more than two minutes.

The effective hour productivity of stump lifting was 6.2 m³/E_0-h when lifting spruce stumps with a diameter of 30 cm (Fig. 6). When the stump diameter was 40 cm, the effective hour productivity of stump lifting was 8.3 m³/E_0-h. The maximum lifting performance was around 9 cubic meters per effective hour. This was achieved when lifting stumps with a diameter of 54 cm (Fig. 6).

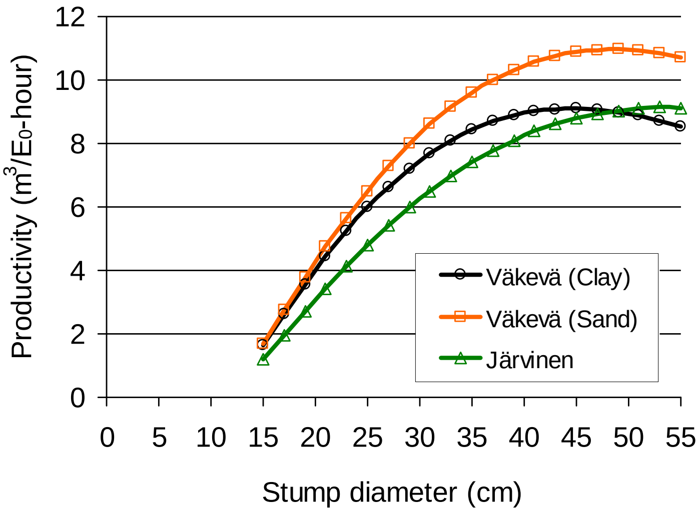

Figure 6. Effective (E_0) hour productivity of spruce stump lifting with the Väkevä Stump Processor in clayey and sandy soils and the Järvinen stump-lifting head. No site preparation was performed for stand regeneration.

4 DISCUSSION AND CONCLUSIONS

4.1 The Väkevä lifting head

It is difficult to compare stump-lifting productivity data from various studies directly. Many aspects have to be taken into account:

- What type of equipment (basic machine, lifting head with or without a splitting knife) was used,
- What was the working method (only lifting, or lifting & site preparation),
- What was the operator's experience in lifting work, and his/her carefulness and efficiency when cleaning and chopping lifted stumps, and
- What were the harvesting conditions (e.g. stump size, stoniness, soil type (fine sand, sand, clay)).

Based on this relatively limited test, we can state that the Väkevä Stump Processor is a reliable, effective stump-lifting device that enables the harvesting of high-quality stump raw material for energy generation [cf. 16]. High-quality stump raw material has the following properties: sufficient size of the stump pieces, and very little mineral soil attached to the stumps.

4.2 The Järvinen lifting head

The productivity of stump-lifting work with the Järvinen lifting head in the time study was smaller than the productivity of earlier stump-lifting studies [e.g. 16]. However, this was undoubtedly affected by the fact that the lifting device was still in a prototype stage, and that the operator also had little experience with this lifting head.

Furthermore, a harvester with more powerful hydraulics would probably have enhanced the lifting work. It is also important to note that there was no rotator between the boom of the excavator and the lifting head. The lifting device suspended from four short chains caused additional work for the operator, e.g. when placing the lifting head onto the stump to be lifted.

There were four spikes on either side of the lifting device clamshell. The spikes should be longer in order to penetrate deeper into the stump. Re-designing the spikes would also give them a better grip on the stump to be lifted.

The diameter of the outer ring of the lifting device is 1.95 cm. The diameter could be larger, e.g. 2.2 to 2.3 meters, especially when lifting large stumps (d_0>40 cm). In the study, the sharp bottom edge of the outer ring easily cut lateral roots up to a diameter of 5 to 10 cm. The lateral roots of larger stumps were thicker, and also were often located so close to the outer edge of the ring that they were not cut easily. In this case whole stumps, “bats”, were lifted, causing problems in off- and on-road transportation, as well as in storage.

A lot of mineral soil was still attached to some of the lifted stumps, although the operator tried to remove it by dropping the stump from a height onto the ground. The removal of soil material was also difficult because the harvesting site was on clayey soil, and it had rained a lot before the time study. In order to cope with the problem of “dirty” lifted stumps, Markku Järvinen has developed and patented a cleaning grapple that can be attached to a stump forwarder or energy wood truck.

Markku Järvinen, who developed the stump-lifting head, is currently looking for partners to participate in the development and commercialization of the lifting head.

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