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COMMUNICATION from G J LYONS BE MEngSc PhD MIEI,* H P POLLOCK BE CEng FIEI MIMechE MInstE† and A HEGARTY BSc MIS‡

Fuel properties of short-rotation hardwood coppice sprouts

1. Introduction

In commenting on our earlier paper,[1] A W T Cleaver and J Heaton[2] highlighted two further fuel properties which are of direct concern to the fuel user: (1) moisture content 'as delivered' and (2) fuel shape and size. This communication is intended to complement the original paper on these topics.

2. Moisture content 'as delivered'

High harvest moisture content (MC) is characteristic of all forest fuels. Our data for short-rotation species[1] gave an average MC of 51.6% for *Populus* and *Salix* clones. Residues from conventional forest logging and saw-milling operations are currently the main souce of fuelwood in Western Europe; moisture contents for this material are typically in the range 50–65%. Combustion of high-moisture wood usually results in poor ignition, large volume of flue gases, and reduced furnace capacity. While furnaces are available that burn wood of up to 50% MC, a moisture level below 30% is desirable for efficient combustion. Even more stringent inlet conditions (as low as 20% MC) are required for gasification, according to Cleaver and Heaton.[2] Fig. 1 illustrates the effect of 'as fired' MC on the net (ie net calorific value, CV) and usable heating values for a typical hardwood fuel of gross anhydrous CV 18.6 MJ/kg. The 'usable heat' plot shown represents the potential heat energy recoverable at the furnace/boiler heat exchange surface, under assumed furnace operating condition.[3]

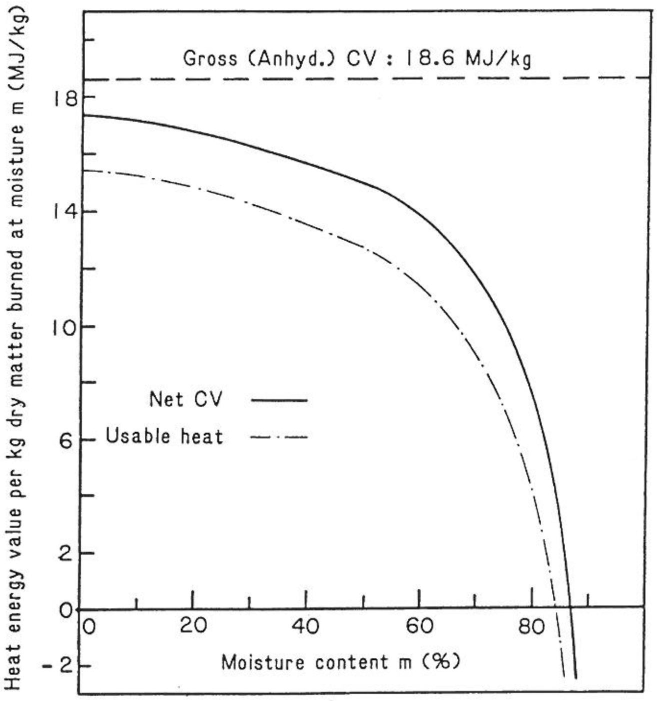

FIG. 1 Variation of net CV and usable heat content per kilogram of dry matter *burned at moisture content* m

3. Fuel shape and size

The particle size/shape and bulk density of fuelwood derived from short-rotation forests (SRF) are governed both by the diameter of parent trees and the type of size-reduction equipment (eg disk- or drum-type chipper, chunker, hammermill, or billeting machine) used in producing the comminuted fuel. At present, a chipped product—as used in the pulp and paper industry (typically 12–40 mm long and up to 15 mm thick)—is the accepted particle type for the industrial use of fuelwood. Such chips made from SRF sprouts yield a high percen-

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TABLE 1 Bulk density (fresh weight and dry weight) of screened and whole-tree chips of six SRF species

	Bulk density (kg/m³) fresh weight					Bulk density (kg/m³) dry weight				
Species / Sieve size (mm)	6.3	13.2	19.0	25.0	Whole-tree chips	6.3	13.2	19.0	25.0	Whole-tree chips
Fraxinus excelsior	188.80	215.42	223.93	234.61	224.11	138.98	170.10	168.20	180.60	168.00
Populus Frotzi Pauley	254.99	228.55	229.47	216.59	238.46	126.96	127.03	131.06	126.35	134.90
Populus Rap	228.32	205.37	202.32	198.14	219.18	124.29	124.22	121.89	129.27	132.30
Salix aquatica gigantea	222.66	244.05	225.90	217.91	202.17	118.56	127.67	126.28	119.05	117.63
Salix dasyclados	212.27	226.24	220.89	209.22	231.11	118.04	135.45	137.58	135.99	126.75
Salix viminalis	213.67	226.47	210.46	209.89	214.62	111.95	122.91	121.48	117.25	117.88
Mean	220.12	224.35	218.83	214.39	221.61	123.13	134.56	134.41	134.75	132.91
SED	1.953	1.847	2.736	2.047	2.164	1.232	2.922	1.638	1.434	1.552
Sig level [P <]	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Overall mean: 220.91.					Overall mean: 131.95.				

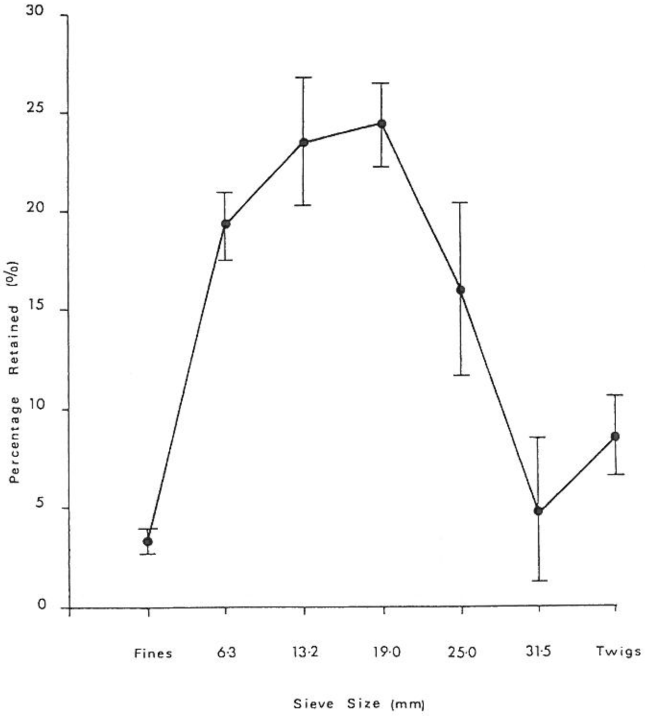

FIG 2 Particle size classification for whole-tree chips of six SRF species

tage of undersize particles and oversize twigs, which may not comply with end-user fuel specifications. Harvester development work in North America and Scandinavia is currently investigating a larger, irregularly shaped particle type, termed 'chunkwood'.[4]

While not state properties of a fuel, particle size/shape and bulk density greatly affect the design of combustion and handling equipment. These properties dictate the exposed surface area, fuel feed rate, excess air and response time for a furnace. Bulk volume, rather than weight, is also likely to determine quantities (and hence costs) for fuel harvesting, handling and transport. In an extension of the work described previously,[1] particle size and bulk density were determined for whole-tree chips produced from the six SRF species and clones studied. The summarised data for particle size are illustrated in Fig. 2. Bulk density results, evaluated at both harvest moisture content and oven-dry, are presented in Table 1. These suggest that the volumetric capacity required for storage and transport is large, at 4-5 m^3 per fresh tonne. To give further insight into the effect of particle size/shape and bulk density on fuel handling and conversion characteristics, the relative solid value* of this chipped material was computed (Table 2). This gives an indication of the compaction efficiency for whole-tree SRF chips, and can thus be used to determine transport and conversion system fuel demands by weight.

TABLE 2 Relative solid volume of whole-tree chips of six SRF species

Species	Relative solid volume (%)	
	Fresh weight	**Dry weight**
Fraxinus excelsior	42.0	32.0
Populus Fritzi Pauley	63.0	36.0
Populus Rap	71.0	43.0
Salix aquatica gigantea	52.0	30.0
Salix dasyclados	56.0	31.0
Salix viminalis	46.0	26.0

4. References

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*Ratio of solid volume to loose volume, the former based on measured specific gravity.

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