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ANALYSIS OF FULL MECHANIZED WOOD CHIPS HARVESTING PROCESS IN THE YOUNG THINNING STANDS

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Abstract: *In Poland more than a half of timber volume is harvested during thinning operations. About 230 thousand cubic meters of low-quality wood are chipped directly at the forest roadside. This kind of assortment can be used to production of fibre boards, particle boards or can be used as an energy source and burnt at the heating plants. The most common way of the harvesting processes in such stands is to work on the motor-manual level with a chain saw use. Hardly ever are applied fully mechanized timber harvesting processes, mainly due to relative high production costs.*
This paper presents work productivity and costs of the fully mechanized wood chips harvesting process where for felling the harvester Ponsse Beaver with a guillotine-style grapple head was applied, designed for multi-stem harvesting. Delimbing and bucking were done in forest by the Hypro 300 processor mounted on the John Deere 5515F agricultural tractor. Afterwards wood was forwarded by the Ponsse Gazelle machine to the forest roadside where it was chipped by the Bandit 254 chipper with a special designed wood feeder contributing to better work efficiency of the whole production system.

1. Introduction

Natural development stage of human activity is to put into effect many new solutions which could contribute to easier work. In the 20th and 21st centuries has been observed a very fast development of technical ideas. This process is noticeable in all aspects of our life, in forestry as well. In European forests have appeared machines which can not only fell trees but also cut them to small pieces, called wood chips. Chips dimensions are included in a range from several millimeters to several centimeters. Depending on the tree species, tree parts, timber sort and dimensions they can be designed for the production of cellulose, particle and fibre boards or for an energy production (Rzadkowski, 1995).

In many cases, during the chipping, is utilized low-quality wood which comes from the forest cleaning and thinning. In Poland, in young pine stands improvement cuts are done relatively often, every 6-8 years, depending on the quality of the standing crop. In this kind of stands, to this time, timber harvesting have been based mainly on chain saws and agricultural tractors. But along with the labour market opening in many EU countries for the new ones, in Poland is starting a problem with the lack of work force interested in providing services, as contractors, to the main owner of Polish forests ‚State Forests NFH' managing 78,2% of the total forest area. As a result of this situation, the contractors have no choice and have to buy new machines reaching high performance.

Taking machines mobility into consideration, wood chippers can be divided into two groups: stationary machines, located mainly at the industrial plants and mobile machines. The second ones can be coupled on an agriculture tractor, mounted on the agricultural tractor, forwarder, bagger or truck.

This paper presents research results of the Bandit 254 wood chipper work and other machines which fell trees, process them and transport wood.

2. Material and method

The research was carried out in the Gidle Forest District on three forest plots (Table 1). The total number of cut trees came to 4420. The main source of the wood chips harvesting in Poland are Scotch pine stands, where in a young stand age are done improvement cuts like clearing or thinning. In the case of analyzed harvesting plots the second selective thinning was carried out.

Table 1: Describing of the research plots

Research location	1 – 95g	2 – 95i	3- 50f
Area [ha]	0.70	3.18	2.15
Age of the stand [years]	34	33	30
Number of cut trees	396 (566/ha)	2402 (755/ha)	1622 (754/ha)
Average stem volume [m^3/tree]	0.07	0.06	0.06
Cutting intensity [m^3/ha]	40.96	46.35	47.01

One of the factors determining the possibility of machine driving through the forest area is an appropriate developed net of strip roads. They were established parallel. Distance between strip roads in all three stands was the same - 20 m, which corresponds to a two maximal boom reaches of the harvester. All machines involved in the process are presented in Table 2.

Table 2: Machines used in the analyzed process

Machine type	**Work place**	**0peration**
Harvester Ponsse Beaver with EH25 head	harvesting site	tree felling
Agricultural tractor John Deere 5515F with the processor Hypro 300	strip road	delimbing, bucking
Forwarder Ponsse Gazelle	strip road – forest road	forwarding
Agricultural tractor Ursus 1634 with the chipper Bandit 254	forest road	wood chipping

A time study was carried out using a continuous-timing method. Work efficiency of all machines was analyzed. There were taken into consideration a structure of work day, a productivity rate and costs.

3. Results and discussion

Tree felling was done by the harvester Ponsse Beaver equipped with a guillotine-style grapple head, designed specially for an energy wood harvesting. Originally, according to a producer's assumption, this head can fell and collect several trees. In Polish conditions, in young pine stands, this operation is not so easy to do because of much higher stand density than in Scandinavian countries. For this reason the machine operator could fell mainly one tree and gather it in bundles at the strip road. An achieved productivity rate was not so high and came to 4 m^3/h (Table 3). It is worth mentioning that in the same conditions a small class harvester, equipped with chain saw head for felling and processing trees can reach comparable work productivity (Moskalik, 2004).

Hourly work costs of the harvester depend on work time period during a year. If the machine is used in one shift, it means 8 hours, costs reach 75 €/h. Calculated unit cost of tree felling in analyzed stands is relatively high and is running at 18.5 €/m^3.

The collected at the strip road trees were pulled to the processor by a winch mounted at the machine head. This operation was done by a machine operator. Trees were processed individually. Work productivity rate varied from 2.23 to 2.38 m^3/h. Figure 2 shows the hourly work costs of the processor and tractor set. They depend, like at the previous machine, on the work period in a year. Calculated unit costs, by the assumption that work lasts on average one shift, reached 10.1 €/m^3.

Table 3: Productivity rate of the harvester Ponsse Beaver and the processor Hypro 300

	Productivity rate						
	1- 95g		2- 95i		3- 50f		Mean productivity rate
	m³/ work day	m³/h	m³/ work day	m³/h	m³/ work day	m³/h	m³/h
Harvester Ponsse Beaver with EH25 head	40.96	4.10	43.30	4.33	40.43	3.37	3.93
Processor Hypro 300	19.91	2.23	21.39	2.38	20.21	2.25	2.29

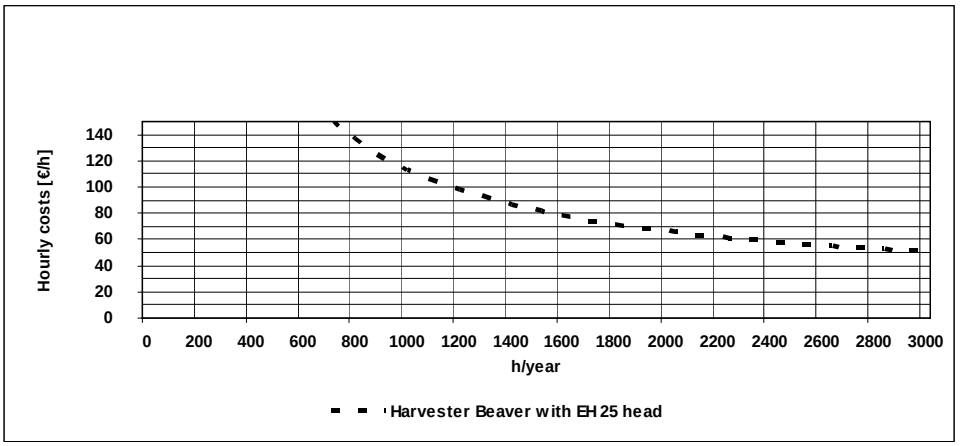

Figure 1: Hourly work costs of the harvester Beaver with the EH25 head depending on the working hours in a year

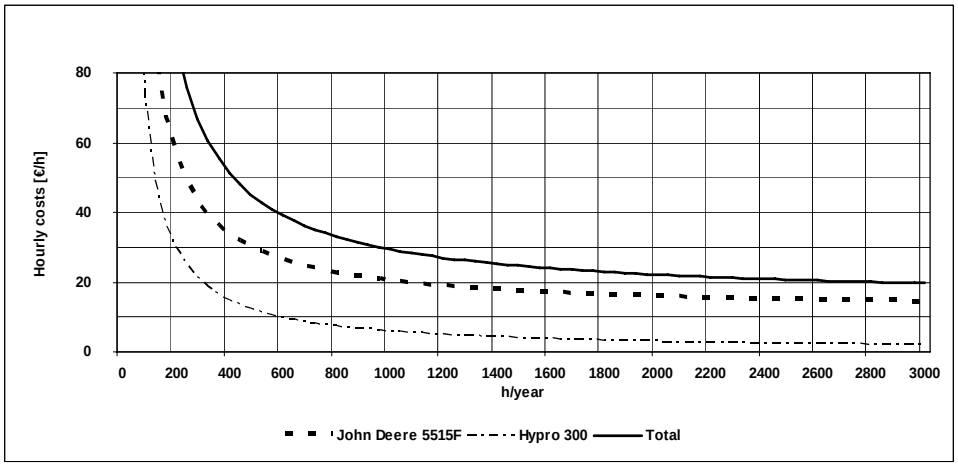

Figure 2: Hourly work costs of the tractor John Deere 5515F equipped with the processor Hypro 300 depending on the working hours in a year

It is worth mentioning that in comparison to operations done on the motor-manual level the achieved costs are much higher. Costs of wood harvesting for an operator equipped with a chain saw, in this kind of stands, are in Poland not higher as 13 €/m^3. The main reasons of this situation are high purchase prices of the machines and relatively low productivity rates.

Processed wood was forwarded from the strip roads to the forest road by Ponsse machine Gazelle. The 20 work cycles were measured. The forwarder transported wood on the distances from 100 m up to 950 m. Figure 3 shows a regression line of the machine productivity rate depending on forwarding distance. Adequately were calculated the unit costs (Figure 4). They reached 4.2 €/m^3 at the 500 m forwarding distance.

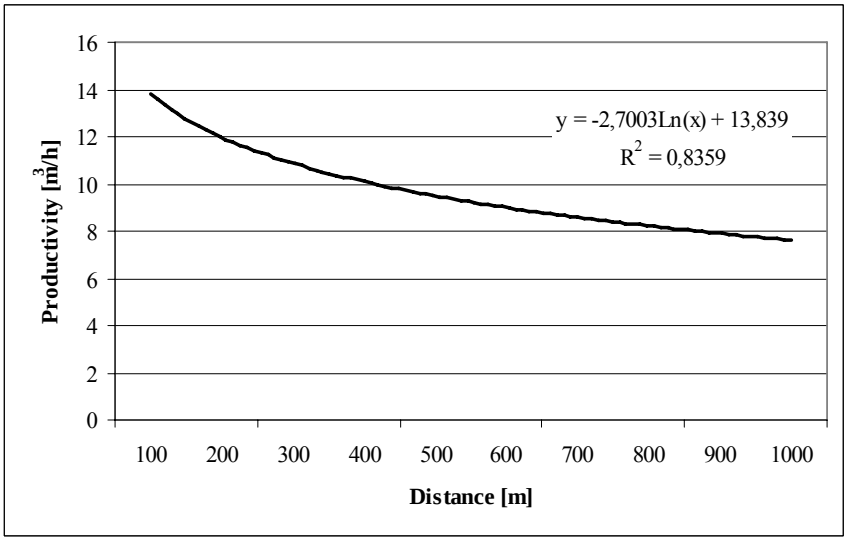

Figure 3: Productivity of the forwarder Ponsse Gazelle depending on the forwarding distance

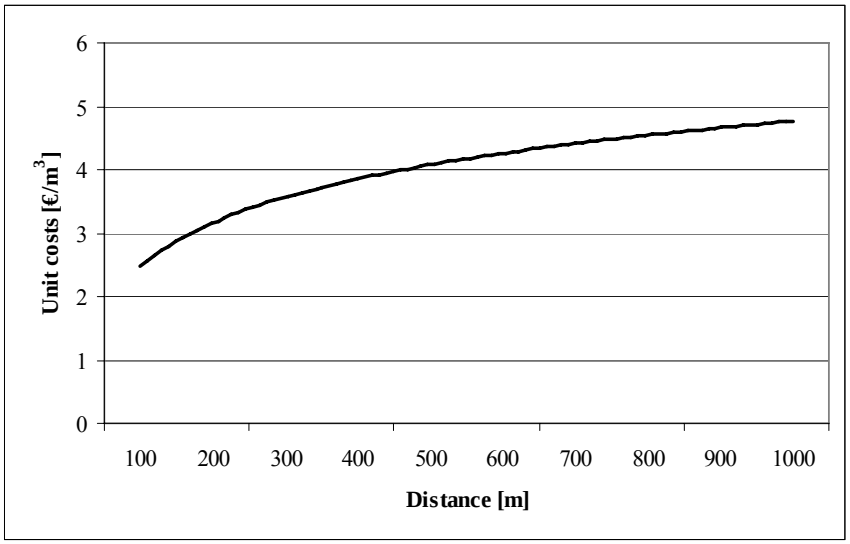

Figure 4: Unit costs of the forwarder Ponsse Gazelle depending on the forwarding distance

The last processing operation was a chipping. There was used the Bandit 254 chipper with a special designed wood feeder. It allowed to reach much higher productivity rates in comparison with a standard equipped machine. During 2-year work period machine produced over 60 thous. m^3 of wood chips. It is a very good result, but so high intensive work caused a significant machine wear.

A 3-day time study of wood chipping was carried out. A pie chart presented in figure 5 shows that the highest share of work time was spent on the chipping, over 60%. Moving to the other places, to new wood piles took 11%.

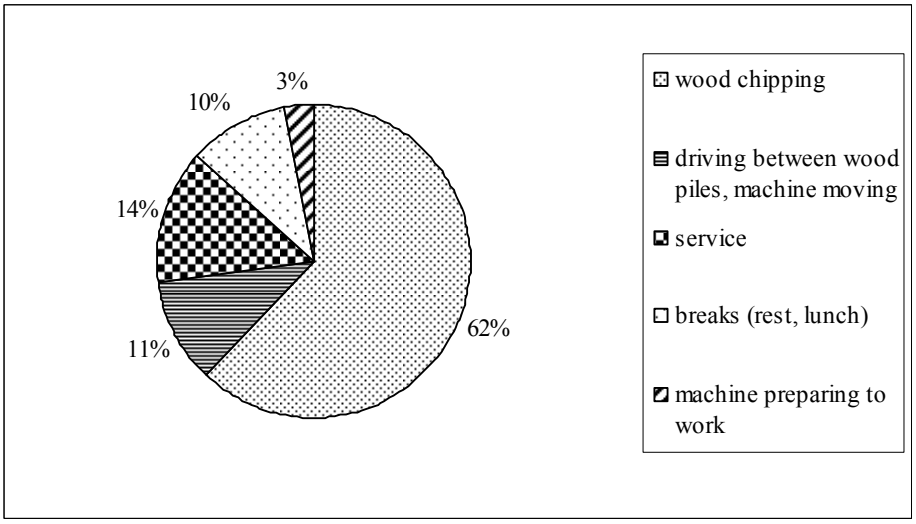

Figure 5: Work time structure of wood chipping by the Bandit 254

During a study period the chipping productivity rate reached 14.8 m^3/h. Figure 6 presents hourly work costs of the tractor Ursus 1634 equipped with the chipper Bandit 254, depending on the working hours in a year. Taking into consideration one shift work, at the achieved productivity, unit costs reach 4.9 €/m^3. It is not different from other Polish research results oscillating between 4-5 €/m^3 (Płotkowski, 2003, Suwała, 2004)

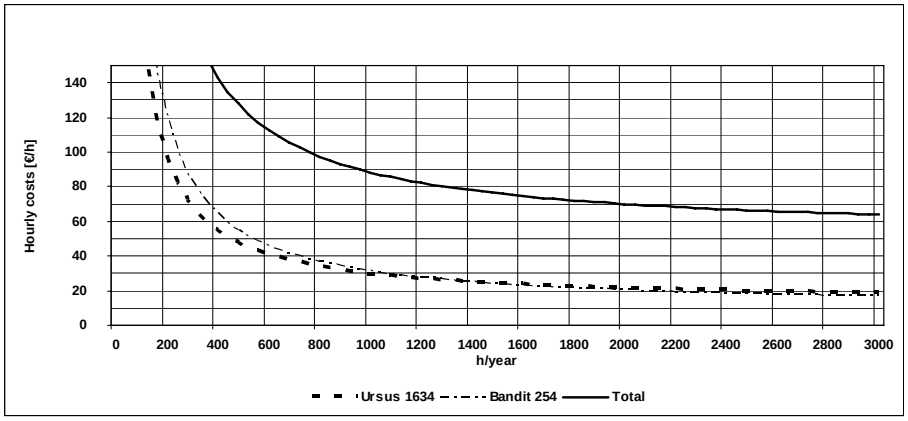

Figure 6: Hourly work costs of the tractor Ursus 1634 equipped with the wood chipper Bandit 254 depending on the working hours in a year

Chipped wood is directly thrown to containers which in the next part of the process are transported by special tractors to the hauling roads and loaded on trucks. The question of efficient production of wood chips is connected to the reduction of transportation costs to the industrial plants (Stampfer and Kanzian, 2006). For that reason, it is necessary to calculate all operations, from the beginning of wood harvesting work to the delivery of wood chips to the plant.

4. Conclusions

In European forestry has been observed a rapid development of the work mechanization level, especially in forest operations connected with timber harvesting. Every year on the market appear new machines which are more and more adjusted to specific forest conditions. On the one hand they should be economically effective; on the other hand they have met all requirements of a balanced forestry management. It concerns particularly young stands where the reduction of damages to trees and soil is very important.

Exploitational analysis of the harvester, equipped with the guillotine-style grapple head, shows that in the Polish forest conditions are reached low productivity rates, which together with relatively high hourly costs contribute to very high unit costs of wood harvesting.

Use effectiveness of the processor Hypro 300 depends on many factors, like mean stem volume of processed trees, wood quality, operator experience, etc. The maximal reached productivity rates are running only at 2.38 m^3/h. Therefore, in this situation at the high purchase machine prices unit costs are high as well.

Wood chipping at the forest road is popular in Polish state forests, especially in northern and western parts of the country. This way is utilized about 230 thous. m^3 of low-quality wood. The chipper Bandit 254 performance, after some improvements, was very high. The machine produces annually about 30 thous. m^3 of wood chips.

An economic analysis of wood chipping benefits should take into consideration, apart from processing operations, a wood supply costs to the plant.

5. References

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