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INTERNAL PROJECT INFORMATION NOTE 09/07

Title: A Comparison between a Hand-fed and a Mechanically-fed Chipper

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SUMMARY

This Internal Project Information Note (IPIN) is a report from one of several sub projects carried out by Technical Development (TD) for the Northern Wood Heat (NWH) project. It presents a comparison between a manually-fed chipper (Bandit 90W disc chipper) and a mechanically-fed one (Biber 7 Plus Eschlbock drum chipper).

The highest output from the three timber specifications used in the trial was from lodgepole pine with an average length of 4.7 m. The other two specifications had average lengths of 3.4 m and 2.9 m. All the roundwood chipped had a moisture content (MC) of less than 26% (wet basis)

Production costs per m^3 of roundwood chipped did not vary greatly between the two chippers.

INTRODUCTION

TD has supported several sub projects undertaken as part of the NWH project, co-financed by the Interreg 3 B Northern Periphery Programme. The main aim of this project was to help develop small to medium scale woodfuel supply chains. This was to be achieved by working jointly with other stakeholders and investigating technical and economic issues associated with woodfuel production and supply.

One of the NWH sub projects supported by TD was to assess the economics of chipping woodfuel in Scotland by comparing output performance of a manually-fed chipper with a mechanically-fed one. This IPIN describes the findings of the sub project undertaken by TD and Deeside Woodland Products (DWP) comparing a small manually-fed Bandit 90W disc chipper and a large mechanically-fed Biber 7 Plus Eschlbock drum chipper in terms of output performance and cost. The two chippers were chosen because they were currently operating in the region. Both machines were operated by an experienced operator on the same site using timber from the same roadside stacks.

Wood chippers range in size from small drum, disc and screw cone chippers usually with a maximum cutting capability of 10 cm diameter to the larger scale machines capable of chipping roundwood with a diameter range of 40–80 cm. These larger machines are usually mechanically fed and achieve a high consistency in wood chip size by having interchangeable screens of different sizes. Screens fit around the part of the drum next to the discharge chute. They consist of a series of equally sized holes through which the comminuted wood must pass before being discharged. Particles of wood that are too big are rotated around the drum until their size is reduced so they can pass through the screen.

THE TRIAL

The trial took place at Cairn Daimh (NJ 170 256) on the Glenlivet Estate in June 2007. Both chippers arrived on site in good working order with sharp blades. They were positioned on the forest road close to the infeed material to minimise the amount of handling particularly for the manually fed Bandit 90W. Weather conditions during the trial were warm and dry and had no effect on safety or output performance of the machines. A single operator fed both chippers.

Three specifications of infeed material were used (Table 1). The lodgepole pine had been felled approximately 12 months ago and was stacked at roadside. The Sitka spruce was part of an earlier drying trial for the NWH project and had been stacked on bearers at roadside since March 2005. In addition DWP arranged for a load of ‘green’ Sitka spruce to be delivered to the site and chipped. This was to investigate any difference in output performance between chipping recently felled and dry wood.

All roundwood to be chipped was measured by recording the length and mid diameter. Volumes calculated were m^3 overbark[1].

Figure 1 Manually feeding lodgepole pine

A sample of the wood chips from each specification was collected for MC determination (wet basis) using the oven dry method[2]. From the results the 'green' Sitka spruce had a MC of 25.83%, indicating this material had been felled for some time and was not fresh (MC of freshly felled timber is normally between 50 to 60%). Therefore no comparison between chipping wet and dry wood could be made.

Specification and moisture content results are shown in Table 1.

Table 1 Infeed specifications and moisture content

Species	Average Length (m)	Average Volume/Piece (m^3)	Moisture Content (wet basis)
Lodgepole pine *Pinus contorta*	4.7	0.075	22.60
Sitka Spruce 'dry' *Picea sitchensis*	3.4	0.040	23.66
Sitka Spruce 'green' *Picea sitchensis*	2.9	0.033	25.83

For the duration of the trial all operators wore the necessary Personal Protective Equipment (PPE) as specified in relevant Arboriculture and Forestry Advisory Group (AFAG) guidance (AFAG 501 and 602).

The operator loading the Bandit chipper wore protective gloves and carried felling tongs to assist with loading the roundwood into the infeed hopper. Forty billets of the lodgepole pine were taken from the stack by the farm forwarder and presented separately at roadside to allow safe manual presentation to the Bandit 90W. The material was offered to the Bandit 90W as single pieces.

The Biber 7 Plus did not have an integral loader and therefore loading of the roundwood was undertaken using a Valmet 6400 tractor with forwarding trailer fitted with a FMV 2500 loader. The loader was able to hold several billets in the grapple and feed them into the Biber 7. On some occasions during the study, billets had to be realigned on the infeed hopper as they failed to be drawn towards the drum by the hydraulic rollers.

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[1] Page 228 - Roundwood volumes (m^3). Forest Mensuration *A Handbook for Practitioners.*

[2] Wood chips are placed in an industrial oven with a constant temperature of 105°C until there is no further loss in weight. Moisture content is then determined from the following equation:
MC (%) = ((wet weight – dry weight)/ wet weight) x 100.

MACHINE SPECIFICATIONS AND SUPPLIERS

Table 2 Machine specifications

Make	Bandit 90W	Biber 7 Plus Eschlbock
Type	Road tow (single axle)	Road tow (single axle)
Power	Deutz – 2.7 litre (90hp) Max. rpm 2800	MF 6280 130 hp tractor Power Take Off (PTO) 1000 rpm
Drive	3 - v belts	6 - v belts 4 - v belts (blower)
Capital Cost (£)	25,000	41,000
Chipping type	Disc 45° feed angle	Drum
Max. cutting diameter (cm)	16	35
No. of blades	2	8
Weight (kg)	1430	4600
Year of manufacture	2004	2006

MACHINE COSTS

The purchase price and operating costs for both chippers were obtained from the respective owners and are shown in Table 3. The hourly usage figures per year is an estimate based on what could reasonably be considered a realistic target for woodfuel production.

Table 3 Comparative machine costs

Cost Element	Bandit 90W	Biber 7 plus Eschlbock
Capital cost (£)	25 000	41 000
Residual value	2500	4100
Life in hours	5	5
Hours/year	800	800
Interest rate	0.05	0.05
Discount factor	0.7835	07835
Equivalent annual cost	0.2310	0.2310
Capital cost/hour	6.65	10.91
Operating costs		
Repair/maintenance	2.50	5.00
Fuel	3.00	3.50
Operator costs(£)	7.50	10.00
Tractor hire(£)	N/A	20.00
Total cost (hr)	19.65	49.41

OUTPUTS AND COSTS

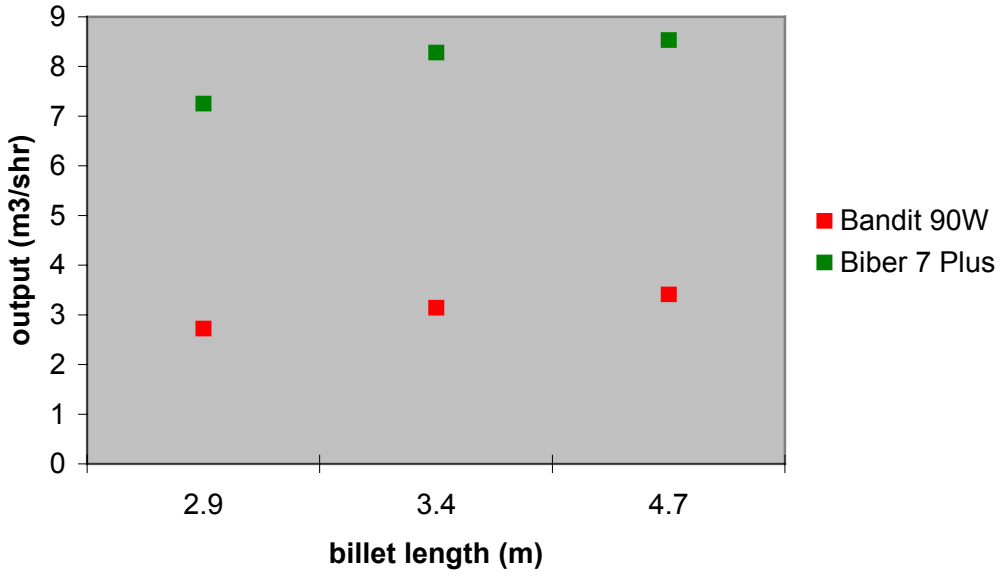
The time study data are shown in Table 4. All output volume measurements are solid roundwood. A 50 mm screen was used in the Biber 7 Plus for the lodgepole pine and Sitka spruce (3.4 m average length). A 30 mm screen was used to produce woodchips from the shorter average lengths of the Sitka spruce (2.9 m).

Table 4 Outputs and costs

Species	Average Volume per piece (m^3)	Bandit 90W			Biber 7 Plus Eschlbock		
		output (m^3/shr)*	cost (£/hour)	Cost (£/m^3/shr)	output (m^3/shr)	cost (£/hour)	Cost (£/m^3/shr)
Lodgepole pine	0.075	3.41	19.65	5.76	8.53	49.41	5.79
Sitka Spruce 'green'	0.040	3.14		6.26	8.28		5.97
Sitka Spruce 'dry'	0.033	2.72		7.22	7.25		6.82

* Shr – includes a 22% Rest and 20% for Other Work Allowance for manually fed chippers (Bandit) and 18% Rest and 20% for Other Work Allowance for mechanically fed chippers (Biber 7 Plus) as per TSI guidance.

Figure 2 Graphical representation of output m^3/shr in relation to average billet length



DISCUSSION

Bandit 90W

The main limiting factors when manually feeding the Bandit 90W were weight and size of material i.e. diameter and length. Manually feeding chippers requires a high degree of lifting and bending by the operator when presenting billets from different heights of a stack, and it is important that the correct techniques are used to avoid injury and maintain performance. Guidance for safe lifting can be obtained from the Health and Safety Executive (HSE 2006).

The size and weight of the infeed material will also determine whether several pieces can be fed at once. During the trial, single pieces were manually fed to the chipper for all specifications. Observations made during chipping identified a tendency by the operator to rest whilst the lengths of lodgepole pine and Sitka spruce billets were being chipped before presenting another one.

The operator carried timber tongs to aid handing of the roundwood. However these were only used occasionally during the trial. Correct use of the tongs could have reduced operator effort and fatigue.

Towards the end of the trial wood chip production was interrupted by a partially chipped piece of billet becoming stuck between the disc and infeed rollers. When extracted the cut face of the wood was scorched. This indicated that the knives had become worn and required sharpening. Regular maintenance as specified by the manufacturer should be carried out to ensure high output performance and maintain woodchip size quality.

Figure 3 Manually loading the Bandit 90W chipper with the shorter lengths of Sitka spruce

Biber 7 Plus Eschlbock

This Austrian-built machine has a higher output capability and can be fitted with different screens to produce different sizes of wood chips. The chipper did not have an integral loader and therefore an independent loader in the form of a farm forwarder[3] was used to present the material to the chipper. The chipper had a larger infeed aperture than the Bandit and therefore several billets could be loaded onto the infeed deck at once. However not all the billets made contact with the infeed rollers and the grab was required to reposition some billets on the infeed deck. This was more frequent when handling the shorter Sitka spruce billets as a greater number of billets per grapple (average of five) were loaded compared to the lodgepole pine specification. The discharge hopper was capable of blowing woodchips to a height of 3.5 m into the top of a high capacity trailer. The direction and angle of discharge were hydraulically controlled by the operator.

Difficulty was encountered changing the 50 mm concave-shaped screen on the Biber 7 Plus. A smaller 30 mm screen was required to produce the woodchip specification for the boiler at the Scottish School of Forestry. Considerable effort was required to free the screen from its position around part of the drum. The screen had been in the machine since the owner took delivery several months ago. The problem was caused by bulges of welded steel formed during the fabrication of the screen. This could be easily remedied using a portable angle grinder.

Two tractors were used for the trial, one to provide power for the chipper (Table 2), the other a Valmet 6400 4 cylinder to load. Delivery to and from site of the tractor and chipper was by low loader. The owner considers a distance of 80 km as economically viable to tow the chipper using a Valtra 8400 (165hp) providing there is a minimum of three days' chipping.

[3] Farm forwarder – an agricultural tractor and forwarding trailer combination

Figure 4 Mechanically loading the Biber 7 Plus with lodgepole pine

CONCLUSIONS

The roundwood specification that produced the highest output for both machines were the longest billets with an average length of 4.7m and average volume of 0.075 m^3.

The Biber 7 Plus achieved the greater hourly output by between 4.5 and 5.1 m^3 for the three specifications chipped. The highest hourly output achieved was 8.53 m^3 from the lodgepole pine specification. The hourly output from Bandit 90W from the same specification was 3.41 m^3.

Comparing production costs showed there is little difference between the two machines for the three specifications. The cost differences ranged from £0.03 to £0.40 £/m^3 /shr. For woodfuel production where consistency of particle size is important, the Biber has the advantage of screens that regulate woodchip size and reduce variation. The Bandit 90W disc chipper did not have a screen and therefore greater woodchip size variation could be expected, however visual inspection during the trial suggested both chippers produced woodchips with a high degree of size consistency.

RECOMMENDATIONS

Both chippers performed to a satisfactory standard throughout the trial. The output capabilities of both machines indicate they are suitable for different scales of work.

For small-scale operations, for example supplying small quantities of woodchips up to 20 m^3 (small roundwood) per eight hour day[4], the Bandit 90W would be more suitable. It also has the advantage that it is self powered and can be towed between sites using a 4-wheel drive vehicle.

Particular care should be taken when handling the billets to feed the chipper and suitable use of tongs should help reduce the physical strain for the operator.

The Biber 7 Plus is capable of producing larger quantities of woodchips and therefore is suitable for large-scale chipping operations. From the output performance of the trial, it is capable of chipping 68 m^3 of roundwood per day. Power is provided by an agricultural tractor PTO and, although most modern tractors are fitted with high ratio gears allowing high road speeds, towing the chipper long distances may be uneconomical. In such instances a low loader would be required.

BIBLIOGRAPHY

Health and Safety Executive (HSE) (2003). *Tractor units in tree work* , AFAG 501. www.hse.gov.uk/pubns.

Health and Safety Executive (HSE) (2003). *Wood chippers*, AFAG 602. www.hse.gov.uk/pubns

Health and Safety Executive (HSE) (2006). *Getting to Grips with manual handling, a short guide* www.hse.gov.uk/pubns/indg143.pdf.

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