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TECHNICAL DEVELOPMENT

INTERNAL PROJECT INFORMATION NOTE 19/06

Title: Large Chippers

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Project leader: Paul Webster

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Large Chippers

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SUMMARY

Technical Development (TD) investigated four high output chippers selected from a range operating in Great Britain (GB). These were:

- Heizohack HM 14-800
- Foresteri 4560C
- Jenz 560Z
- Musmax Terminator 8.

Output and other aspects of performance were tested and the main findings were:

- From an infeed specification of 2.8m lengths with a top diameter range of between 40 and 6 cm the Heizohack and Musmax produced woodchips that conformed to the P16 specification of the CEN/TC 335 standard. The other two machines produced woodchips that met the P45 specification.

- Wood chips produced by all four chippers conformed to the G30 Austrian standard.

- Presentation of timber for chipping is important and should aim to minimise the need for grapple rotation and boom extension.

- Outputs ranged between 11.39 m^3 and 21.10 m^3 of solid wood per standard hour

- Fuel consumption ranged between 1.18 and 1.92 litres/ m^3 of solid wood.

INTRODUCTION

Wood chips are increasingly being used as fuel to provide heat for domestic and industrial use and on a larger scale to generate electricity. From previous TD research, the majority of wood chippers, particularly hand-fed machines, were used to reduce woody material for a range of purposes (horticulture, footpath surfacing, equestrian and cattle bedding) for which the quality of wood chips produced was of little or no importance.

Quality in terms of particle size is particularly important where the wood chips are used for burning in a domestic sized boiler (20–300kW). Particle sizes greater than the wood chip specification for a boiler can cause 'nesting' or bridging during storage and blockages in auger-fed systems. Smaller particle sizes can also reduce the combustion efficiency of the boiler especially when there are large amounts of fine particles.

Wood chips can be produced by mechanical methods such as chipping, shredding and hammer milling. Initial discussions about machine selection with the owners of large purpose-built chippers highlighted the main reason chippers had been chosen over other comminution machinery which was their capability to produce a range of wood chip sizes with a high degree of consistency. This was considered important when supplying wood chips to several boilers with different size specifications.

Recent TD work has focused on the production of wood chips from smaller hand-fed machines (IPIN 06/05 *Chipper Review*). These play an important role in small-scale wood chip production for heating but have limitations in terms of output, maximum diameter of infeed material and, with certain machines, the consistency in particle size.

With a developing woodfuel market there is a need to produce quality wood chips on a larger scale. Larger purpose-built high output chippers are mechanically fed, usually operated from the comfort and safety of a tractor cab, have the capability to chip larger diameter material and can achieve higher outputs than hand-fed machines.

This IPIN describes a trial of four purpose-built chippers.

OBJECTIVES

1. Identify all types of purpose-built, high output chippers (>100 m^3/hr)[1] operating in the GB in early 2006.

2. From a selected range of chippers (identified as a result of Objective1 and selected using specified criteria) time study the chippers in operation.

3. Test the quality of wood chips in terms of consistency of particle size and moisture content produced by each machine, using an approved independent assessment centre, against the CEN/TC 335 European standard.

4. Assess energy input from the tractor or independent power source by monitoring fuel usage per volume output.

5. Measure sound pressure levels if the chipper is controlled by the operator standing outside the cab of the tractor and sound power levels of each chipper used in the trial. A visual assessment of any wear to the cutting edges of the knives should be made on each machine.

MACHINE SELECTION

Personal communication with colleagues in the forest industry and wood chipper suppliers revealed a number of high output purpose-built machines operating in GB producing wood chips for the woodfuel market. The results of the investigation are found in Appendix 1.

Four Morbark disc and one Alabama drum chipper, all with independent loaders, were operated from Aberdeenshire. The chippers supplied the panel board industry with wood chips (c. 70–80% of work) with the remaining output to supply wood chips to Drax Power station and Shotton paper mill.

Three types of machine were operating in North Yorkshire, a Jenz 560, Heizohack 14-800 and Foresteri 4560C. All have integral loaders and supply several woodfuel markets throughout Yorkshire.

A Musmax Terminator 8 for the production of wood chips for heating in Shropshire, Worcestershire and Herefordshire, was situated in the West Midlands. The Musmax has an independent engine and is fed by a separate loader.

A Bandit 280 disc chipper, fed by a separate loader, operated from Nottingham. Wood chips are supplied to several schools, industrial and domestic wood fuelled boilers in Nottinghamshire.

Four Heizohack 14-800 machines were operated from West Sussex. Large supplies of wood chips are delivered to Slough Heat and Power, for electricity generation.

[1] Manufacturers' stated figure. This refers to the volume of woodchips produced.

The information gained was not definitive however it provided sufficient information to decide which machines should be included in the trial. Machine selection was based on the following selection criteria:

- Chippers to have a chip output of > 100 m^3/hr (according to the manufacturer)
- Chippers designed to be mechanically fed
- Chippers to have the appropriate screen to produce a G30 (Austrian wood chip standard) size of wood chip
- Chippers to have a maximum cutting diameter of no less than 400 mm.

The machines chosen for the trial were:
- Heizohack HM 14-800
- Foresteri 4560C
- Jenz 560Z
- Musmax Terminator 8.

All of these met the criteria apart from the Musmax which had a stated chip output of 60m^3/hour. However Marches Wood Energy were the only identified large scale wood chip supplier in the Midlands (England) and have been operating successfully for 3 years. It was therefore decided to evaluate this machine in the trial.

It is important to note the output figures quoted by the manufacturers refer to the bulk density of woodchips produced and not solid volume of timber. The volume of woodchips produced is assessed by discharging woodchips into a container or trailer of known volume. This is then related to the time taken to fill it.

THE TRIALS

The trials took place at two sites:

- Esholt Water Treatment Works, Bradford, North Yorkshire
- Pasford Farm, Pattingham, Wolverhampton, West Midlands.

The trial of the Heizohack, Jenz and Foresteri machines took place at Esholt Water Treatment Works and the Musmax at Pasford Farm, Pattingham. Both sites had good access and concrete standings.

Previous TD work on chipping had identified the importance of length of in feed material in terms of output performance (IPIN 06/05).

Forest Enterprise provided the feedstock for the trial which was Corsican pine logs, 2.8 m long with a top diameter range of between 6 and 40 cm. All timber was stacked on bearers with the smaller diameter ends facing towards the chipper. This was not considered to have an operational advantage but allowed easier measurement of all top diameters.

Prior to chipping all timber was measured to calculate the total volume. The condition of all blades was checked and new blades inserted onto the drums of the Jenz, Foresteri and Musmax. The blades on the drum of the Heizohack were in a good condition.

The four machines were drum chippers and material was horizontally fed onto the drum. All machines were positioned close to the timber stacks and no machine movement was required during the trial.

Table 1 Machine Specifications

Model	Type	Cost (£)	Max. Cutting Diameter	PTO Speed	Screen Size	No. of Knives	Chassis	Tractor
Heizohack HM 14-800	Drum	85 000 Tractor 107 000	800mm	1000	30mm x 40mm	14	Single Axle trailer mounted	Valtra 280S (280hp)
Foresteri 4560C	Drum	65 000 Tractor[2] 70 000	450mm	1000	50mm	6	Double Axle trailer mounted	Valtra 8750 (190 hp)
Jenz 560 Z	Drum	108 000 Tractor 126 000	550mm	1000	50mm	10	Double Axle trailer mounted	Fendt 930Vario TMS (300hp)
Musmax Terminator 8	Drum	90 000 Tractor 37 500[3]	420mm	1000	50mm	10	Double Axle Ro Ro trailer mounted	Valtra 170 (175 hp)

Operational efficiency

Timber was presented on bearers directly in line with the infeed chutes. Presentation of timber for chipping can directly affect performance and should aim to minimise the need for grapple rotation and boom extension.

Once the chipper is powered the only task for the operator is to load timber onto the infeed bed. The position of the loaders was different on the four machines. All were operated from the seat of the tractor cab. The loader on the Jenz was positioned between the chipping drum and tractor, in a similar position to forwarders (between the cab and bunk). The loader used to feed the Foresteri was roof mounted and the one for the Musmax mounted on the 3-point linkage of the tractor. In contrast the loader on the Heizohack was mounted to the rear of the chipping drum and was operated using a radio-controlled console mounted in the tractor cab.

All loader movement was constant and efficient apart from loading timber for the Heizohack where movement was intermittent and slow. Loaders mounted in this position are not common on forest machines and the operator lacked the skills and speed of operation acquired through frequent operation. Loading performance could be improved with a more experienced operator.

Three of the four chippers used the power from the tractor. This was transmitted to the chipper through the PTO shaft. The Musmax has a 400 hp independent Mann diesel engine and the power is delivered to the drum through a series of belts.

The operator should be able to view the grapple during the operation. On all tractors visibility was restricted due the rear side pillar of the cab. The study man observed operators leaning sideways to see the grapple when grabbing billets from the stack. Anti-stress devices were fitted to all the chippers.

From a visual inspection after the trial no damage had occurred to the cutting edges of the knives on any of the chippers. The operators emphasised the importance of uncontaminated ‘clean’ timber to preserve sharp cutting edges of the knives.

[2] Roof mounted Foresteri 400 loader
[3] Three point linkage mounted Botex 360 TL loader

COSTS AND OUTPUTS

Table 2 Machinery Costs

	Heizohack 14-800	**Foresteri 4560C**	**Jenz 560Z**	**Musmax Terminator 8**
Capital Cost (£)[4]	192 000	135 000	234 000	119 000
Residual Value (£)	192 00	13 500	23 400	11 900
Life in Years	5	5	5	5
Hours per Year	900	900	900	900
Interest (%)	5	5	5	5
Discount Factor	0.7835	0.7835	0.7835	0.7835
Equivalent Annual Cost	0.2310	0.2310	0.2310	0.2310
Capital Cost (£/hr)	**45.41**	**31.93**	**55.35**	**30.16**
Operating Costs(£/hr)				
Repair & Maintenance	10.00	10.00	10.00	10.00
Fuel	4.70	8.46	12.48	8.63
Insurance	1.00	1.00	1.00	1.00
Operator (including on costs)	15.00	15.00	15.00	15.00
Operating costs	30.70	34.46	38.48	34.63
Total hourly Charge (£)	**76.11**	**66.39**	**93.83**	**64.79**

Table 3 Chipper Output Summary

Chipper	**Average Volume per Piece (m^3)**	**Volume (m^3)**	**Output (m^3/Shr)***	**Cost (£/m^3/shr)**
Heizohack 14-800	0.075	9.904	11.39	6.68
Foresteri	0.059	12.99	12.59	5.27
Jenz 560	0.065	12.99	21.10	4.44
Musmax Terminator 8	0.062	14.80	15.04	4.31

*An allowance of 18% for rest and 20% for other work has been used to convert basic time to standard time

Approximately 10 m^3 of solid wood was used for each chipper. This quantity was agreed with Biometrics Division to ensure significant results were obtained.

Discussion

The increase in bulk density from solid wood to wood chips can be between a factor of 2 and 5. Applying a factor of 3 to the outputs in Table 3 suggests that none of machines achieved the chip output stated by the manufacturers (>100 m^3 /hour). This adjustment factor has been commonly used by TD to assess the bulk density of wood chips.

The limiting factor for wood chip output was the size (diameter) difference between the solid wood and the size of the screens. With smaller diameter material a greater output can be expected. The wood chips produced from the solid wood rotated around the drum several times before particle sizes reduced to less than 50 mm to pass through the screen and onto the discharge auger. This build up of chips in the drum activated the anti-stress devices on all machines. When activated, these stop material being offered to the drum by stopping the hydraulic infeed bed and rollers. It was noticed during the study the anti stress device was activated on each machine and most frequently on the Foresteri. This indicated that the volume of timber fed onto the drum was too great to allow continuous

[4] Includes the cost of the tractor

chipping. The anti-stress devices on the other three machines were activated less frequently. Although large diameter in feed material could be used to supply the log fuel market, these results indicated that the greater the particle size reduction from in feed material to woodchips the lower the output achieved.

Table 3 shows a wide range of solid wood outputs with the Jenz having the highest of 21.10 m^3 and the Heizohack the lowest at 11.39 m^3 per standard hour. From study observations, the anti-stress device on the Foresteri was activated on every load. Experience and skill of the operator, power of the chipper drum and speed of chipping are the three main factors that affected output during the trial. There appears to be no direct relationship between number of knives and output.

WOOD CHIP QUALITY

A common theme raised during discussions with the selected machine operators was the demand for woodchips conforming to the Austrian woodfuel standard G30. Machine operators were requested to fit the screen that would produce the G30 specification.

The European specification for wood chips is the CEN/TC 335 standard. To assess particle size variation two samples were taken from each machine and tested against the CEN/TC 335 standard and the Austrian G30 standard. Sampling and particle size determination was carried out in accordance with the CEN/TC 335 standard. TES Bretby, an accredited testing laboratory (United Kingdom Accreditation Service 17025:2005) tested for the moisture content and particle size of both the CEN/TC 335 and the Austrian standard G30. .

Plate 1 The Screen on the Foresteri 4560C

Table 4 Wood Chip Quality – CEN/TC 335 Standard and Moisture Content and Particle Size Analysis

CEN TC/335		Coarse Fraction maximum length of particle		Main Fraction > 80% weight		Fine Fraction <5 weight %	
P16 Specification		<1%> 45mm, maximum length of particle < 85mm		3.15mm ≤ P ≤ 16mm		<1mm	
P45 Specification		<1% >63mm		3.15mm ≤ P ≤ 45mm		<1mm	
P63 Specification		<1% >100mm		3.15mm ≤ P ≤ 63mm		<1mm	
Moisture Content and Particle Size Analysis							
Chipper	**MC % (wet basis)**	**Size Distribution (mm)**	**+ 63**	**63 – 45**	**45 –16**	**16 – 3.15**	**3.15 –1.0**	**<1.0**
Heizohack 14-800	60.5	% Weight	Nil	Nil	5.3	82.3	11.6	0.8
Foresteri 4560C	60.5	% Weight	Nil	Nil	14.6	74.9	9. 3	1.2
Jenz 560	60.1	% Weight	Nil	Nil	16.5	74.0	8.0	1.5
Musmax Terminator 8	59.6	% Weight	Nil	Nil	7.0	87.6	4.5	0.9

Table 5 Wood Chip Quality – Austrian G30 Standard and Moisture Content and Particle Size Analysis

Austrian G30			**>16mm ≤ 20%**	**16-2.8mm ≥ 60%**	**2.8 –1 mm ≤ 20%**	**< 1mm ≤ 20%**
Moisture Content and Particle Size Analysis						
Chipper	**MC % (wet basis)**	**Size Distribution (mm)**	**+ 16**	**16 – 2.8**	**2.8 – 1.0**	**- 1.0**
Heizohack 14-800	60.5	% Weight	5.6	87.8	6.1	0.8
Foresteri 4560C	60.5	% Weight	12.0	80.1	6.7	1.2
Jenz 560	60.0	% Weight	17.2	73.1	8.2	1.5
Musmax Terminator 8	59.4	% Weight	7.7	87.6	3.8	0.9

Discussion

CEN/TC 335 Specification

The particle size distribution from the four machines with the G30 screen was overall very consistent with no wood chips being greater than 45 mm. The Heizohack had the most knives on the drum and produced the best quality of wood chips with 82% being within the main fraction. Both the Heizohack 14-800 and Musmax Terminator 8 produced a quality to conform with the P16, a specification with the smallest particle sizes in the CEN/TC 335 standard. The Foresteri 4560C and Jenz 560 achieved the P45 Specification with a similar percentage of wood chips in both the 45–16 mm and 16 –3.25 mm size range.

Austrian G30 Specification

The wood chips produced by all four chippers conformed to the G30 standard. The main fraction of the standard should be equal to or greater than 60% and the wood chips produced ranged between 73.1% to 87.8%, with the Heizohack producing the best quality of wood chips. The demand for this specification provides some indication of the types of boilers installed.

The CEN/TC 335 specification is a relatively new European standard and it is expected the demand for both the CEN and Austrian G30 specifications for domestic sized boilers will continue for the next few years.

Sound monitoring

As part of the trial both sound power and sound pressure levels from the chipping operations were to be assessed. Sound pressure levels are the measurement of the small pressure fluctuations superimposed on the normal atmospheric pressure and are measured using a sound level meter at the measurement position. Sound pressure levels were to be assessed at the operator's ear only if the chipping operation was controlled outside the cab of the tractor. All chippers were operated from the tractor cab (Q cabs[5]) therefore no sound pressure levels were necessary.

Sound power level is a measurement of the noise created by the machine and radiated in all directions. Sound power levels must be specified in instructions and sales literature for equipment conforming to the EU Machinery Safety Directive.

[5] A tractor cab specifically designed to reduce noise levels on the operator

Sound power levels during the chipper operations were assessed using dosimeters (CEL 360 and CEL 460 manufactured by Casella CEL, IEC standard 1252:1993) The meters were operated on a 70 to 140dB measurement range. Each meter was checked using a sound calibrator providing a 1kHz, 114 dB tone. The meters logged the A-weighted Leq and C-weighted peak levels every 10 seconds to provide a record of sound level variation during chipping. Dosimeters were mounted on tripods at a height of 1.5m and equally positioned around the chippers at a distance of between 8 – 12 m.

The sound power level assessments were relatively unsuccessful due to various problems. Recording of the Musmax chipping operation was the most successful however due to rainfall the dosimeters stopped recording before the chipping was completed and so the data can only be indicative.

Based on consultation with Noise and Vibration Section, Health and Safety Laboratory the C–peak levels from the Musmax are well under the action values and are not likely to cause a concern as environmental noise. The A weighted levels reached maximums between 83 and 86 dB (A). No noise level information on the Musmax could be found from the manufacturers technical data on the website and therefore no comparison made.

Fuel Consumption

Most modern large tractors are fitted with electronic fuel measurement systems. These were available and used to determine fuel consumption on the Fendt and Valtra 280S. The method used for the older Valtra 8750 and Musmax was to fill the fuel tanks to the top before the trial and refilled with a known quantity of fuel at the end of the trial. An estimated 2 litres was used by the Valtra T170 during loading, this was added to the fuel consumption of the Musmax. None of tractors in the trial were using biofuel.

Table 6 Fuel Consumption

Tractor	Chipper	Fuel Usage (l/m^3)
Valtra 280S (280 hp)	Heizohack HM 14-800	1.18
Valtra 8750 (190 hp)	Foresteri 4560C	1.92
Fendt 930 (300 hp)	Jenz 560Z	1.69
Valtra T170 (175hp)	Musmax Terminator 8	1.64

Table 7 Machine Comparison

Chipper	Capital Cost[6] (£)	Operating Costs (£/hr)	Maximum Cutting diameter (mm)	Output (m^3/shr)	CEN /TC 335	Austrian G30	Fuel Consumption (l/m^3)
Heizohack HM 14-800	85 000	76.11	800	11.39	P16	√	1.18
Foresteri 4560C	65 000	66.39	450	12.59	P45	√	1.92
Jenz 560Z	108 000	93.83	550	21.10	P45	√	1.69
Musmax Terminator 8	90 000	64.79	420	15.04	P16	√	1.64

CONCLUSIONS

An experienced loader operator is an important factor in increasing the output of the operation.

Presentation of infeed material should aim to minimise the amount of loader movement and grapple rotation.

Chippers with an integral screen have the flexibility to produce a range of woodchip particle sizes with a high degree of particle size consistency. The size of the screen in relation to the diameter range of the infeed material can directly affect output.

[6] Excluding cost of tractor

Outputs quoted on manufacturers' literature refer to the volume of wood chips produced and do not consider chip size or degree of compaction in container. A measurement of the solid wood to be chipped would provide a better indication of actual wood chipped.

All four chippers were capable of meeting the Austrian G30 wood chip specification. The Heizohack 14-800 and Musmax Terminator 8 produced chips which met the CEN/TC 335 P16 specification and the Foresteri 4560C and Jenz 560Z met the P45 specification.

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Appendix 1

PURPOSE BUILT HIGH OUTPUT CHIPPERS AVAILABLE IN THE UK

Type	Type	Maximum Cutting Diameter
Bandit 280	Disc	450 mm
Biber 7 Plus	Disc	350 mm
Chipper 35	Disc	350 mm
Doppstadt DH910	Drum	900 mm
Dynamic 565	Drum	550 mm
Foresteri 4560C	Drum	450 mm
Heizohack HM 14-800	Drum	800 mm
Jenz 560Z	Drum	550 mm
Junkkari HJ 500	Disc	450 mm
Morbark	Disc	Various
Musmax	Drum	400 mm