A NEW TYPE OF RENEWABLE ENERGY SOURCE DERIVED FROM FORESTRY

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Abstract:
In forestry, dendromass for energy purposes can be obtained in the form of firewood. Alternatively, it can be sourced as so-called logging debris, which remains in the forest after logging trees, among other things, as stumps or roots. Stumps and roots are difficult to transport and contain a large proportion of soil and stones. One of the possible ways of stump extraction is with grubbing heads.
Therefore, a new prototype of a grubbing head has been developed and it will be used to obtain logging waste from forest clearance areas. The advantage of this grubbing head is that it is possible to move the stump after it has been torn out, so that the soil is separated from the stump. The surface is then adjusted and aligned with the head. With the help of the excavator boom, parts of the stump are stored in piles, from which they are transported to the dendromass storage. After reaching 30% moisture, they are pulverized into energy chips, which are then taken to an incinerator or power plant. The resulting wood chips have an optimal calorific value and are presented as a renewable energy source produced from logging debris.
After processing all the data, which are based on several field measurements undertaken, the average processing time of one stump was found to be three minutes. In one hour, an experienced operator is able to process up to 20 stumps on average.
Key words: dendromass, grubbing head, logging debris, renewable energy source, woodchip
JEL Classification Codes: O13, O30, Q23, Q42, Q50

Introduction

The current situation regarding the so-called bark beetle calamity offers consumers a large amount of wood in the form of firewood. However, after the cutting down of these "bark beetle" mature trees, large forest clearing areas often remain, on which there is a large amount of unused wood mass in the form of stumps and roots, which would rot in a few years. However, it is not advisable to leave stumps for gradual decomposition, as wood-destroying fungi may occur in some localities, in which the rot is transferred to the root systems. There would be a risk that new plantings on regenerated areas would be infected with this fungal pathogen from the beginning. Therefore, it is desirable to use this wood material for further processing. One of the possible ways to extract this wood waste is with grubbing heads.

For this reason, a new prototype of a grubbing head was developed at the Faculty of Forestry and Wood Technology of Mendel University in Brno, which will be used to obtain this wood material. This is because we can obtain dendromass from forestry not only in the form of firewood, but also as so-called logging debris, which remains in the forest after logging in the form of branches, cuttings, stumps or roots. We

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estimate that stumps on an area of at least 1,000 ha could be grubbed up annually in the Czech Republic, which, with a stock of stump wood of approx. 50 m^3 / ha, represents an annual source of approx. 50K m^3 of stump wood.

Literature review / Research Background

Logging creates numerous clearing areas in the middle of the involved stands (HUNTER et al. 1999, p. 2). On such clearing areas, there is a lot of so-called logging debris in the forests, which could be used to produce heat. After main felling, 35 to 40% of the dendromass produced + bark remains in the forest without direct benefit, 10% for conifers and 15% for deciduous trees. Thus, about 50% of the dendromass produced is removed from the forest. Almost the same amount in the form of bark, stumps, roots, branches, tree tops and assimilation organs remains in the forest stands (Simanov 2008, p. 33).

Dendromass from forestry can be used for energy by direct combustion without its dimensional adjustment, or in the case of wood, after cutting, splitting, chipping or crushing (Neruda et al. 2015, p. 201).

However, stumps and roots are obtained by grubbing up underground parts of trees (Neruda et al. 2015, p. 217). Until recently, grubbing-up was common in the Czech Republic only in some forms of forest management, or in the case of deforestation. Currently, there is an effort to use this secondary source of biomass, which will arise after tree felling, for energy purposes. Technologies are also being developed that are able to process this material efficiently.

The most common way of stump extraction in the Czech Republic is to grub them with a bulldozer blade. After grubbing-up, stumps are usually folded by bulldozers into ramparts or terrain depressions, in which they are left to disintegrate naturally. Locally, the so-called "burial" of stumps is also carried out, during which a ditch is excavated and into which the stumps are piled up and covered with soil (Neruda et al. 2015, p. 217). The disadvantage of this system is the non-usage of wood for further processing.

A very important feature of a dendromass intended for energy utilization is its calorific value and the associated moisture. In general, it can be said that with increasing moisture of biomass, its calorific value decreases and vice versa. It is due to the fact that the heat generated by combustion is consumed during the evaporation of the water contained in the biomass (Simanov 1993, p. 116).

Forest dendromass always contains at least 10% water. Freshly felled wood has a moisture content of 40 - 60%, so it is necessary to let it dry for at least 2 years. This brings it to a value of 15 - 20%, which is much more advantageous for combustion (Pastorek et. al. 2004, p. 286).

When burning wood from standing trees, a larger part of energy is used to dry it out than with other fuels. Because wood moisture has a large range, its effective calorific value also has a large range (Neruda et al. 2015, p. 210). The same is true when burning stumps or roots. Therefore, it is recommended to allow this organic material to dry before using it, for example in incinerators.

Methodology

Operational tests of the prototype grubbing head were carried out at location LZ Boubín, Lesy ČR, s.p. in November 2020. The grubbing head was mounted as an adapter for the boom of the JCB 220 crawler excavator and was controlled by remote control from the excavator cab.

The stump was first cleaved in the soil with the help of a cleaving arm of the grubbing head and pulled out of the ground in parts to a height of about one meter. During the subsequent position of the head above the ground, the soil and stones, which were located on the cut stump or between the root system, were released. The advantage of this grubbing head is the possibility to move the stump, or its parts, after being pulled out of the subsoil, until the soil and other undesirable materials are separated from the pulled stump. The soil fell into the space where the stump was torn out, and with the help of the bottom part of the head body, the surface was subsequently adjusted, leveled and compacted. This operation cannot be performed when using other types of grubbing heads.

With the help of the excavator's hydraulic boom, parts of the stump were then stacked. The number of the piles and the distance between them were mainly determined by the reach of the boom of the used excavator, which carries the grubbing head. During the operational tests, the distance between the piles was about 12 meters.

The last operation occurred during the transport of parts of the stumps by a modified tractor vehicle, which transported this logging waste from the created piles from the clearing area to the dendromass repository. They were stored there until their moisture content reached 30%.

After reaching this value, with the help of crushers, they were pulverized into energy chips. It was then transported in containers to the incinerator as a renewable energy source, which has an optimal calorific value and is produced from forestry.

Results

After completion of the operational tests of the grubbing head prototype, during which a sufficient statistical set of ripped out and cleaned stumps were left in the clearing following stump extraction of Norway spruce, the average time spent on one torn and cleaned stump was recorded as 1 min 21 s. One stump is defined as the remaining stump: the part of the trunk that remained rooted in the ground after the tree was felled. Using existing techniques and technology, this process would not currently be possible, even if the stumps were not cleaned of soil and similar unwanted material.

After processing all data providing real values, which are based on several field measurements, the average processing time of one stump, including the treatment of the subsoil after extraction and moving the excavator to the next stump, was found to be three minutes. In one hour, an experienced operator is able to process an average of up to 20 stumps occurring on the clearing. A more detailed percentage distribution of individual work operations spent on processing one stump, which

occurs after logging, is presented in Figure 1. In our measurement, stumps were torn out, the diameter of which ranged from 15 to 80 cm, while the diameter of the stump did not significantly affect the time needed to tear them out. The soil, the number of stones in the root system and the level of experience or training of the operator had a significant influence on the processing time of stumps, both for the actual handling of the excavator and for the handling of the adapter in the form of a grubbing head.

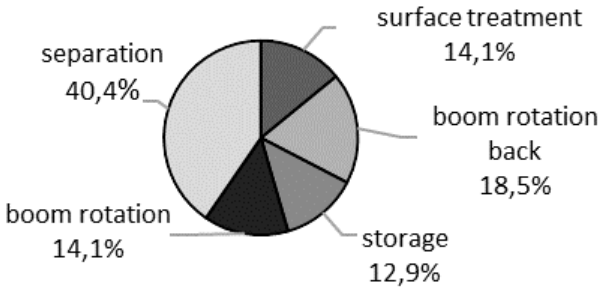

Figure 1. Percentage distribution of individual operations during stump grubbing

Discussion

Although in the Czech Republic, stump extraction for energy purposes is currently an almost unused process, which could also reduce the cost of subsequent preparation of the clearing for reforestation (Eriksson, Gustavsson 2008, p. 2), in Finland, the grubbing-up of stumps and coarse roots has been gradually increasing since 2000. In 2010, the increase in the extraction of this logging waste was approximately 20% compared to the previous year. (Ylitalo 2011, p. 139).

Although stump extraction was identified in the 1930‘s as one of the most promising technologies in the forestry sector for securing the supply of solid biofuels (Lazdiņš, Zimelis 2012, p. 1), Stupavský et al. (2008, p. 32) claims that logging residues are still a little - used source of renewable energy, with the exception of the Scandinavian countries. This opinion is shared by Melin et al. (2010, p. 1) and Alam et al. (2012, p. 1), who agree that in Finland a large part of the current forest harvest for energy from dendromass represents residues after harvest, i.e. the tops of trees, branches, leaves, but also stumps and strong roots. In Latvia, by contrast, forest dendromass is becoming increasingly important for forest owners and the forestry industry. In Latvia, post-logging waste is used to produce biofuels and has become a widely accepted technology in both public and private forests. (Lazdiņš, Zimelis 2012, p. 1). According to von Hofsten (2006, p. 5) Norwegian spruce is the main tree species in the Scandinavian countries and it is the focus of stump extraction. At the same time, he states that the methods used for stump extraction in 2006 remove the above-ground part of the stump as well as coarse roots with a diameter of more than 5 cm. This results in a recoverable stump biomass consisting of 32% aboveground stump wood and 68% root stump wood (Hakkila 1975, p. 14).

Stumps consist of wood and the bark of a harvested tree. Extraction is carried out with heavy machinery after tree felling. Usually excavators are used, which are equipped with special teeth for stump extraction, which can divide the stumps into smaller pieces. The harvested wood mass, which is obtained from stumps and roots, represents 23-25% of the biomass of the trunk wood in both spruce and pine (Eriksson, Gustavsson 2008, p. 1). Alam et al. (2012, p. 1) report that in mature forests, stumps and strong roots represent about 25-30% of the total tree biomass. A year later, the same author published that it was found that stump and root extraction can increase total biomass production (energy biomass and trunk wood) by approximately 21-36%. (Alam et al. 2013, p. 12).

The amount of stumps and strong roots available on the clearing after harvesting depends on the type of forest management. These have a significant impact on the growth rate and further development of forest stands (Renshaw et al. 2009, p. 11). In order to obtain more sources of biofuels from forests, stumps are sometimes harvested after felling (Ranlund, Victorsson 2018, p. 1). Stumps and their strong roots are becoming an important as a source of bioenergy due to growing concerns about climate change. For instance, in Sweden it is estimated that stump extraction could replace 2.5-5% of the energy currently obtained from fossil fuels (Victorsson, Jonsell 2016, p. 1). The same opinion is shared by Björheden (2006, p. 1), who argues that the utilization of bioenergy through logging waste, which will remain on the clearing after tree felling, is growing due to concerns about climate change and the growing demand for bioenergy.

The energy content of stumps varies in different studies (Lazdiņš, Zimelis 2012, p. 1). According to studies in Finland (Hakkila 2004, p. 98) approximately 140 to 160 MWh/ha can be obtained. Tekes corporation provides 200 MWh/ ha (Tekes 2004, p. 2). Von Hofsten (2006, p. 3) believes that stump extraction has the potential to produce 5-10 terawatt hours (TWh) per year.

Conclusion

The results show that the use of this new prototype of a grubbing head represents a fast and harmless way of obtaining so-called logging debris in the form of stumps and roots that remain in a clearing after logging. This extracted waste will not be left on clearings for gradual decay, but will be used as a renewable energy source that can be used in heating plants or incinerators. Also the surroundings around the torn-out stump will be minimally disturbed and after the tear-out with the head will be modified. The stump extraction will thus enable a fully mechanized restoration of forest clearings, which will be free of "stump obstacles". Additionally, in premature stands where the frequency of stumps is higher, it will bring new economic opportunities with a link to extensive calamity logging in all forest stands.

Directive 2009/28 / EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources sets a target for the European Union as a whole to achieve a 20% share of energy from renewable sources in final energy consumption by 2035. One way to meet the target for forestry is to secure a new source of renewable energy by extracting stumps and roots in an

economic and environmental way. One of the significant obstacles to the development of bioenergy projects in the conditions of the Czech Republic is the current high costs of heat production from biomass compared to fossil fuels. The utilization of tree stumps is one of the possible alternatives to additionally mobilize the unused potential of these types of sources of high quality energy chips.

This article contains partial results because the research is still ongoing. Further results will be supplemented and commented in another subsequent article, after the end of the research.

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