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Using disposable chipper knives to decrease wood fuel processing cost

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ABSTRACT

For many years, tool manufacturers have proposed disposable micro-knives as a solution to both the vulnerability and the frequent maintenance problems of standard full-size knives. The study compared disposable micro-knives and standard full size-knives for replacement time and management costs. It also quantified the cost of severe damage caused to conventional knife set-ups, following accidental introduction of metal contaminants inside the chipper. In this case, damage can amount to over 30,000 €. Adoption of disposable micro-knives may avoid such severe damage and mitigate its consequences. The simpler replacement procedure also allows a 15% reduction of knife replacement time, compared with the standard knife option. On the other hand, these same benefits are also obtained with other measures, such as the adoption of a swing-away counter-knife and the use of a pneumatic wrench for knife replacement. However, disposable micro-knives do offer a significant reduction of knife-related cost, due to an extended sharpness retention. Savings may amount to 30% of the knife-related cost of a conventional knife set, or about 18 Euro cents per tonne. Further studies should investigate the reasons for the better performance of micro-knives, with a view in improving the durability of both knife types.

1. Introduction

For decades, the European Union (EU) has supported the use of wood biomass as an effective substitute for conventional energy sources, but the new targets set for 2020 are even more ambitious than all the previous ones and may boost the demand for energy biomass, including wood fuel [1]. In turn, this may help in mobilizing the large unutilized wood resource already available in the territories of member states [2].

New technologies are going to increase the share of wood resource within technical and economical reach, by reducing the cost of harvesting, processing and transportation [3]. Chipping is an essential element of all modern energy wood chains, because automated boilers only accept homogeneous fuel particles within specified size limits [4]. Besides, chipping offers additional benefits in terms of increased load density and improved handling quality [5]. For this reason, low-density raw materials should be chipped as early as possible, in order to accrue such important benefits all along the supply chain [6].

That explains the widespread popularity of mobile chippers, which allow size reduction directly in the forest or at the roadside landing, before transportation [7]. However, mobile chippers are less efficient than stationary models and incur large fuel consumption [8]. There is a keen interest in optimizing mobile chippers, so as to reduce the efficiency gap between mobile and stationary operations [9].

Knife wear has a dominant effect on fuel consumption, chipper productivity and product quality [10,11]. The effect of knife wear is generally stronger than the effect of tree species or chipper configuration [12]. Substantial benefits could be obtained if knives were replaced more often, or if their blades lasted longer. However, frequent knife replacement incurs an increased maintenance cost per tonne, whereas very hard slow-wearing blades are inherently fragile and especially vulnerable to the presence of large contaminants, such as stones or stray metal. These materials can cause extensive damage to the chipper, and determine a marked increase of maintenance cost [13].

For many years, tool manufacturers have proposed disposable micro-knives as a solution to both the vulnerability and the frequent maintenance problems of standard full-size knives. In essence, micro-knives are much smaller and cheaper than standard knives, so that they can be replaced more often (Fig. 1). For the same reason, the cost of a premature write-off is much lower. Contrary to standard knives, disposable micro-knives are discarded when their blades are worn out, saving the cost and the complication of sharpening [14]. The economical viability of disposable micro-knives depends on the delicate balance between shorter service life and lower investment and maintenance cost, but older studies mention an overall saving in the order of 30% [15]. Use of disposable micro-knives may increase both uptime and chip quality [16]. For these reasons, disposable micro-knives have

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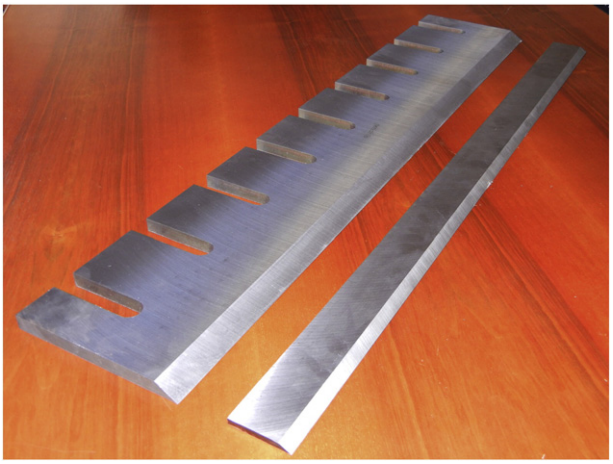

Fig. 1. Standard knife (left) and disposable micro-knife (right).

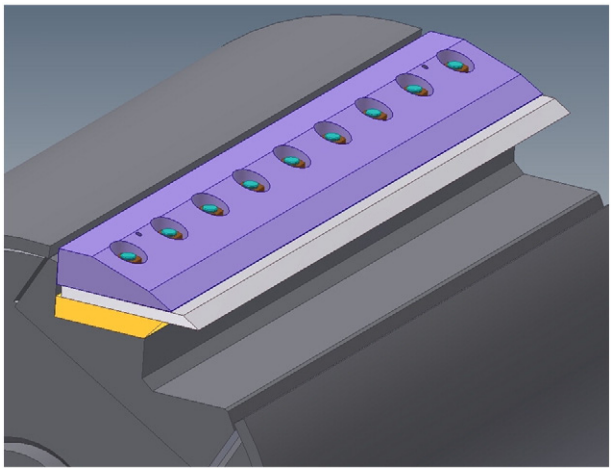

Fig. 3. Standard knife with conventional bolted plate holder. Note: All figures to be rendered in black & white.

encountered some popularity in North America with stationary chippers, without ever achieving a definite breakthrough [17].

Recently, an Italian manufacturer (www.pezzolato.it) has developed a new disposable micro-knife design for industrial drum chippers, including mobile models. The new design includes a special knife-mount with a wedge-shaped holding device (Fig. 2), which replaces conventional plate holders (Fig. 3). According to the manufacturer, this new mount offers two main benefits: it simplifies and speeds up knife replacement and it removes the massive plate holders, which are most vulnerable to contaminants. The new wedge-shape mount requires a much lower tightening force compared to a conventional plate holder (180 Nm vs. 430 Nm), which should make replacement easier for the operator.

The goal of this study was to determine: 1) what is the cost of the eventual damage caused by contaminants in drum chippers, equipped with standard knives; 2) if replacing disposable micro-knives is faster and simpler than replacing standard knives; and 3) if the investment and maintenance cost of micro-knives are lower than for standard knives.

2. Materials and methods

The cost of the eventual damage caused by contaminants in drum chippers equipped with standard knives was determined by searching the manufacturer files for bills documenting significant repair events after contaminant damage. In particular, we extracted the three most relevant events, all occurring on the same PTH 1000/1000 chipper model, which is the most representative of the Pezzolato industrial chipper line. Using damage reports, we reconstructed the chain of events leading to damage, while the detailed repair bills allowed us to separate the cost of damage to the different chipper components. Due to the novelty of the new disposable micro-knife option, we could only locate one event of contaminant damage on this chipper type. It was therefore impossible to make a sound comparison between expected damage costs for both knife options. As a result, the figures obtained from this part of the study are only indicative of the maximum cost for contaminant damage sustained by industrial chippers equipped with standard knives.

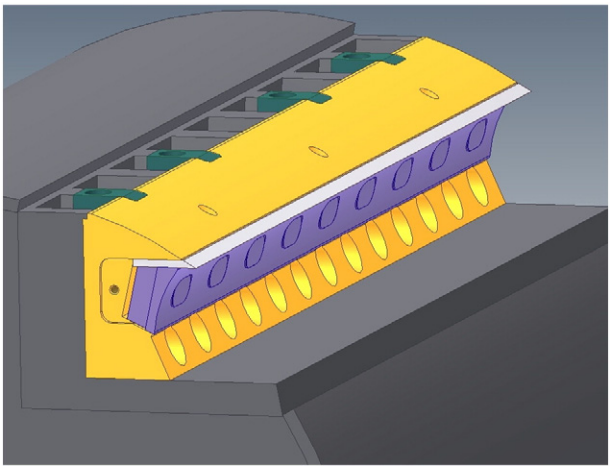

Fig. 2. Disposable micro-knife with the innovative wedge-shaped mount.

The time required for knife replacement was determined with a conventional time study, conducted on two PTH 1000/1000 industrial chippers. The two machines featured identical one-meter wide drums, with a diameter of 1 m. However, one drum was equipped with conventional knives and the other with disposable micro-knives. The machines were taken to the same workshop, and three professional mechanics were selected for the test. All operators had significant experience with knife replacement, and with the specific machine make and model. The experiment tested three treatments and namely: standard knives replaced with manual tools; standard knives replaced with air wrench; and micro-knives replaced with manual tools. The micro-knife mount was very tight, leaving no room for an air wrench, which explains why there was no treatment for micro-knives replaced with an air wrench. In both cases, operators needed to replace two knives, each retained by nine bolts. In the conventional knife treatment, operators received sets of new knives with the rear indexing screws voluntarily unadjusted, so that they would need to check and index the knives, as usual when replacing conventional knives. Each treatment was repeated 5 times by each operator, for a total of 45 repetitions. Treatments and operators were arranged in a random sequence, in order to dampen the effect of nuisance factors, such as the circadian variation of operator strength and motivation. Knife replacement time was determined with a Husky Hunter handheld computer [18], running the Siwork3 dedicated time study software [19]. The time for opening and closing the drum maintenance hatch was separated from the time for removing the old knives and installing new ones, because the chipper equipped with disposable micro-knives featured an optional hydraulic lift hatch, blocked by 2 bolts instead of 5. Fitting of a hydraulic hatch was independent from the type of knives installed on the chipper drum, and by isolating hatch opening time one could estimate the effect of hatch type on knife replacement time for both knife options. Both productive and delay times were measured [20], and those minor delays that could not be attributed to the specific treatment on test were spread on all