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Density Of Selected Wood Fuels

By

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And
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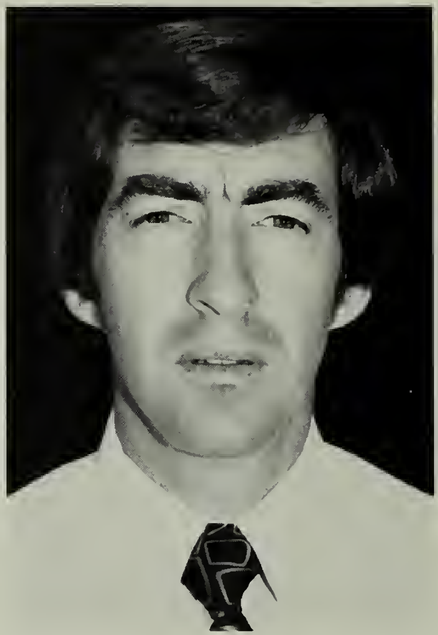
About The Authors



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ABSTRACT

Seven types of wood fuel were measured, in an industrial setting, to determine the density of each type of fuel. The type, density and moisture content of each fuel was: pine whole-tree chips, 18.8 lbs./cu. ft. @ 40% MC; hardwood whole-tree chips, 20.4 lbs./cu. ft. @ 35% MC; mixed pine-hardwood sawdust, 23.1 lbs./cu. ft. @ 41% MC; hardwood sawdust and bark, 25.8 lbs./cu. ft. @ 45% MC; hogged dry furniture waste (mixed hardwoods), 15.7 lbs./cu. ft. @ 12% MC; hardwood pulp chips, 22.9 lbs./cu. ft. @ 43% MC; hardwood shavings, 10.8 lbs./cu. ft. @ 8% MC. Dry weight density is also reported for each fuel type. This information is useful in calculating payloads and storage requirements of various types of wood fuel.

Introduction

The use of wood as an industrial fuel has increased dramatically over the last 10 years, and the switch from fossil fuel to wood fuel continues. Wood fuel comes in various forms, including sawdust, bark, shavings, hogged furniture waste, and whole-tree chips, and the form affects its storage, handling and use.

The weight density or weight per unit volume of wood fuel (hereinafter called density) is an important variable when considering the storage, handling, and transportation of wood fuel. Density is a function of the type of wood fuel, the moisture content, and the way the material has been handled. Bois (1968)[1/] showed that packing of sawdust increases its density by over 50 percent. Thompson and Darwin (1968)[2/] measured the density of the sawdust of several hardwood species and found considerable variation. The studies by Bois (1968) and Thompson and Darwin (1968) dealt strictly with sawdust and were based on a relatively small number of samples.

The study described here was undertaken to document the density of various types of wood fuel. Data were collected at an industrial wood yard using large sample sizes for the density measurements.

1/ Bois, P. J. 1968. Weight of sawdust from several southern appalachian wood species. For. Prod. J. 18(10):52-53.

2/ Thompson, W. S. and W. N. Darwin. 1968. Weight, volume, and moisture content of sawdust from selected southern species. For. Prod. J. 18(9):96.

Figure 1. Leveling of front-end loader bucket filled with wood fuel.

Figure 2. Truck loaded with four front-end loader buckets of wood fuel, ready for weighing.

MATERIALS AND METHODS

Seven types of wood fuel were measured: pine whole-tree chips, hardwood whole-tree chips, mixed pine-hardwood sawdust, hardwood sawdust and bark, hogged dry furniture waste (mixed hardwoods), hardwood pulp chips and hardwood shavings.

The density was measured by filling a 141 cu. ft. bucket of a front-end loader with material, and placing the known volume of material in a dump truck (Figure 1). The truck was capable of holding four buckets of material (564 cu.ft.); after filling, a net weight was determined (Figure 2). A second method was tried, in which a dump truck was filled to overflowing. The excess material was raked off and the level full truck was weighed. The weight was divided by the known volume to give the density. Two problems developed--one, it was difficult to obtain an accurately leveled truck load; two, it was difficult to level the truck without putting pressure on the material and causing it to be compacted. When the two methods were compared, they were found to produce results that differed by less than 0.5 lbs./cu.ft. Since the technique of measuring bucket loads of 141 cu.ft. was more convenient and was judged to be more accurate, it was selected for all subsequent measurements.

The moisture contents of fuels were determined using grab samples which were taken from each load of fuel during green weight sampling. Samples were dried in ovens at $103^{o}\pm2^{o}C$ until weight loss ceased. Moisture content was determined on a green weight basis. Dry weight per green cubic foot was determined by adjusting green weight to dry weight by factoring out the moisture.

RESULTS AND DISCUSSION

A summary of green and dry densities for the seven fuels is given in Table 1. The green density is the weight per unit volume of the material as it arrived at the fuel yard. This value depends upon the moisture content of the material at the time of sampling. Average moisture contents (wet basis) are shown in Table 1. Dry density is the weight of the ovendry wood per unit of green volume of the wood. Dry densities are also shown in Table 1.

On the basis of delivered moisture content, mixed hardwood sawdust and bark had the highest green density--25.8 lbs./cu.ft. at an average moisture content (MC) of 45 percent. The second most dense was sawdust (23.1 lbs./cu.ft. @ 43% MC). The lightest material was hardwood shavings, with a bulk density of 10.8 lbs./cu.ft. at a moisture content of 8 percent.

Bois (1968) gave density of sawdust at three compaction levels: light, shaken, and packed. He indicated that filling a truck by gravity drop (such as from an overhead conveyor) represented the "light" category. However, his sampling unit was small (2.43 cu.ft.) and the weight of the sawdust itself was not a factor in the compaction of the material. Bois (1968) found the average density for pine and hardwood sawdust for the light and shaken categories to be 17.8 and 22.9 lbs./cu.ft. at a moisture content of 43 percent. This study, based on large volume loads, showed the density of mixed pine-hardwood sawdust to be 23.1 lbs./cu.ft. at a moisture content of 41 percent. Thus, our results indicate that the "shaken" category from Bois corresponds favorably to the density of large truck-loads of sawdust. Similar results could also be expected where sawdust is bulk stored at industrial sites.

Mixed hardwood sawdust and bark had the highest dry density, 14.2 lbs./cu.ft. (Table 1). As with green bulk density, the lightest material was hardwood shavings, which had a density of 9.8 lbs./cu.ft. The curling of shavings creates voids when the material is piled. It is interesting that hogged dry trims were next to highest in dry density but next to lowest in green density. Hogged dry trims pack very well due to the large range of partical sizes; however, the low initial moisture content keeps the green density low. After correcting for moisture content, hardwood whole-tree chips and hardwood pulp chips were nearly identical in density. However, similarily corrected, pine whole-tree chips were considerably lighter than moisture corrected hardwood whole-tree chips. Density was fairly consistent between loads, with low standard deviations for each fuel type.

To measure the level of load compaction during hauling, the volume of pine sawdust in a 40-foot trailer was determined before and after hauling. The material was hauled over approximately 3 miles of rough gravel road and approximately 10 miles of a paved highway. After transport, the material had settled to approximately 96 percent of its original volume. Due to the rough road and 13-mile haul distance, the 4 percent reduction in volume is probably close to the maximum settlement that could be expected during transport. Bois (1968) reported that pine sawdust that had been packed was 97 percent of the volume of sawdust that had been shaken. Reduction in volume during transport of green material does not help increase the payload, since the extra space is available only after transport and not during loading.

The impact that density has on the transport of fuels can be observed through a simple example. If the volume of a trailer is 2560 cubic feet (40' X 8' X 8') and the maximum allowable payload is 48,500 pounds (78,500 pound gross weight legal limit minus 30,000 pound average truck and trailer weight), any material that weighs over 19 lbs/cu. ft. will exceed the weight limit if the trailer is filled to capacity. Thus, according to data in this study, excess space is still available in a trailer after it is loaded to the legal weight limit with sawdust, sawdust and bark, hardwood whole-tree chips and hardwood pulp chips. The legal weight of whole-tree chips would almost exactly fill the trailer, while hogged trims and shavings would leave the trailer full but below legal weight limit and a full payload.

Table 1. Average density of seven types of wood fuel.

Fuel type	No. of samples	Average moisture content[1]	Green density			Dry density		
			Average	St. Dev.	Range	Average	St. Dev.	Range
		--- % ---	lbs/cu ft					
Mixed sawdust and bark (hardwood and pine)	10	45	25.8	0.95	24.2-27.2	14.2	0.35	13.3-15.0
Sawdust (pine and hardwood)	10	41	23.1	1.40	21.0-25.1	13.7	0.98	12.4-14.8
Clean hardwood pulp chips	11	43	22.9	1.09	21.5-23.8	13.1	1.16	12.3-13.6
Hardwood whole-tree chips	10	35	20.4	0.35	19.9-20.9	13.2	0.20	12.9-13.6
Pine whole-tree chips	11	40	18.8	0.32	18.3-19.2	11.3	0.25	11.0-11.5
Hogged dry trims (hardwood)	10	12	15.7	1.27	12.9-16.8	13.8	0.74	11.4-14.8
Shavings (hardwood)	9	8	10.8	1.77	8.8-13.4	9.8	1.65	8.1-12.3

[1] Wet basis

This recently completed wood heating complex at Central State Hospital is an example of the dramatic increase in the use of wood as fuel. The system is designed to burn wood chips that provides steam for heating, cooling and domestic hot water for numerous buildings at the institution.

John W. Mixon, Director
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