Biomass and Bioenergy 83 (2015) 152–158

Contents lists available at ScienceDirect

Biomass and Bioenergy

journal homepage: http://www.elsevier.com/locate/biombioe

Research paper

Performance of a new industrial chipper for rural contractors

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ARTICLE INFO

Article history:
Received 27 June 2014
Received in revised form
28 March 2015
Accepted 24 September 2015
Available online xxx

Keywords:
Chipping
Productivity
Particle size distribution

ABSTRACT

A new chipper was designed around a versatile wheeled carrier, capable of both in-field and road traffic. This solution reduces relocation cost, and it is especially valuable when dealing with small, scattered fields. At the same time, good off-road mobility allows taking a large industrial operation directly into the field, to the benefit of improved downstream handling. The new machine is especially conceived for use by rural contractors, who must negotiate wood crops established on ex-arable land. Trials were conducted on three sites, representative of the most common conditions encountered by these contractors. Productive potential was very high, averaging 120 m^3 loose chips (or 42 tonnes of green chips) per productive machine hour. Such a high productivity may strain the capacity of the chipper support fleet, especially if the latter needs to reach the chipper directly into the field. Therefore, actualizing the potential of the new system requires a good organization, possibly assisted by modern precision control technology.

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1. Introduction

In 2006 the European Union (EU) reformed the Common Market Organization for sugar [1], which has greatly affected the EU agricultural production and markets [2]. With the downsizing of the internal production of sugar, less competitive sugar beet producers have turned to other sources of income. One of the main strategies adopted to limit the economic consequences of the EU sugar phase-off was sector re-conversion. Energy production seems the most promising alternative, because sugar beet fields could be easily established with energy crops, and the old sugar processing factories could be transformed into bio-refineries and/or bio-energy plants. The re-conversion of the sugar sector represents one further steps towards the ambitious renewable energy targets set by the EU for 2020, with the intent of reducing reliance on imported fuels and mitigating climate change [3]. Efforts of the European Union in this area are not isolated, but they are a part of a global renewable energy drive [4].

The new machine tested in our research fits well within this background. Because the production of sugar beet has declined, the market for sugar beet mechanization has shrunk. Companies producing sugar beet harvesting equipment are looking for new markets, and none seems most suited than that offered by the growing bio-energy industry, which is proposed by the EU itself as the substitute for the old sugar beet economy. As a result, a renowned manufacturer of sugar-beet harvesting equipment has already expanded its product range by developing an innovative wood chipper. This chipper derives from the adaptation of a sugar beet harvester carrier, which now supports a state-of-the-art drum chipper and a powerful log loader.

Chipping is a very important element of all energy wood chains. Modern boilers only accept homogeneous chips, that are within specified size limits [5]. Like for any product, chip price is also significantly affected by quality, which explains why a lot of research and development is focused on chip quality improvement [6,7].

The goal of this study was to determine the performance of this new chipper, uniquely derived from the adaptation of a sugar-beet harvester design. Due to its versatile carrier base, this machine is especially suitable for rural contractors, who want to run a diversified contracting business in order to cope with today's changing agriculture. The new machine is a dedicated chipper, built for the specific purpose of chipping wood biomass. The versatile carrier allows easy in-field access, as well as road traffic, with minimal time loss for the conversion from chipping to driving mode. The mobility of the chipper is crucial, as wood crops established on ex-

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http://dx.doi.org/10.1016/j.biombioe.2015.09.010
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arable land usually grow on marginal sites, often small and dispersed. That calls for quick independent relocation between work sites, which can be done at a speed of up to 40 km h^{-1}. Driving off-road does not present any problems, either. The large wheels enable good terrain trafficability, which is indispensable for reaching the wood directly into the field.

2. Materials

The chipper tested with this study was an Albach Silvator 2000. The machine is a new generation dedicated chipper. It has been built on the chassis of a sugar beet harvester (Fig. 1). Total engine power is 450 kW, which qualifies the machine for industrial use [8]. New generation chippers have a single engine, which powers the wheels, the loader and the chipper. The main machine characteristics are presented in Table 1.

The chipper chassis is supported by 2 axles, in a four-wheel drive configuration. An additional retractable wheel carriage is placed right under the machine nose, and is deployed when traveling on public roads in order to re-distribute weight and meet the maximum axle load limits imposed by road regulations. Much thought has been devoted to maximize maneuverability, overcoming the constraints imposed by the large machine size. Wheels on both axles can steer, thus reducing turning radius (8.5 m). The traversing blower enables discharging chips to all three machine sides: front, rear and port side. The starboard side is unavailable for chip discharge because it carries the chipper in-feed and it must always face the wood stack, which makes it impossible to park a container on that side. Traction power is delivered through both axles (4 × 4) onto large-diameter wheels. This results in high off-road mobility, which is indispensable for in-field traffic.

When the study started, the machine was 7 months old, with about 800 h on its meter. The study consisted of field trials at three different sites in Northern Italy. The attributes of terrain, landing characteristics and feedstock type were considered representative for the conditions commonly confronted by wood chipping contractors working in agricultural areas, rather than in conventional forestry. The chipping basket of the machine owner was quite diversified, and it included a variety of sites and conditions scattered across much of the Po Valley, in northern Italy. The list of work sites and chipping material is shown in Table 2.

Supply chain logistics were different between sites, which may have influenced the results of individual trials. Each field trial lasted

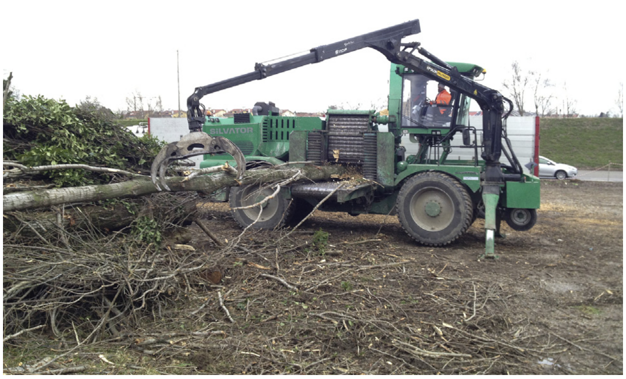

Fig. 1. The Albach Silvator 2000 (note the retractable wheel carriage under the nose end, on the right side of the picture).

Table 1
Main machine characteristics.

Manufacturer	Albach Maschinenbau GmbH
Model	Silvator 2000
Engine type	Mercedes OM502LA
Engine power	450 kW (612Hp)
Weight	32000 kg
Length	9.7 m
Width	3.0 m
Height (transport position)	3.7 m
Height (work position)	4.8 m
Transmission	Hydraulic
Propulsion	4 × 4
Tires	Nokian TRI2 650/65R42
Crane	Epsilon Palfinger S110F
Crane reach	10.1 m
Chipping	Open drum with 12 chipping knives
In-feed size	1230 mm × 980 mm
Drum diameter	1200 mm
Drum turning speed	Up to 8.33 Hz

Note: Data provided by the manufacturer.

from one to four workdays. On site 1 and 2 logistics were managed with one or two trucks and a tractor-trailer unit, serving as a surge container. In site 3, chips were blown into a single tractor-trailer unit that shuttled the chips to a roadside landing, and dumped it onto a large pile built on the ground. Chips were then loaded with a front-end loader into a container truck. The chipper used the same work settings on all work sites, and in particular the same cut length and screen size.

On all sites, trees were cut using a chain saw. On sites 1 and 2, whole trees were gathered into piles using a modified excavator, or a tractor equipped with a grapple loader. On site 3, good quality poplar trees were processed into different timber assortments, and chipping concerned only tops and branches. These were piled in the field with an excavator-base loader.

All tests were conducted between February 2013 and early July 2013. Total study time amounted to 48.5 h, including delays but excluding relocation between sites. During this time the chipper produced 60 full containers, amounting to 1627 m^3 of loose chips. The operator was the same on all sites, and he was also the machine owner and contracting firm manager. He was a trained and well experienced professional, who was very proficient with his job and equipment. Before purchasing the new machine, he had owned and operated a variety of chippers for the last 15 years. We did not normalize operator performance by means of productivity rating. All observed cycles were included into the master database.

3. Methods

A typical time study [9] was performed using a handheld computer, running the dedicated Laubrass UMT Plus time studies software. The study was conducted according to the snap-back timing method, and it was designed to evaluate chipper productivity and identify those variables that were most likely to affect it.

Productive time was separated from delay time. Timing sessions lasted for the entire workday, with the purpose of obtaining a good representation of the structure of a typical workday, subdivided between different productive and non-productive activities [10]. All delays were included in the study, and not only those delays that were below a set duration threshold, because such practice could misinterpret the incidence of downtime, especially on comparatively long observation periods [11]. Delays caused by the study itself were separated and excluded from the data set. The filling of one chip container was considered as one work cycle. Study time was divided into defined time elements, in accordance with the most recent harmonized European guidelines [9].

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