

Logistic analysis of wood chips procurement chain from forest to power industry plants - method

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Abstract: We present an analysis of the wood harvesting residues procurement process. In this case chips are supplied to large power plants. Analysis is based on data collected in north-eastern Poland. Typical logistic division of the system objects categories are applied - movable or active objects (vehicles skidding, trucks, choppers, etc.) and stationary or passive ones (storage yards, warehouses). To determine the time of execution of the operations by the active objects (machines), because of the stochastic character of the process and its environment, we apply description of uncertain dynamic systems derived from dynamic programming. The necessary data were obtained during field research of wood harvesting and transport process

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1. Introduction

Biomass is one of the most important renewable energy sources. In Poland, due to its geographical location and climate, biomass is the most important renewable energy source. In the case of forest biomass, for energy purposes can be allocated medium sized firewood (retail customers only) and without such a limits, fuelwood (e.g. rejected pulp wood), thin trees and branches and tops from final fellings. The last one is the main source of energy wood in Poland. Harvesting residues procurement is carried out on a large scale and has the character of completely mechanized production process. In its implementation there are numerous interruptions, the occurrence of which can be minimized by conducting analyzes using the methods of operations research and logistics. We present an analysis of the wood harvesting residues procurement process. In this case chips are supplied to large power plants. Analysis is based on data collected in north-eastern Poland.

2. Material and Methods

Investigated process has a clear biphasic nature, in the first phase raw material is processed and transported to the place of transfers (next to forest road), from that point wood material (predominantly chips) is transported to customers – this is second phase. Energy wood harvesting can be described as a parallel process of production, the first and second phase are carried out simultaneously and are interconnected. Typical logistic division of the system objects categories are applied - movable or active objects (vehicles skidding, trucks, choppers, etc.) and stationary or passive ones (storage yards, warehouses). Depots are described by the following characteristics: location, load capacity, input capacity and output capacity. Depots serve as a buffers to reduce the probability of interruptions, that cause downtime and prolongs the process. To determine the time of execution of the operations by the active objects (machines), because of the stochastic character of the process and its environment, we apply description of uncertain dynamic systems derived from dynamic programming.

A typical description of the duration of the cycle (n) of operation (t_i) has the following form:

$$t_i(n) = t_{mi}(n) + w_i(n) + p_i(n)$$

and consequently duration of the process (T_i) after implementation of the n cycles is presented as the following sum:

$$T_i(n) = T_i(n-1) + t_i(n) + z_i(n)$$

A key advantage of the method is the formal record of duration of interruptions (z_i) and thus the possibility of minimizing that time. The duration of the next (n) cycle of operations (t_i) results from the function describing the average duration (t_{mi}), function defining random deviation (w_i) and randomly occurring or planned downtime (p_i). The interruptions (z_i) are described by following equations.

Interruptions at the beginning of cycle number n:

$$z_i(n) = \begin{cases} T_{i-1}(n) - T_i(n-1), & \text{if } T_{i-1}(n) > T_i(n-1) \\ 0, & \text{if } T_{i-1}(n) \leq T_i(n-1) \end{cases}$$

Interruptions at the end of the cycle number n:

$$z_i(n) = \begin{cases} T_{i+1}(n-1) - [T_i(n-1) + t_i(n) + z_i'(n)] \\ 0, & \text{if } T_{i+1}(n-1) > T_i(n-1) + t_i(n) + z_i'(n) \\ 0, & \text{if } T_{i+1}(n-1) \leq T_i(n-1) + t_i(n) + z_i'(n) \end{cases}$$

In order to gather the necessary data, time studies of operation cycles of machines used in the reporting process were performed (e.g. mobile chipper with or without chip bin, forwarder adopted to transportation of tree branches, truck with hook lift container, semi-trailer truck etc.). Variants of machines (vehicles) modifications, that enable to decrease the duration of the downtime, were also considered. The operational cycle can be described in typical way.

As example we present below the operational cycle of mobile chipper.

Operation cycle of chipper has been divided into the following components:

t_1 - driving without load, from the unloading site to the point of start of residues collection and chipping;

t_2 - chipping, containing a collection of the remains using a crane and the necessary movements of the machine;

t_3 - driving back with a cargo (storage tank filled with wood chips) to the place of unloading, after the completion of chipping;

t_4 - discharge, spillage of chips to truck semitrailer.

As a result of field measurements average values of individual times are specified and also probability distributions characterize their variability. For the example variability of mobile chipper chips dumping time is presented on figure 1.

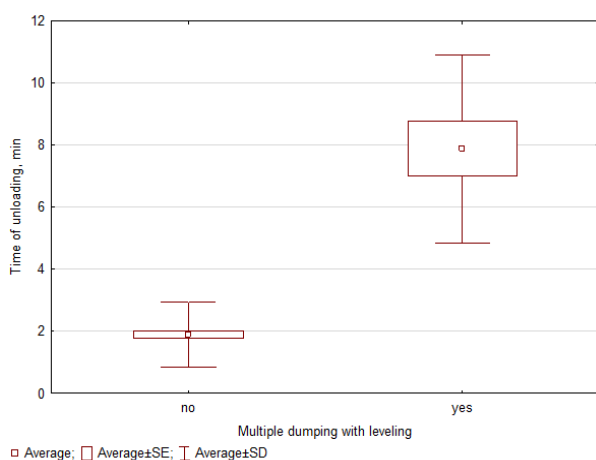


Figure 1: The comparison of chips dumping time. On the left - the entire container at one time, on the right - chips dumping spread over several stages with chips leveling using a crane

The results of simulation can be used to calculate the parameters characterizing the efficiency of the use of machinery.

3. Results and conclusions

It has been shown that analyzed process is very sensitive to the size and distribution of post-harvesting areas. This method can be very useful for quickly changing production processes carried out by machine groups consisting of at least several interacting units. The method of description of uncertain dynamic systems derived from dynamic programming can be applied in forestry on the condition of gathering large enough data sets. Only then it is possible to satisfactory fit probability distributions. Especially demanding is the description of the operation of transport vehicles for which the distribution parameters depend on the distances of transport. Preliminary calculations were fulfilled for the process in which logging residues were collected by the forwarder (suitable for transporting branches and tops), and then transported to the storage yard at forest road. Further branches were collected from the piles by self-propelled chipper, equipped with a bin for chips. After filling the bin, chipper was moving to the truck and chips were spilled out into semitrailer. In case of absence of reserve of logging residues average time of truck loading can rise from 121,4 to 219,7 minutes.

4. References

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