BIOMASS AND BIOENERGY XXX (2014) 1–8

Available online at www.sciencedirect.com

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Determining long-term chipper usage, productivity and fuel consumption

Raffaele Spinelli, Natascia Magagnotti*

CNR IVALSA, Via Madonna del Piano 10, Sesto Fiorentino (FI) I-50019, Italy

ARTICLE INFO

Article history:
Received 12 February 2014
Received in revised form
10 April 2014
Accepted 11 April 2014
Available online xxx

Keywords:
Efficiency
Logging
Forestry
Mountain
Wood

ABSTRACT

The Authors surveyed 6 industrial chipping operations for a whole work year, collecting data about machine usage, product output, fuel consumption and chipper knife wear. Despite the challenging work conditions offered by mountain operations, industrial chipping contractors manage to achieve a high machine use, ranging from 500 to over 2,500 h year^{-1}. Product output varies between 18,000 and over 120,000 m^3 loose chips per year. In order to acquire enough jobs, operators may travel between 1,500 to over 20,000 km in a year. Industrial chipping contractors adopt different operational strategies to achieve their production targets, and they equip accordingly. Some operators prefer to tap smaller local areas and opt for smaller tractor-powered chippers, which are less powerful and productive than larger independent-engine units, but cheaper and capable of negotiating low-standard forest roads. Others prefer to explore larger areas and achieve higher product outputs, and they opt for larger independent-engine chippers, often mounted on trucks. Long term productivity varies with machine type: tractor-powered units produce between 40 and 50 m^3 loose chips per hour, whereas larger independent-engine chippers produce between 60 and 90 m^3 loose chips per hour. Specific fuel consumption is about 0.5 L diesel per m^3 loose chips, regardless of chipper type. A sharp knife set can process between 200 and 1,500 m^3 loose chips before getting dull. Disposable knives last longer and are cheaper to manage than standard re-usable knives.

1. Introduction

Due to a booming bioenergy sector, chip demand has grown to the benefit of logging companies that operate near the new plants. Chips have to be delivered regularly and in large amounts, which makes good planning a crucial issue. In turn, planning requires a correct estimate of chipping productivity and cost, otherwise shortfalls are experienced in both supply chain management and price setting. Underestimating chipping cost will eventually result in a financial loss for the operator/contractor, whereas an overestimate will make the operator/contractor much less competitive. This is particularly important for operations that are characterized by borderline profitability, such as thinning operations [1] and fuel reduction treatments [2], where correct estimates of harvesting productivity and cost are necessary when deciding whether to salvage some biomass products or treat to waste. Similar problems are faced by prospective operators, who are equipping to get into the chipping business and need as much detail as possible on the performance of their equipment.

* *Corresponding author.*
E-mail addresses: spinelli@ivalsa.cnr.it (R. Spinelli), magagnotti@ivalsa.cnr.it (N. Magagnotti).
http://dx.doi.org/10.1016/j.biombioe.2014.04.016

The acquisition of an industrial chipper involves a significant capital investment, much higher than required by traditional small-scale equipment. That makes the formulation of a correct machine rate even more dependent on a reliable estimate of fuel use, material consumption, and annual usage. Such figures play a crucial role in all costing methods, from the basic system codified by Miyata for the USDA Forest Service [3] and by Eliasson [4] for the European Union, to the more sophisticated approaches offered by Bright [5], Koger & Dubois [6] and Price [7]. Due to the large capital investment, the assumptions taken for annual usage also have a significant impact on the accounting of interest charges [8]. In turn, productivity is the crucial element for converting an hourly rate into a proper piece rate.

Chipper productivity has been explored with many studies, documenting the performance of a wide range of wood chipping equipment, under a variety of work conditions [9–12]. Available aids include dedicated spreadsheet calculators capable of returning reliable estimates of chipping productivity and cost, based on user-defined input data [13]. However, our current knowledge of chipper performance is mostly based on short-term trials (for the rare exception, see Ref. [14]). Even when many trials are consolidated into the same data pool and analyzed as a whole, the result still reflects the short-term character of the individual studies and may not be taken as the equivalent of a proper long-term follow-up study [15].

Chippers incur high fuel and knife consumption, which must be determined with some accuracy in order to minimize costing errors. Several studies have gauged the fuel consumption of wood chippers, but they offer instant estimates, which are best suited to the comparative purpose of these studies, but may not provide an accurate representation of long-term fuel consumption under operational conditions [16]. No scientific studies have yet explored knife replacement frequency, and current estimates are based on anecdotal evidence [17]. Finally, available literature offers no reference figures for the annual usage of industrial chippers. Such information is crucial to estimating machine rate. In fact, annual usage may experience wide variations, based on firm type, market conditions and resource constraints. Therefore, it is especially difficult to express an overall reference figure for annual usage, capable of reflecting the whole range of work conditions. Nevertheless, the total absence of solid references increases the value of any experimental data, despite their specific character.

The goal of this study was to produce reliable estimates for the long-term productivity, fuel consumption and annual usage of industrial chippers, under the typical conditions of Northern and Central Italy. Furthermore, we endeavored to determine long term knife wear, as well as job size, relocation frequency and relocation distance.

The study was conducted in the Italian mountains, where chipping emerged as an important business sector already in the late 1990s. Italian chipper operators use a large variety of chippers and chipping techniques, although industrial roadside chipping is generally preferred to both terrain chipping and chipping at a biomass terminal [17]. The growing demand for energy biomass makes wood chipping a profitable activity, still unharmed by the current economical downturn. Many operators have gained significant experience and are now at their second or third chipper. Despite its strong Italian bias, this study may also represent other countries, since the Italian chipper fleet is quite international and local business models are similar to those found elsewhere in Europe, all based on specialized contracting.

2. Materials and methods

Six industrial chippers were selected for the study, of which three were equipped with their own independent engines (Fig. 1) and three were powered by large farm tractors, through their power take-offs (Fig. 2). Each machine was considered as a study unit, and it belonged to a different contractor. All machines operated in Northern and Central Italy, and one of them traveled as far as Croatia to get additional contract work. Overall, the study covered 8 of the 21 administrative regions of Italy.

These two groups were meant to reflect the main technical choices available to industrial chipping contractors. These contractors may opt for a large chipper equipped with its own independent engine if they want to maximize available power and minimize any interface problems. Otherwise, they may choose a smaller tractor-powered unit, which is cheaper to acquire and easier to re-sell if the business does not grow as expected. Furthermore, chippers with an independent engine are often mounted on trucks, which makes them most suited for quick relocation between distant work sites. In contrast, tractor-powered chippers cannot move as fast as truck-mounted units, but they are more agile when confronted with low-standard roads. Therefore, truck-mounted chippers may explore wider areas, whereas tractor-powered units are most suited to contractors who work locally and need to access remote work sites.

The six machines in the study were considered representative of the whole population of industrial chippers used in Italy, and generally in Europe [17]. Their technical characteristics are described in Table 1, while Fig. 3 shows their work areas (e.g. home range).

All machines were road-legal and relocated independently. Occasionally, tractor-powered chippers were relocated on

Fig. 1 – Truck-mounted independent-engine chipper (Unit 1).